Cellular effects and delivery propensity of penetratin is influenced by conjugation to parathyroid hormone fragment 1-34 in synergy with pH

The cell-penetrating peptide (CPP) penetratin, has demonstrated potential as a carrier for transepithelial delivery of cargo peptides, such as the therapeutically relevant part of parathyroid hormone, i.e. PTH(1-34). The purpose of the present study was to elucidate the relevance of modifying the pH for PTH(1-34)-penetratin conjugates and for co-administered penetratin with PTH(1-34) in terms of transepithelial permeation of PTH(1-34) and cellular effects. Transepithelial permeation was assessed using monolayers of the Caco-2 cell culture model, and effects on Caco-2 cellular viability kinetics were evaluated by using the Real-Time-GLO assay as well as by microscopy following Tryphan blue staining. Morphological Caco-2 cell changes were studied exploiting the impedance-based xCELLigence system as well as optically using the oCelloscope setup. Finally, the effect of pH on the folding propensity of the PTH(1-34)-penetratin conjugate and its ability to disrupt lipid membranes were assessed by circular dichroism (CD) spectroscopy and the calcein release assay, respectively. The transepithelial PTH(1-34) permeation was not pH-dependent when applying the co-administration approach. However, by applying the conjugation approach, the PTH(1-34) permeation was significantly enhanced by lowering the pH from 7.4 to 5, but also associated with a compromised barrier and a lowering of the cellular viability. The negative effects on the cellular viability following cellular incubation with the PTH(1-34)-penetratin conjugate were moreover confirmed during real-time monitoring of the Caco-2 cell viability as well as by enhanced Tryphan blue uptake. In addition, morphological changes were primarily observed for cells incubated with the PTH(1-34)-penetratin conjugate at pH 5, which was moreover demonstrated to have an enhanced membrane permeating effect following lowering of the pH from 7.4 to 5. The latter observation was, however, not a result of better secondary folding propensity at pH 5 when compared to pH 7.4.
Combined detection of C-reactive protein and PBMC quantification from whole blood in an integrated lab-on-a-disc microfluidic platform

There is an increasing need for portable and low-cost diagnostic devices for detecting inflammatory/infectious diseases in a rapid and user-friendly fashion. Here, we present a lab-on-a-disc solution, which performs automated sample pre-treatment and combinedly detects small molecules and counts cells in a whole blood sample with a volume of 8.75 μL with a sample to answer time of 14 min. It is used to detect two common inflammation/infection biomarkers, C-reactive protein (CRP) and peripheral blood mononuclear cell (PBMC) count. The whole blood sample was separated into plasma and PBMC fractions using density gradient centrifugation and centrifuguo-pneumatic valving. On-disc CRP detection was performed in the extracted plasma using a CRP-antibody-functionalized magnetic nanobead (MNB)-based agglutination assay and a Blu-ray-based optomagnetic detection unit. On-disc PBMC scanning and quantification was performed using an optical imaging unit. Both detection units were integrated on the centrifugal platform and the entire study was
automated in order to ensure reliability of the assay and user-friendliness of the method. We measured the CRP level of subjects with different CRP levels and obtained approximately 73% PBMC extraction efficiency compared to hospital results. The concurrent/combined detection of these two common biomarkers in an automated microfluidic platform with integrated detection units and with a low sample-to-answer time is a significant step forward towards a low-cost, out-of-lab, and portable tool to detect multiple biomarkers of significantly different nature (molecules and cells).

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Magnetic Systems, BluSense Diagnostics
Authors: Uddin, R. (Intern), Donolato, M. (Ekstern), Hwu, E. T. (Intern), Hansen, M. F. (Intern), Boisen, A. (Intern)
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BFI (2015): BFI-level 1
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Web of Science (2015): Indexed yes
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.261 SNIP 1.638 CiteScore 4.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
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ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.485 SNIP 1.752 CiteScore 4.08
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.434 SNIP 1.437
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.317 SNIP 1.518
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.448 SNIP 1.566
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.446 SNIP 1.598
Scopus rating (2006): SJR 1.359 SNIP 1.535
**Combined Used of Rheology and LF-NMR for the Characterization of PVP-Alginates Gels Containing Liposomes**

This paper is based on the characterization of the rheological and Low Field NMR (LF-NMR) properties of an interpenetrated hydrogel made up by poly(N-vinyl-2-pyrrolidone) and sodium alginate. The final aim is to use the hydrogel as a delivery matrix for liposomes, widely used tools in the drug delivery field.

**General information**
- **State:** Published
- **Organisations:** Department of Micro- and Nanotechnology, Nanoprobes, Technical University of Denmark, University of Trieste
- **Authors:** Fanesi, G. (Ekstern), Abrami, M. (Ekstern), Zecchin, F. (Ekstern), Giassi, I. (Ekstern), Ferro, E. D. (Ekstern), Boisen, A. (Intern), Grassi, G. (Ekstern), Bertoncin, P. (Ekstern), Grassi, M. (Ekstern), Marizza, P. (Intern)
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  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 2
  - Scopus rating (2016): SJR 1.112 SNIP 0.986 CiteScore 3.49
  - BFI (2015): BFI-level 2
  - Scopus rating (2015): SJR 1.155 SNIP 1.099 CiteScore 3.6
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): SJR 1.35 SNIP 1.303 CiteScore 3.93
  - Web of Science (2014): Indexed yes
  - BFI (2013): BFI-level 2
  - Scopus rating (2013): SJR 1.57 SNIP 1.422 CiteScore 4.7
  - ISI indexed (2013): ISI indexed yes
  - BFI (2012): BFI-level 2
Detecting forensic substances using commercially available SERS substrates and handheld Raman spectrometers

Ultra-sensitive in-field measurements of most forensic substances still today remain a challenge for first responders and forensic investigators. Handheld Raman spectroscopy equipment is getting more and more routinely used in the field for evidence collection, however, restricted to measurements of pure or high concentration samples. Here, surface-enhanced Raman scattering (SERS) sensing of common forensic substances with commercially available SERS substrates and handheld spectrometers, have been investigated. 3D Finite Element Method (FEM) and Density Functional Theory (DFT) simulations were used to interpret the high SERS enhancement of the Ag nanopillar substrate and the detection of the substances, respectively. The forensic generality and high performance of the analytical method were demonstrated by explicit detection of close to unprecedented amounts, down to femtograms, of Cyclosarin, RDX, Amphetamine and Picric acid. Implications are ultra-sensitive in-field SERS detection of these substances with commercial equipment.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Sensor Visions AB, Swedish Defense Research Agency FOI
Authors: Hakonen, A. (Ekstern), Wu, K. (Intern), Schmidt, M. S. (Intern), Andersson, P. O. (Ekstern), Boisen, A. (Intern), Rindzevicius, T. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
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Web of Science (2016): Indexed yes
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Scopus rating (2015): SJR 1.173 SNIP 1.316 CiteScore 3.99
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.192 SNIP 1.284 CiteScore 3.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.2 SNIP 1.385 CiteScore 3.74
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.417 SNIP 1.451 CiteScore 3.74
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.432 SNIP 1.507 CiteScore 3.91
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.466 SNIP 1.368
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.328 SNIP 1.332
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 1.35 SNIP 1.304
Scopus rating (2007): SJR 1.439 SNIP 1.483
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.308 SNIP 1.353
Scopus rating (2005): SJR 1.115 SNIP 1.438
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.169 SNIP 1.514
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.989 SNIP 1.337
Scopus rating (2002): SJR 0.859 SNIP 1.252
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.925 SNIP 1.148
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.817 SNIP 1.181
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.907 SNIP 1.089
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Development of electrosprayed mucoadhesive chitosan microparticles

The efficacy of chitosan (CS) to be used as drug delivery carrier has previously been reported. However, limited work has been pursued to produce stable and mucoadhesive CS electrosprayed particles for oral drug delivery, which is the aim of this study. Various CS types with different molecular weight (MW), degree of deacetylation (DD), and degree of polymerization (DP) were assessed. In addition, the effect of the solvent composition was also investigated. Results showed that stable CS electrosprayed particles can be produced by dissolving 3% w/v of low MW CS in mixtures of aqueous acetic acid and ethanol (50/50% v/v). The stable CS particles displayed diameters of approximately 1 μm as determined by dynamic light scattering. The zeta potential of these particles was found to be approximately 40 mV confirming the mucoadhesion properties of these CS electrosprayed particles and its potential to be used as drug delivery carrier.
Efficiency enhancement of InGaN amber MQWs using nanopillar structures

We have investigated the use of nanopillar structures on high indium content InGaN amber multiple quantum well (MQW) samples to enhance the emission efficiency. A significant emission enhancement was observed which can be attributed to the enhancement of internal quantum efficiency and light extraction efficiency. The size-dependent strain relaxation effect was characterized by photoluminescence, Raman spectroscopy and time-resolved photoluminescence measurements. In addition, the light extraction efficiency of different MQW samples was studied by finite-different time-domain simulations. Compared to the as-grown sample, the nanopillar amber MQW sample with a diameter of 300 nm has demonstrated an emission enhancement by a factor of 23.8.

General information
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Organisations: Department of Photonics Engineering, Diode Lasers and LED Systems, Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, King Abdullah University of Science and Technology, Sun Yat-Sen University
Authors: Ou, Y. (Intern), Iida, D. (Ekstern), Liu, J. (Ekstern), Wu, K. (Intern), Ohkawa, K. (Ekstern), Boisen, A. (Intern), Petersen, P. M. (Intern), Ou, H. (Intern)
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Web of Science (2016): Indexed yes
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Scopus rating (2014): SNIP 2.714 SJR 3.475
Scopus rating (2013): SNIP 2.247 SJR 3.023
ISI indexed (2013): ISI indexed no
Gold Nanoparticles Sliding on Recyclable Nanohoodoos as SERS Substrates – Bridging the Gap between Low Cost and Excellent Performance

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Self-Organized Nanoporous Materials
Authors: Wu, K. (Intern), Li, T. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Ndoni, S. (Intern), Boisen, A. (Intern)
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Main Research Area: Technical/natural sciences

Gold Nanoparticles Sliding on Recyclable Nanohoodoos-Engineered for Surface-Enhanced Raman Spectroscopy
Robust, macroscopically uniform, and highly sensitive substrates for surface-enhanced Raman spectroscopy (SERS) are fabricated using wafer-scale block copolymer lithography. The substrate consists of gold nanoparticles that can slide and aggregate on dense and recyclable alumina/silicon nanohoodoos. Hot-spot engineering is conducted to maximize the SERS performance of the substrate. The substrate demonstrates remarkably large surface-averaged SERS enhancements, greater than $10^7$ ($>10^8$ in hot spots), with unrivalled macroscopic signal uniformity as characterized by a coefficient of variation of only 6% across 4 cm. After SERS analyses, the nanohoodoos can be recycled by complete removal of gold via a one-step, simple, and robust wet etching process without compromising performance. After eight times of recycling, the substrate still exhibits identical SERS performance in comparison to a new substrate. The macroscopic uniformity combined with recyclability at conserved high performance is expected to contribute significantly on the overall competitiveness of the substrates. These findings show that the gold nanoparticles sliding on recyclable nanohoodoo substrate is a very strong candidate for obtaining cost-effective, high-quality, and reliable SERS spectra, facilitating a wide and simple use of SERS for both laboratorial and commercial applications.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Center for Nanostructured Graphene, Self-Organized Nanoporous Materials, University College London
Authors: Wu, K. (Intern), Li, T. (Ekstern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern), Ndoni, S. (Intern)
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Volume: 28
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The optical pickup unit (OPU) within a CD/DVD/Blu-ray drive integrates 780, 650, and 405 nm wavelength lasers, diffraction-limited optics, a high-bandwidth optoelectronic transducer up to 400 MHz, and a nano-resolution x-, z-axis and tilt actuator in a compact size. In addition, the OPU is a remarkable piece of engineering and could enable different scientific applications such as sub-angstrom displacement sensing, micro and nanoimaging, and nanolithography. Although off-the-shelf OPUs can be easily obtained, manufacturers protect their datasheets under non-disclosure agreements to impede their availability to the public. Thus, OPUs are black boxes that few people can use for research, and only experienced researchers can access all their functions. This review details the OPU mechanism and components. In addition, we explain how to utilize three commercially available triple-wavelength OPUs from scratch and optimize sensing quality. Then, we discuss scientific research using OPUs, from standard optical drive-based turnkey-biomarker array reading and OPU direct bio-applications (cytometry, optical tweezing, bioimaging) to modified OPU-based biosensing (DNA chip fluorescence scanning, biomolecular diagnostics). We conclude by presenting future trends on optical storage devices and potential applications. Repurposing low-cost and high-performance OPUs may spread micro and nanoscale biosensing research from research labs to citizen scientists around the globe.

Hacking CD/DVD/Blu-ray for Biosensing

General information
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Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes
Authors: Hwu, E. E. (Intern), Boisen, A. (Intern)
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InGaN/GaN ultraviolet LED with a graphene/AZO transparent current spreading layer

We report an approach of using an interlayer of single layer graphene (SLG) for electroluminescence (EL) enhancement of an InGaN/GaN-based near-ultraviolet (NUV) light-emitting diode (LED) with an aluminum-doped zinc oxide (AZO)-based current spreading layer (CSL). AZO-based CSLs with and without a SLG interlayer were fabricated on the NUV LED epi-wafers. The current-voltage (I-V) characteristic and the EL intensity were measured and compared. We find that the LED without the SLG interlayer can possess a 40% larger series resistance. Furthermore, a 95% EL enhancement was achieved by the employment of the SLG interlayer.
Injection molded lab-on-a-disc platform for screening of genetically modified E. coli using liquid-liquid extraction and surface enhanced Raman scattering

We present the development of an automated centrifugal microfluidic platform with integrated sample pre-treatment (filtration and liquid-liquid extraction) and detection (SERS-based sensing). The platform consists of eight calibration and four assay modules, fabricated with polypropylene using injection molding and bonded with ultrasonic welding. The platform was used for detection of a secondary bacterial metabolite (p-coumaric acid) from bacterial supernatant. The obtained extraction efficiency was comparable to values obtained in batch experiments and the SERS-based sensing showed a good correlation with HPLC analysis.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Research Groups, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Politecnico di Torino
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BFI (2018): BFI-level 1
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.98 SJR 2.162 SNIP 1.569
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.239 SNIP 1.721 CiteScore 5.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.555 SNIP 1.797 CiteScore 5.6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.397 SNIP 1.693 CiteScore 5.9
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.405 SNIP 1.731 CiteScore 5.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.54 SNIP 1.788 CiteScore 5.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.718 SNIP 1.876
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Laser ablation and injection moulding as techniques for producing micro channels compatible with Small Angle X-Ray Scattering

Microfluidic mixing is an important means for in-situ sample preparation and handling while Small Angle X-Ray Scattering (SAXS) is a proven tool for characterising (macro-)molecular structures. In combination those two techniques enable investigations of fast reactions with high time resolution (< 1 ms). The goal of combining a micro mixer with SAXS, however, puts constraints on the materials and production methods used in the device fabrication. The measurement channel of the mixer needs good X-ray transparency and a low scattering background. While both depend on the material used, the requirement for low scattering especially limits the techniques suitable for producing the mixer, as the fabrication process can induce molecular orientations and stresses that can adversely influence the scattering signal. Not only is it important to find a production method that results in a device with low background scattering, but it also has to be versatile enough to produce appropriate mixer designs. Here we discuss two methods – laser ablation of polycarbonate and injection moulding of Topas – which were found suitable for our needs, provided care is taken in aligning the mixing/reaction channel, where the actual measurements will be carried out. We find injection moulding to be the better of the two methods.
Microfabricated devices for oral drug delivery
Oral administration of drugs is most convenient for patients and therefore the ultimate goal when developing new medication. The physical barriers in the body, low pH of the stomach and degradation by enzymes in the gastrointestinal tract are a few of the obstacles to succeeding with oral drug delivery. Microfabricated devices show promise to overcome some of these hindrances and thereby improve the bioavailability of drugs after oral administration. There is an increasing focus on microfabricated oral drug delivery systems, and so far there have been three main groups of designs: patch-like structures, microcontainers and microwells. Here, we review the newest development in top-down microfabricated devices for oral drug delivery with coverage of the aspects of design, choice of material and fabrication techniques. Furthermore, the drug loading techniques and methods for testing are discussed. In addition, we discuss the future perspectives for microfabricated devices.
Micromotors for drug delivery in vivo: The road ahead

Autonomously propelled/externally guided micromotors overcome current drug delivery challenges by providing (a) higher drug loading capacity, (b) localized delivery (less toxicity), (c) enhanced tissue penetration and (d) active maneuvering in vivo. These microscale drug delivery systems can exploit biological fluids as well as exogenous stimuli, like light-NIR, ultrasound and magnetic fields (or a combination of these) towards propulsion/drug release. Ability of these wireless drug carriers towards localized targeting and controlled drug release, makes them a lucrative candidate for drug administration in complex microenvironments (like solid tumors or gastrointestinal tract). In this report, we discuss these microscale drug delivery systems for their therapeutic benefits under in vivo setting and provide a design-application rationale towards greater clinical significance.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Colloids and Biological Interfaces
Authors: Srivastava, S. K. (Intern), Clergeaud, G. (Intern), Andresen, T. L. (Intern), Boisen, A. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 13.96 SJR 4.262 SNIP 3.669
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 5.054 SNIP 4.264 CiteScore 16.01
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 4.877 SNIP 4.35 CiteScore 15.08
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Real-time electrochemical detection of paracetamol interaction with intestinal tissue

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Malmö University
Authors: Thoppe Rajendran, S. (Intern), Ruzgas, T. (Ekstern), Boisen, A. (Intern), Zor, K. (Intern)
Publication date: 2018
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2018

Spray dried cubosomes with ovalbumin and Quil-A as a nanoparticulate dry powder vaccine formulation

Subunit vaccine formulations are often produced as liquid dispersions through complicated processes. It is desirable, however, to have simple, cheap and up-scalable methods to produce nanoparticulate subunit vaccines in powder form. Here, a simple single-step spray drying process for production of powder cubosome precursors with the model antigen ovalbumin (OVA) and the adjuvant Quil-A is presented. The cubosomes were characterized in vitro and evaluated in vivo by subcutaneous and oral administration for their potential as a vaccine formulation. Hydrated cubosomes had average particle size of 257±8nm and zeta potential of −18.0±0.6mV. The powder contained 10.6±0.7% w/w OVA prior to hydration, of which 65±1% was released within the first 20min in 9.5mM PBS at pH 7.3, with the remaining OVA gradually released over the following 24h. Immunization with cubosomes resulted in significantly stronger antigen-specific serum IgG responses (p<0.01), CD8+ T cell expansion (p<0.0001) and target T cell killing compared to controls when given s.c., and was ineffective orally. This study shows that spray drying is a suitable method for producing nanoparticulate vaccine formulations in dry powder form.
Tailoring stress in pyrolytic carbon for fabrication of nanomechanical string resonators

In order to achieve high resonance frequencies and quality factors of pyrolytic carbon MEMS string resonators the resonator material needs to have a large tensile stress. In this study, the influence of pyrolysis temperature, dwell time and ramping rate on the residual stress in thin pyrolytic carbon films is investigated with the bending plate method. The results show that the pyrolysis temperature is the most important parameter for tailoring the residual stress, with a transition from tensile stress at temperature below 800ºC to compressive stress at temperatures above 800ºC. Two kinds of photoresist: positive (AZ5214E) and negative (SU-8) and different pyrolysis conditions are used to fabricate pyrolytic carbon string resonators at variable pyrolysis conditions. The best performance is obtained for devices with a length of 400 µm fabricated at a pyrolysis temperature of 700ºC, ramping rate of 30ºC/min and 10 minutes dwell time corresponding to the conditions for maximum tensile stress in pyrolytic carbon thin films. The optimized pyrolytic carbon string resonators had resonant frequencies above 300 kHz and quality factors (Q) in the order of $10^4$, which is suitable for their application as nanomechanical sensors.
Temperature Modulated Nanomechanical Thermal Analysis
The response of microcantilever deflection to complex heating profiles was used to study thermal events like glass transition and enthalpy relaxation on nanograms of the biopolymer Poly(lactic-co-glycolic acid) (PLGA). The use of two heating rates enables the separation of effects on the deflection response that depends on previous thermal history (non-reversing signal) and effects that depends only on the heating rate variation (reversing signal). As these effects may appear superposed in the total response, temperature modulation can increase the measurement sensitivity to some thermal events when signals are isolated. Initially, it was shown how the signal can be processed to extract reversing, total and non-reversing signals and how the temperature modulation affects the cantilever sensitivity to temperature. Then, this technique was used to study how the different aging times affects the non-reversing curve but has no effect on the reversing curve, enabling more precise extraction of glass transition (Tg) in aged samples. With non-reversing data at different aging times, we measured the aging rate by means of average relaxation time (τ) using the Cowie-Ferguson model, obtaining τ = 348 minutes for PLGA aged at 20 °C and at 50 % RH. Tg for PLGA at 50 % RH was measured 37.8 °C using the reversing signal with 0.32 °C of variation between aging times.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, University of São Paulo
Authors: Alves, G. M. A. (Ekstern), Bose-Goswami, S. (Intern), Mansano, R. D. (Ekstern), Boisen, A. (Intern)
Pages: 4001 - 4007
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Sensors Journal
Using microcantilever sensors to measure poly(lactic-co-glycolic acid) plasticization by moisture uptake

Polymeric materials absorb water when exposed to humidity or in contact with aqueous solutions. The polymer and water molecules interact, changing the physicochemical parameters of the material; the most noticeable effect is a decreased glass transition temperature (T_g), known as plasticization. We used microcantilever sensors to measure the T_g versus moisture content in poly(lactic-co-glycolic acid) (PLGA), a biodegradable polymer used in implants and as a drug carrier. We demonstrate a concomitant measurement of the mass absorption and T_g using nanograms of material and an inexpensive setup. The standard deviation of T_g for this system was 0.025 °C, and the variation in T_g with respect to a 1%
RH change was clearly resolved. The decrease in the $T_g$ of PLGA was linear ($R^2 = 0.99$) at a rate of $6.03 \pm 0.57 \, ^\circ\text{C}$ per mass% of water absorbed. The initial dry $T_g$ of PLGA was extrapolated to $41.24 \pm 0.07 \, ^\circ\text{C}$.
A METHOD FOR PREPARING A SUBSTRATE BY APPLYING A SAMPLE TO BE ANALYSED
The invention relates to a method for preparing a substrate (105a) comprising a sample reception area (110) and a sensing area (111). The method comprises the steps of: 1) applying a sample on the sample reception area; 2) rotating the substrate around a predetermined axis; 3) during rotation, at least part of the liquid travels from the sample reception area to the sensing area due to capillary forces acting between the liquid and the substrate; and 4) removing the wave of particles and liquid formed at one end of the substrate. The sensing area is closer to the predetermined axis than the sample reception area. The sample comprises a liquid part and particles suspended therein.

A nanofiltration technique for analyte extraction from complex matrix and surface enhanced Raman spectroscopy based sensing

General information
State: Published
Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes
Authors: Durucan, O. (Intern), Schmidt, M. S. (Ekstern), Rindzevicius, T. (Intern), Boisen, A. (Intern)
Publication date: 9 Nov 2017

Publication information
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Patent number: WO2017191080
Date: 09/11/2017
Priority date: 02/05/2016
Priority number: EP20160167956
Original language: English
Electronic versions:
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Main Research Area: Technical/natural sciences
Source: espacenet
Source-ID: WO2017191080
Publication: Research › Patent – Annual report year: 2017

A METHOD FOR PREPARING A SUBSTRATE BY APPLYING A SAMPLE TO BE ANALYSED
The invention relates to a method for preparing a substrate (105a) comprising a sample reception area (110) and a sensing area (111). The method comprises the steps of: 1) applying a sample on the sample reception area; 2) rotating the substrate around a predetermined axis; 3) during rotation, at least part of the liquid travels from the sample reception area to the sensing area due to capillary forces acting between the liquid and the substrate; and 4) removing the wave of particles and liquid formed at one end of the substrate. The sensing area is closer to the predetermined axis than the sample reception area. The sample comprises a liquid part and particles suspended therein.

A nanofiltration technique for analyte extraction from complex matrix and surface enhanced Raman spectroscopy based sensing

General information
State: Published
Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes
A nanofiltration technique for analyte extraction from complex matrix and surface enhanced Raman spectroscopy based sensing

An integrated lab-on-a-disc approach to detect inflammatory biomarkers from whole blood

A pseudo-Voigt component model for high-resolution recovery of constituent spectra in Raman spectroscopy
Blu-Ray-based micromechanical characterization platform for biopolymer degradation assessment

Degradable biopolymers are used as carrier materials in drug delivery devices. A complete understanding of their degradation behaviour is thus crucial in the design of new delivery systems. Here we combine a reliable method, based on spray coated micromechanical resonators and a disposable microfluidic chip, to characterize biopolymer degradation under the action of enzymes in controlled flow condition. The sensing platform is based on the mechanics and optics from a Blu-Ray player, which automatically localize individual sensors within the array, and sequentially measure and record the resonance frequency of up to twelve resonators within 4 min. Such fast and automated measuring technology, combined with the use of thin polymers layers in the degradation experiments, allows to reduce the experimental time needed for degradation studies from 6 weeks to 8 h. We first present a full characterization of sensor properties and then perform degradation studies of poly(lactic-co-glycolic acid) (PLGA) in steady flow for three different enzyme concentrations. The degradation has been performed in liquid environment. Before each resonator measurement, the measuring chamber has been automatically dried, since the resonator characteristics are much approved when measuring in air compared to liquid. The obtained degradation profiles are comparable to profiles obtained by conventional approaches, which have shown to require up to 6 weeks of experimental time frame.
Challenges in the integration of silicon SERS substrates into a polypropylene injection moulded microfluidic chip

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Serioli, L. (Intern), Morelli, L. (Intern), Matteucci, M. (Intern), Zor, K. (Intern), Boisen, A. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Integration, SERS, Microfluidics
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Source: PublicationPreSubmission
Source-ID: 140300954
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Chemical Engineering in the "BIO" world
Modern Chemical Engineering was born around the end of the 19th century in Great Britain, Germany, and the USA, the most industrialized countries at that time. Milton C. Whitaker, in 1914, affirmed that the difference between Chemistry and Chemical Engineering lies in the capability of chemical engineers to transfer laboratory findings to the industrial level. Since then, Chemical Engineering underwent huge transformations determining the detachment from the original Chemistry nest. The beginning of the sixties of the 20th century saw the development of a new branch of Chemical Engineering baptized Biomedical Engineering by Peppas and Langer and that now we can name Biological Engineering. Interestingly, although Biological Engineering focused on completely different topics from Chemical Engineering ones, it resorted to the same theoretical tools such as, for instance, mass, energy and momentum balances. Thus, the birth of
Biological Engineering may be considered as a Darwinian evolution of Chemical Engineering similar to that experienced by mammals which, returning to water, used legs and arms to swim. From 1960 on, Biological Engineering underwent a considerable evolution as witnessed by the great variety of topics covered such as hemodialysis, release of synthetic drugs, artificial organs and, more recently, delivery of small interfering RNAs (siRNA). This review, based on the activities developed in the frame of our PRIN 2010-11 (20109PLMH2) project, tries to recount origins and evolution of Chemical Engineering illustrating several examples of recent and successful applications in the biological field. This, in turn, may stimulate the discussion about the Chemical Engineering students curriculum studiorum update.

**General information**

State: Published

Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics


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Main Research Area: Technical/natural sciences

**Publication information**

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- Web of Science (2017): Indexed yes
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- Scopus rating (2015): SJR 0.513 SNIP 0.712 CiteScore 1.76
- Scopus rating (2014): SJR 0.599 SNIP 0.737 CiteScore 1.85
- Scopus rating (2013): SJR 0.677 SNIP 0.861 CiteScore 2.17
- Scopus rating (2012): SJR 0.804 SNIP 0.937 CiteScore 2.43
- Scopus rating (2011): SJR 0.599 SNIP 0.743 CiteScore 1.94
- Scopus rating (2010): SJR 0.673 SNIP 1.163
- Scopus rating (2009): SJR 0.808 SNIP 0.88
- Scopus rating (2008): SJR 1.055 SNIP 1.015
- Scopus rating (2007): SJR 0.959 SNIP 1.154
- Scopus rating (2006): SJR 0.498 SNIP 0.52
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DOIs:

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Publication: Research - peer-review › Journal article – Annual report year: 2017

**Design and development of electrochemical polymer-based lab-on-a-disc devices for biological applications**

The need for reliable, fast, easy to use, portable and cost effective analytical tools has led to several novel approaches in the development of miniaturized microfluidic platforms integrated with electrochemical sensors. This thesis presents the design and development of an electrochemical detection based centrifugal microfluidic platforms towards applications in bioprocess monitoring, medical diagnostics, food and environmental analysis, etc. Stencil based electrode fabrication approach was developed and optimized to pattern reliable and reproducible electrodes on a polymeric substrate. Also, a fast, easy to use and simplified approach was established for interfacing the electrodes integrated with the polymeric Lab-on-a-disc (LoD) devices. On-disc filtration and supported liquid membrane (SLM) extraction was adapted on LoD devices for sample pre-treatment (e.g., filtration, extraction, enrichment). The applicability of the developed microfluidic systems was demonstrated by monitoring a biological process, namely quantifying the amount of the bacterial metabolite p-Coumaric acid (pHCA) produced by genetically modified E. coli cells. The first generation LoD device (with integrated filtration) was used to quantify pHCA at the end of bacterial culture (24 hours) when the cell density is the highest. We demonstrated the efficiency of the centrifugal filtration, which enabled cell-free electrochemical detection eliminating the effect of high cell density on electrochemical quantification of pHCA. The second generation LoD device (with integrated
SLM extraction) was more advanced and facilitated extraction, enrichment, as well as electrochemical detection of pHCA from the complex sample matrix, i.e., E. coli supernatant at different time points during the cell culture. Realizing the need for more advanced sensors that can be integrated with microfluidic devices, we developed dual functionality sensors facilitating surface-enhanced Raman spectroscopy (SERS) based sensing as well as electrochemical detection. Moreover, to eliminate the need for bulky peripheral instrumentation connected through slip rings for on-disc electrochemical measurements, we present a miniaturized smartphone controlled wireless potentiostat, which can be integrated on a rotating microfluidic platform.

Detection of melamine in milk using nanopillar filters and Raman spectroscopy

Detection of p-coumaric acid from cell supernatant using surface enhanced Raman scattering

A standard protocol for analysis of microbial factories requires the screening of several populations in order to find the best performing ones. Standard analytical methods usually include high performance liquid chromatography (HPLC), thin layer chromatography (TLC) or spectrophotometry, which are expensive and time-consuming processes. Surface Enhanced Raman Spectroscopy (SERS), instead, is a highly sensitive spectroscopic technique for specific, fast and real-time sensing of biological samples. Here we demonstrate the use of SERS to discriminate between two different bacterial populations based on detection of p-coumaric acid (pHCA) in cell supernatant. SERS active substrates, based on leaning gold-capped silicon nanopillars, were used for detection. They were successfully used to detect culture medium spiked with pHCA, and the effect of medium dilution was studied. For analysis of biological production of pHCA, triplicate cultures of E. coli strains expressing a pHCA-forming enzyme (P) as well as of a non-producing strain (C) were grown. Then, supernatant samples were collected and their pHCA content was measured using SERS and HPLC for comparison. The intensity of the pHCA Raman mode at 1169 cm\(^{-1}\) (CH-rocking motion) showed different trends for P and C strains, similar to the results obtained using the HPLC method. Results illustrate that SERS can be used for quick and semiquantitative discrimination of pHCA concentrations in cell supernatant medium.
Detection of Surface-Linked Polychlorinated Biphenyls using Surface-Enhanced Raman Scattering Spectroscopy

We present an improved procedure for analytical detection of toxic polychlorinated biphenyls (PCB) using surface-enhanced Raman scattering (SERS) spectroscopy. A gold-capped silicon nanopillar substrate was utilized to concentrate PCB molecules within an area of high electromagnetic fields through formation of microsized nanopillar clusters, and consequently, so-called “hot spots” can be formed. In order to improve PCB detection limit, 3,3',4,4'-tetrachlorobiphenyl (PCB77) compounds were chemically modified with a –SCH3 (PCB77-SCH3) group. Experimental and numerical analysis of vibrational modes showed only minor differences between standard PCB77 and PCB77-SCH3. Consequently, we observe significantly increased SERS signals for –SCH3 modified PCB77 while retaining most vibrational modes that characterize standard PCB77. Results point towards more efficient path for detecting different PCB congeners from real-life samples. We interpret the result as PCB77-SCH3 link to gold surface via sulfur atoms that facilitates accumulation of the modified PCB molecules on the metal surface. For similar SERS experimental conditions most spectral characteristics of PCB77 are identifiable down to concentrations of ~10-5 M while PCB77-SCH3 spectral fingerprint is retained in ~10-8 M range.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Research Groups, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Rindzevicius, T. (Intern), Barten, J. (Ekstern), Vorobiev, M. (Ekstern), Schmidt, M. S. (Intern), Castillo, J. J. (Ekstern), Boisen, A. (Intern)
Number of pages: 6
Pages: 1-6
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Vibrational Spectroscopy
Volume: 90
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.55
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.76
Extraction And SERS Based Detection Of Bacterial Metabolites In Mixture On A Centrifugal Microfluidic Device

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Politecnico di Torino
Authors: Morelli, L. (Intern), Serioli, L. (Intern), Centorbi, F. A. (Ekstern), Matteucci, M. (Intern), Demarchi, D. (Ekstern), Zor, K. (Intern), Boisen, A. (Intern)
Publication date: 2017
Event: Abstract from 21st International Conference on Miniaturized Systems for Chemistry and Life Sciences, Savannah, United States.
Main Research Area: Technical/natural sciences
Surface enhanced Raman scattering (SERS), Centrifugal microfluidics, liquid-liquid extraction (LLE), p-coumaric acid, Cinnamic acid
Electronic versions:
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Fabrication and characterization of Au dimer antennas on glass pillars with enhanced plasmonic response

We report on the fabrication and dark-field spectroscopy characterization of Au dimer nanoantennas placed on top of SiO$_2$ nanopillars. The reported process enables the fabrication of nanopillar dimers with gaps down to 15 nm and heights up to 1 μm. A clear dependence of the plasmonic resonance position on the dimer gap is observed for smaller pillar heights, showing the high uniformity and reproducibility of the process. It is shown how increasing the height of nanopillars significantly affects the recorded elastic scattering spectra from Au nanoantennas. The results are compared to finite-difference time-domain (FDTD) and finite-element method (FEM) simulations. Additionally, measured spectra are accompanied by dark-field microscopy images of the dimers, showing the pronounced change in color. Placing nanoantennas on nanopillars with a height comparable to the in-plane dimer dimensions results in an enhancement of the scattering response, which can be understood through reduced interaction of the near-fields with the substrate. When increasing the pillar height further, scattering by the pillars themselves manifests itself as a strong tail at lower wavelengths. Additionally, strong directional scattering is expected as a result of the interface between the nanoantennas and nanopillars, which is taken into account in simulations. For pillars of height close to the plasmonic resonance wavelength, the scattering spectra become more complex due to additional scattering peaks as a result of larger geometrical nonuniformities.

Fabrication of completely free-standing pyrolytic carbon string resonator

General information
State: Published
Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes
Authors: Nguyen, Q. L. (Intern), Larsen, P. E. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
Number of pages: 1
Fabrication of completely free-standing pyrolytic carbon string resonators

General information
State: Published
Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes
Authors: Nguyen, Q. L. (Intern), Larsen, P. E. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Pyrolytic carbon, MEMS resonator, Mass sensor
Electronic versions:
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

From concept to in vivo testing: Microcontainers for oral drug delivery
This work explores the potential of polymeric micrometer sized devices (microcontainers) as oral drug delivery systems (DDS). Arrays of detachable microcontainers (D-MCs) were fabricated on a sacrificial layer to improve the handling and facilitate the collection of individual D-MCs. A model drug, ketoprofen, was loaded into the microcontainers using supercritical CO2 impregnation, followed by deposition of an enteric coating to protect the drug from the harsh gastric environment and to provide a fast release in the intestine. In vitro, in vivo and ex vivo studies were performed to assess the viability of the D-MCs as oral DDS. D-MCs improved the relative oral bioavailability by 180% within 4h, and increased the absorption rate by 2.4 times compared to the control. This work represents a significant step forward in the translation of these devices from laboratory to clinic.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Physics, Neutrons and X-rays for Materials Physics, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, University of Copenhagen
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.56 SJR 2.463 SNIP 1.85
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.738 SNIP 2.074 CiteScore 8.11
Web of Science (2015): Indexed yes
Geometrically Optimized 3D Printed Mini-Devices for Oral Drug Delivery

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Mechanical Engineering, Manufacturing Engineering, Technical University of Denmark
Authors: Vaut, L. (Intern), Juszczyk, J. J. (Ekstern), Jensen, K. E. (Intern), Andersen, A. J. (Intern), Tosello, G. (Intern), Boisen, A. (Intern)
Publication date: 2017
Event: Poster session presented at 44th Annual Meeting & Exposition of the Controlled Release Society, Boston, United States.
Main Research Area: Technical/natural sciences
Geometrically Optimized 3D Printed Mini-Devices for Oral Drug Delivery

Hand-Held Femtogram Detection of Hazardous Picric Acid with 2 Hydrophobic Ag Nanopillar SERS Substrates and Mechanism of Elasto-Capillarity

High-Throughput Fabrication of Nanocone Substrates through Polymer Injection Moulding For SERS Analysis in Microfluidic Systems
Metal-coated nanostructured surfaces have shown promise as substrates for surface-enhanced Raman spectroscopy (SERS) as they allow chemical trace detection with high sensitivity and rapid response. This sensitivity and specificity makes SERS especially interesting for environmental and biological analysis. Metal-capped silicon nanopillars, fabricated through a maskless ion etch, are state-of-the-art for on-chip SERS substrates. A dense cluster of high aspect ratio polymer nanocones was achieved by using high-throughput polymer injection moulding over a large area replicating a silicon nanopillar structure. Gold-capped polymer nanocones display similar SERS sensitivity as silicon nanopillars, while being easily integrable into a microfluidic chips.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Spectro Inlets ApS
Authors: Viehrig, M. (Intern), Matteucci, M. (Intern), Thilsted, A. H. (Ekstern), Schmidt, M. S. (Intern), Boisen, A. (Intern)
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Event: Abstract from 21st International Conference on Miniaturized Systems for Chemistry and Life Sciences, Savannah, United States.
Main Research Area: Technical/natural sciences
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Electronic versions: Untitled.pdf

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**IR spectroscopy with pyrolytic carbon string resonator as a tool for particle detection**

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Nguyen, Q. L. (Intern), Larsen, P. E. (Intern), Schmid, S. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
Publication date: 2017
Event: Poster session presented at 14th International Workshop on Nanomechanical Sensors, Keauhou Bay, United States.
Main Research Area: Technical/natural sciences
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**IR spectroscopy with pyrolytic carbon string resonator as a tool for particle detection**

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Vienna University of Technology
Authors: Nguyen, Q. L. (Intern), Larsen, P. E. (Intern), Schmid, S. (Ekstern), Boisen, A. (Intern), Keller, S. S. (Intern)
Publication date: 2017
Event: Abstract from 14th International Workshop on Nanomechanical Sensors, Keauhou Bay, United States.
Main Research Area: Technical/natural sciences
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

**Lab-on-a-disc platform for screening of genetically modified E. coli cells via cell-free electrochemical detection of p-Coumaric acid**

We present a robust easy to use lab-on-a-disc (LoD) device with integrated sample pre-treatment and electrochemical detection system for cell-free detection of a secondary metabolite, p-Coumaric acid (pHCA), produced by genetically modified E. coli. In the LoD device, which incorporates eight filtration and electrochemical detection units, the sample
filtration was performed by rotating the disc using a programmable closed-loop stepper motor. The electrodes, patterned on plastic substrate, were connected through a printed circuit board to the slip ring using a robust magnetic clamping system that enables easy assembly and robust electrical connections. pHCA was quantified in a linear range from 0.125 up to 2 mM using square wave voltammetry. The platform was successfully used for the quantification of pHCA produced by two genetically modified E. coli strains after 24 h of cell culture. The data obtained from the electrochemical measurements showed good correlation with high performance liquid chromatographic analysis. The developed LoD system offers fast and easy detection of pHCA, enabling screening of genetically modified organisms based on the quantity of produced secondary metabolites.

**General information**

**State:** Published

**Organisations:** Department of Micro- and Nanotechnology, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Bioanalytics, Research Groups

**Authors:** Sanger, K. (Intern), Zor, K. (Intern), Jendresen, C. B. (Intern), Heiskanen, A. (Intern), Amato, L. (Intern), Nielsen, A. T. (Intern), Boisen, A. (Intern)

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**Publication date:** 2017

**Main Research Area:** Technical/natural sciences

**Publication information**

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- Scopus rating (2017): CiteScore 5.67 SJR 1.406 SNIP 1.453
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 5.07 SJR 1.343 SNIP 1.464
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 1.225 SNIP 1.484 CiteScore 4.84
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.229 SNIP 1.658 CiteScore 4.37
- Web of Science (2014): Indexed yes
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- Scopus rating (2013): SJR 1.261 SNIP 1.638 CiteScore 4.25
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 1.412 SNIP 1.674 CiteScore 3.92
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.485 SNIP 1.752 CiteScore 4.08
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.434 SNIP 1.437
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.317 SNIP 1.518
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
Large-scale, Lithography-free Production of Transparent Nanostructured Surface for Dual-functional Electrochemical and SERS Sensing

In this work, we present a dual-functional sensor that can perform surface-enhanced Raman spectroscopy (SERS) based identification and electrochemical (EC) quantification of analytes in liquid samples. A lithography-free reactive ion etching process was utilized to obtain nanostructures of high aspect ratios distributed homogeneously on a 4-inch fused silica wafer. The sensor was made up of three-electrode array, obtained by subsequent e-beam evaporation of Au on nanostructures in selected areas through a shadow mask. The SERS performance was evaluated through surface-averaged enhancement factor (EF), which was ~6.2 x 10^5, and spatial uniformity of EF, which was ~13% in terms of relative standard deviation. Excellent electrochemical performance and reproducibility were revealed by recording cyclic voltammograms. On nanostructured electrodes, paracetamol (PAR) showed an improved quasi-reversible behavior with decrease in peak potential separation (∆Ep ~90mV) and higher peak currents (Ipa/Ipc ~1), comparing to planar electrodes (∆Ep ~560mV). The oxidation potential of PAR was also lowered by ~80 mV on nanostructured electrodes. To illustrate dual-functional sensing, quantitative evaluation of PAR ranging from 30 µM to 3 mM was realized through EC detection, and presence of PAR was verified by its SERS fingerprint.
Loading of Drug-Polymer Matrices in Microreservoirs for Oral Drug Delivery

For major advances in microfabricated drug delivery systems (DDS), fabrication methods with high throughput using biocompatible polymers are required. Once these DDS are fabricated, loading of drug poses a significant challenge. Here, hot punching is presented as an innovative method for drug loading in microfabricated DDS. The microfabricated DDS are microcontainers fabricated in photoresist SU-8 and biopolymer poly-ε-caprolactone (PCL). Furosemide (F) drug is embedded in poly-ε-caprolactone (PCL) polymer matrix. This F-PCL drug polymer matrix is loaded in SU-8 and PLLA microcontainers using hot punching with >99% yield. Thus, it is illustrated that hot punching allows high-throughput, parallel loading of 3D polymer microcontainers with drug-polymer matrices in a single process step.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Petersen, R. S. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern)
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Macroscale SERS Uniformity and Reproducibility Using Densely Clustered Nanopillars

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Authors: Wu, K. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Thilsted, A. H. (Intern), Boisen, A. (Intern)
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Magnetic Bead-Based Biosensing on an Automated & Integrated Lab-on-a-Disc Platform
The PhD thesis presents the development and utilization of magnetic bead-based agglutination assays for the detection of biomarkers in biofluids as well as discovery of a biomarker relevant to the mechanism of action of a type-2 diabetes (T2D) drug while integrating the assays on an automated centrifugal microfluidic platform with incorporated readout units. The assays were developed through surface functionalization of micro or nano-sized magnetic beads with specific antibodies or aptamers to specifically bind with the biomarker of interest resulting in the formation of the biomarker-bridged magnetic bead clusters and hence called ‘agglutination’ assay. The concentration of the analyte or biomarker was quantified based on the size of the clusters. The model biomarkers studied in this project were thrombin – a blood coagulation protein; C-reactive protein – an acute phase protein-biomarker for inflammatory diseases; and mononuclear white blood cell count – a biomarker for the prognosis of different medical conditions. Furthermore, the concept of the agglutination assay was utilized for a biomarker discovery application by investigating the mechanism of action of a T2D drug - metformin through the analysis and quantification of the aggregation and disaggregation phenomena of the magnetic beads in response to the presence of the drug.

The assays were either partially or fully integrated on disc-shaped polymeric microfluidic substrates i.e. microfluidic discs for incorporating the advantages of centrifugal microfluidics e.g. eliminating the need for external fluidic connectors or pumps, and facilitating simple, compact and low-cost instrumentation along with effective multiplexing of microfluidic units. All the discs were fabricated in-house using multiple layers of polymeric substrates. Two specific valving mechanisms namely centrifugo-pneumatic and event-triggered valving were incorporated into the microfluidic platform in order to facilitate the integration of the assay from sample-to-answer.

The readouts were performed by two different optical methods: Blu-ray based optomagnetic readout and optical imaging method. The readout instruments were customized and incorporated with the automated centrifugation microfluidic platform to produce an integrated and automated biosensing platform with a potential for operating in an out-of-lab setting which can pave the way for future development of a point-of-care diagnostic tool.
Mechanical Resonators for Material Characterization: Sensor Development and Applications

The goals of this PhD project were to provide new approaches and developing new systems for material characterization, based on micro and nanomechanical sensors. Common issues that have shown to hinder large-scale integration of sensing techniques based on a micromechanical sensor are the readout and sample handling. To address the first point, a semi-automatic characterization platform based on the optics and the mechanics of a commercial Blu-Ray pickup head unit was developed. Microbridges were chosen instead of microcantilevers to provide more robustness to the sensor. By embedding the sensor in a single-use microfluidic cartridge, the experimental condition was improved. The sample handling, as well as the environmental condition of the phenomena under test, are better controlled. As proof of concept to test the capabilities of the system, we studied the biopolymer degradation of Poly Lactic-co-Glycolic Acid (PLGA), which is of high relevance in the biomedical research field. A second version of the system is currently under development, and it aims to increase the throughput of the system allowing to read out multiple microbridge arrays.

For material characterization, spectroscopy analysis is often considered a benchmark technology. Conventional infrared spectroscopy approaches commonly require milligram amount of sample. Considering the frame of reference given by the overall aim of the project, mechanical sensors can be exploited to provide a unique tool for performing spectroscopy on a limited amount of sample. In this project, a nanomechanical photothermal sensor has been designed, developed and exploited to perform thin film Infrared Spectroscopy. Contrary to what has been previously shown, this work has focused on a membrane sensor providing a robust experimental approach which better suit sample quantification and preparation. The purpose of the studies presented here is to show the real potential of photothermal spectroscopy based on a nanomechanical sensor and to provide a method to maximise the signal to noise ratio (SNR) from a single acquisition. The methodology presented showed that it is possible obtaining a high SNR of 300 on a 20nm thick polymer layer showing a substantial improvement compared to the benchmark technique, attenuated total reflectance spectroscopy (ATR-FTIR). This high sensitivity allowed us to observe the chemical modification occurring during the gelification of a submicron thick layer of poly-vinyl-pyrrolidone (PVP) corresponding to picogram quantity of material.

Microcontainers as an oral delivery system for spray dried cubosomes containing ovalbumin

The purpose of this study was to prepare cubosomes encapsulating the model antigen ovalbumin (OVA) via spray drying, and to characterise such cubosomes with a view for their potential application in oral vaccine delivery. Furthermore the cubosome formulation was loaded into polymeric microcontainers intended as an oral drug delivery system. The cubosomes consisted of commercial glyceryl monooleate, Dimodan®, containing OVA and were surrounded with a dextran shell prepared by spray drying. Cryo-TEM was used to confirm that cubosomes were formed after hydration of the spray dried precursor powder. The precursor powder had a mean particle size of 1.3±0.1μm, whereas the mean diameter...
of the dispersed cubosomes was 282±7nm (PDI: 0.18) measured by dynamic light scattering. 8.5±0.3% (w/w) of OVA was present in the cubosome powder and OVA was found released slowly over the first 70h, followed by a more rapid release. Total release of 47.9±2.8% of loaded OVA occurred over 96h in a buffer at pH 6.8. When the powder was filled into microcontainers, and the opening covered with the pH sensitive polymer Eudragit S100, the pH sensitive 'lid' was intact at gastric pH, but release of OVA from the cubosomes and microcontainers occurred at pH 6.8, releasing 44.1±5.6% of the OVA in 96h. Small-angle X-ray scattering (SAXS) revealed that the 'dry' particles possessed an internal ordered lipid structure (lamellar and inverse micellar phase) by virtue of a small amount of residual water, and after hydration in buffer at pH 6.8, the particles formed the hexagonal inverse cubic phases, thereby indicating that cubosomes were formed when released from microcontainers.
Nanomechanical Infrared Spectroscopy with Vibrating Filters for Pharmaceutical Analysis

Standard infrared spectroscopy techniques are well-developed and widely used. However, they typically require milligrams of sample and can involve time-consuming sample preparation. A promising alternative is represented by nanomechanical infrared spectroscopy (NAM-IR) based on the photothermal response of a nanomechanical resonator, which enables the
chemical analysis of picograms of analyte directly from a liquid solution in only a few minutes. Herein, we present NAM-IR using perforated membranes (filters). The method was tested with the pharmaceutical compound indomethacin to successfully perform a chemical and morphological analysis on roughly 100 pg of sample. With an absolute estimated sensitivity of 109±15 fg, the presented method is suitable for ultrasensitive vibrational spectroscopy.

**General information**
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Silicon Microtechnology, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Technical University of Denmark, University of Copenhagen, Vienna University of Technology
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Scopus rating (2008): SJR 5.589 SNIP 2.153
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 4.528 SNIP 1.888
Nanopillar Filters for Surface-Enhanced Raman Spectroscopy

We present a simple, robust, and automated molecule extraction technique based on a centrifugal microfluidic platform. Fast and facile extraction of a food adulterant (melamine) from a complex sample medium (milk) on a SERS substrate is demonstrated. The unique characteristic of the detection method is the obtained "filter paper/chromatographic" effect which combines centrifugal force and wetting properties of the SERS substrate. The work addresses issues related to SERS-based detection of analytes in complex media, which is important for realizing next generation SERS platforms applicable for a broad variety of real-life applications.

General information

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
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New Evidence for the Mechanism of Action of a Type-2 Diabetes Drug Using a Magnetic Bead-Based Automated Biosensing Platform

The mechanism of action (MOA) of the first line type-2 diabetes drug metformin remains unclear despite its widespread usage. However, recent evidence suggests that the mitochondrial copper (Cu)-binding action of metformin may contribute toward the drug's MOA. Here, we present a novel biosensing platform for investigating the MOA of metformin using a
magnetic microbead-based agglutination assay which has allowed us to demonstrate for the first time the interaction between Cu and metformin at clinically relevant low micromolar concentrations of the drug, thus suggesting a potential pathway of metformin's blood-glucose lowering action. In this assay, cysteine-functionalized magnetic beads were agglutinated in the presence of Cu due to cysteine's Cu-chelation property. Addition of clinically relevant doses of metformin resulted in disaggregation of Cu-bridged bead-clusters, whereas the effect of adding a closely related but blood-glucose neutral drug propanediimidamide (PDI) showed completely different responses to the clusters. The entire assay was integrated in an automated microfluidics platform with an advanced optical imaging unit by which we investigated these aggregation-disaggregation phenomena in a reliable, automated, and user-friendly fashion with total assay time of 17 min requiring a sample (metformin/PDI) volume of 30 μL. The marked difference of Cu-binding action between the blood-glucose lowering drug metformin and its inactive analogue PDI thus suggests that metformin's distinctive Cu-binding properties may be required for its effect on glucose homeostasis. The novel automated platform demonstrating this novel investigation thus holds the potential to be utilized for investigating significant and sensitive molecular interactions via magnetic bead-based agglutination assay.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Tampere University of Technology, University of Dundee, Academia Sinica Taiwan
Authors: Uddin, R. (Intern), Nur-E-Habiba (Ekstern), Rena, G. (Ekstern), Hwu, E. T. (Ekstern), Boisen, A. (Intern)
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Optimizing silver-capped silicon nanopillars to simultaneously realize macroscopic, practical-level SERS signal reproducibility and high enhancement at low costs
The ideal surface-enhanced Raman spectroscopy (SERS) substrate should fulfill the following: (a) predictable SERS enhancement, (b) macroscale SERS signal uniformity, and (c) suitability for mass production at low costs. Macroscale SERS uniformity and reproducibility at practical levels are big obstacles, which have been preventing most SERS substrates from reliable sensing applications. We have previously shown that SERS-active nanopillar structures, fabricated by lithography-free processes, exhibit high average SERS enhancements and are mass producible. Here, we report an optimized process and show that the improved structures exhibit unrivalled macroscale SERS uniformities (RSD: ~2.5% in millimeter scale, ~7% in wafer scale) and reproducibility (RSD: ~1.5% across 3 wafers), while at the same time exhibiting a very large average SERS enhancement factor of >10^8. The obtained SERS uniformity (~2.5% RSD in millimeter scale) is the best to date measured on large-area solid SERS substrates. Fast and reproducible SERS analysis of trans-1,2-bis (4-pyridyl) ethylene down to 4x10^{-13} mol is demonstrated using the optimized structures. We emphasize that achieving simultaneously macroscopic, practical-level SERS signal reproducibility and high enhancement via a lithography-free process is a notable advance towards industrialization of substrate-based SERS sensors.

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Mask-less reactive ion etching, Nanopillars, SERS substrate, SERA uniformity, Surface-enhanced Raman spectroscopy
Photothermal IR spectroscopy with perforated membrane micromechanical resonators

Rapid progress in nanofabrication techniques resulted in the emergence of ultrasensitive nanomechanical sensors, commonly consisting of simple vibrating structures such as cantilevers, strings or membranes that exhibit resonance behavior. The principle of operation is based on monitoring the resonance frequency shift due to various external factors, including mass, force and temperature change. The high sensitivity of nanomechanical resonators has already been exploited to create a group of photothermal spectroscopy devices capable of exceptionally fast chemical analysis of compounds on the femtogram level.

Nanomechanical infrared spectroscopy (NAM-IR) originated from photothermal bilayer cantilever deflection spectroscopy and is based on the photothermal response of a nanomechanical resonator. It has already been presented with a string resonator, which was acting as sampling element and temperature sensor. The string could be considered as a single filter-fiber and guaranteed relatively high overall sampling efficiency through impaction of airborne nanoparticles on the resonator surface. When the analyte, collected by the sensor, is exposed to IR radiation it absorbs light at a certain wavelength corresponding to its specific molecular vibrations. This thermal energy heats the resonator and leads to its thermal expansion followed by a decrease of the tensile stress in the resonator. In turn it eventually causes the resonance frequency to shift towards lower values.

However, further development of this approach was curbed by difficult and inefficient coupling of the IR light beam to a nanometer-sized resonator. In addition, readout of vibration was done by laser Doppler vibrometer, a precise but bulky and expensive instrument. These issues hindered a realworld application of the NAM-IR method. In order to overcome them, string resonators were replaced by membranes. A reliable sampling technique was maintained by adding perforation to membranes and thereby essentially getting membrane porous filters. Membranes gave also access to fully integrated magnetic transduction that allowed for significant shrinkage and simplification of the system.

An analytical model of a locally heated membrane was developed and confirmed through FEM simulations. Then, low stress silicon nitride perforated membranes were fabricated and characterized using two different experimental setups that employed optical and magnetomotive readout. Finally, spectroscopic measurements and crystalization study of about 100 pg of the model drug 'indomethacin' were performed. Obtained IR spectra were in good agreement both with conventional Fourier transform IR spectroscopy (FTIR) reference and literature reports. The performance of the magnetic transduction scheme was found to be comparable to the traditionally used optical detection with a minimum sample mass required for analysis of roughly 100 fg.

NAM-IR technique requires exceptionally small amount of sample and does not involve timeconsuming sample preparation. Therefore, it is a promising alternative to standard IR spectroscopy with vast possible applications for example in the pharmaceutical industry.
of back-action is not only dependent on position but also the shape of the resonance mode. Relevant silicon nitride material parameters are extracted by fitting finite element (FE) simulations to the temperature-dependent frequency response of the first three modes. In a second round of simulations, using the extracted parameters, we successfully fit the FEM results with the measured mode and position dependent back-action. From the simulations, we can conclude that the observed frequency tuning is due to temperature induced changes in stress. Effects of changes in material properties and dimensions are negligible. Finally, different routes for minimizing the effect of this optical detection back-action are described, allowing further improvements of cantilever-based sensing in general.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Technical University of Denmark, University of Melbourne
Authors: Larsen, T. (Intern), Schmid, S. (Intern), Dohn, S. (Intern), Sader, J. E. (Ekstern), Boisen, A. (Intern), Villanueva, L. (Ekstern)
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Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
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The present study introduces powder embossing as a novel method to enhance loading of polymeric microcontainers with drug. With current loading approaches, it is not possible to handle pure powder drug in a scalable, homogenous and reproducible manner. In this work, we demonstrate simultaneous loading of 625 microcontainers with powder formulation. This is achieved in a single step by aligning a shadow mask prepared by micro-milling to an array of microcontainers in order to limit drug deposition to the container cavities with diameters of 220 μm. A pressure of 8.9 MPa is applied by a bonding press and thereby the desired powder is embossed into the container cavities. Powder in the form of pure drug, lipid-based microparticles, and pure polymer was successfully loaded with minimal residues in between the microcontainers and with 100% loaded cavities demonstrating the versatility of the method. The current work is thus contributing to the loading of powder formulations into microscale drug delivery systems such as microcontainers in a facile and reproducible manner.

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Quantification of a bacterial secondary metabolite by SERS combined with SLM extraction for bioprocess monitoring

During the last few decades, great advances have been reached in high-throughput design and building of genetically engineered microbial strains, leading to a need for fast and reliable screening methods. We developed and optimized a microfluidic supported liquid membrane (SLM) extraction device and combined it with surface enhanced Raman scattering (SERS) sensing for the screening of a biological process, namely for the quantification of a bacterial secondary metabolite, p-coumaric acid (pHCA), produced by Escherichia coli. The microfluidic device proved to be robust and reusable, enabling efficient removal of interfering compounds from the real samples, reaching more than 13-fold up-concentration of the donor at 10 μL min⁻¹ flow rate. With this method, we quantified pHCA directly from the bacterial supernatant, distinguishing between various culture conditions based on the pHCA production yield. The obtained data showed good correlation with HPLC analysis.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, BioLabChip, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Research Groups, Bioanalytics, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
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BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.11
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.88
ISI indexed (2012): ISI indexed yes
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Scopus rating (2011): CiteScore 4.16
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Quantitative Detection of Trace Level Cloxacillin in Food Samples Using Magnetic Molecularly Imprinted Polymer Extraction and Surface-Enhanced Raman Spectroscopy Nanopillars

There is an increasing demand for rapid, sensitive, and low cost analytical methods to routinely screen antibiotic residues in food products. Conventional detection of antibiotics involves sample preparation by liquid-liquid or solid-phase extraction, followed by analysis using liquid chromatography-mass spectrometry (LC-MS), capillary electrophoresis (CE), or gas chromatography (GC). The process is labor-intensive, time-consuming, and expensive. In this study, we developed a new analytical method that combines magnetic molecularly imprinted polymer (MMIP)-based sample preparation with surface-enhanced Raman spectroscopy (SERS)-based detection for quantitative analysis of cloxacillin in pig serum. MMIP microspheres were synthesized using a core-shell technique. The large loading capacity and high selectivity of the MMIP microspheres enabled efficient extraction of cloxacillin, while the magnetically susceptible characteristics greatly simplified sample handling procedures. Low cost and robust SERS substrates consisting of vertical gold capped silicon nanopillars were fabricated and employed for the detection of cloxacillin. Quantitative SERS was achieved by normalizing signal intensities using an internal standard. By coherently combining MMIP extraction and silicon nanopillar-based SERS biosensor, good sensitivity toward cloxacillin was achieved. The detection limit was 7.8 pmol. Cloxacillin recoveries from spiked pig plasma samples were found to be more than 80%.

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Web of Science (2015): Indexed yes
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Pseudomonas aeruginosa is the primary cause of chronic airway infections in cystic fibrosis (CF) patients. Persistent infections are seen from the first P. aeruginosa culture in about 75% of young CF patients, and it is important to discover new ways to detect P. aeruginosa at an earlier stage. The P. aeruginosa biomarker hydrogen cyanide (HCN) contains a triple bond, which is utilized in this study because of the resulting characteristic C≡N peak at 2135 cm⁻¹ in a Raman spectrum. The Raman signal was enhanced by surface-enhanced Raman spectroscopy (SERS) on a Au-coated SERS substrate. After long-term infection, a mutation in the patho-adaptive lasR gene can alter the expression of HCN, which is why it is sometimes not possible to detect HCN in the breath of chronically infected patients. Four P. aeruginosa reference strains and 12 clinical P. aeruginosa strains isolated from CF children were evaluated, and HCN was clearly detected from overnight cultures of all wild type-like isolates and half of the later isolates from the same patients. The clinical impact could be that P. aeruginosa infections could be detected at an earlier stage, because daily breath sampling with an immediate output could be possible with a point-of-care SERS device.

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- Main Research Area: Technical/natural sciences
SERS spectroscopy for detection of hydrogen cyanide in breath from children colonised with P. aeruginosa

There is a need for a fast and non-invasive tool to detect Pseudomonas aeruginosa airway colonisation in cystic fibrosis (CF) patients unable to expectorate. Fifty CF children and 19 controls aged 5–17 years were included in the feasibility study. A surface-enhanced Raman spectroscopy (SERS) nanochip optimised for detection of trace amounts of the P. aeruginosa biomarker hydrogen cyanide (HCN) was mounted inside a Tedlar bag, which the patient breathed into. The SERS chip was then analysed in a Raman spectrometer, investigating the C≡N peak at 2131 cm⁻¹ and correlated with sputum cultures. One new P. aeruginosa colonisation occurred during the trial period. The C≡N peak intensity was enhanced in this sample in contrast to the subject’s 3 other samples. Three additional patients had intense C≡N SERS signals from their breath, but no P. aeruginosa was cultured from their sputum. It is concluded that SERS spectroscopy can be developed into an easy to use hypersensitive clinical prescreening method for detection of HCN in human breath.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Infection Microbiology, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Rigshospitalet, University of Copenhagen, Copenhagen University Hospital
Number of pages: 6
Pages: 5757-5762
Single step fabrication and loading of biopolymer microcontainers for oral drug delivery

General information

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Abid, Z. (Intern), Petersen, R. S. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Microcontainers, Hot punching, Oral drug delivery, Embossing

Surface Enhanced Raman Scattering for Quantification of p-Coumaric Acid Produced by Escherichia coli

The number of newly developed genetic variants of microbial cell factories for production of biochemicals has been rapidly growing in recent years, leading to an increased need for new screening techniques. We developed a method based on surface-enhanced Raman scattering (SERS) coupled with liquid-liquid extraction (LLE) for quantification of p-coumaric acid (pHCA) in the supernatant of genetically engineered Escherichia coli (E. coli) cultures. pHCA was measured in a
dynamic range from 1 μM up to 50 μM on highly uniform SERS substrates based on leaning gold-capped nanopillars, which showed an in-wafer signal variation of only 11.7%. LLE using dichloromethane as organic phase was combined with the detection in order to increase selectivity and sensitivity by decreasing the effect of interfering compounds from the analytes of interest. The difference in pHCA production yield between three genetically engineered E. coli strains was successfully evaluated using SERS and confirmed with high-performance liquid chromatography. As this novel approach has potential to be automated and parallelized, it can be considered for high-throughput screening in metabolic engineering.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Research Groups, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Morelli, L. (Intern), Zor, K. (Intern), Jendresen, C. B. (Intern), Rindzevicius, T. (Intern), Schmidt, M. S. (Intern), Nielsen, A. T. (Intern), Boisen, A. (Intern)
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Towards a fully automated lab-on-a-disc system integrating sample enrichment and detection of analytes from complex matrices

Lab-on-a-chip systems (LoC) has been actively researched and developed for at least the last 25 years, yet integration of an efficient and robust sample pretreatment method still proves to be a challenge in the field. This lack of sample pretreatment methods in LoC platforms prevents the technology on a large scale from fulfilling its potential for maturing into applied technologies and products. In this work, we have taken the first steps towards realizing a capable and truly automated "sample-to-answer" analysis system, aimed at small molecule detection and quantification from a complex sample matrix. The main result is a working prototype of a microfluidic system, integrating both centrifugal microfluidics for sample handling, supported liquid membrane extraction (SLM) for selective and effective sample treatment, as well as in-situ electrochemical detection. As a case study, the system is used to extract and quantify p-coumaric acid, a phenolic metabolite, produced by bacterial factories. The bacterial culture supernatant is a particularly challenging sample matrix as it contains both molecules that are derivatives of the target molecule, and therefore highly interfering for the analytical procedure, as well as a range of other compounds, e.g. vitamins, proteins, and salt ions. However, with the SLM extraction applied here, very clear and enhanced signals, with no sign of contaminants, is demonstrated. The strategies developed for the integration of the SLM extraction on the centrifugal platform, as well as the design, fabrication and optimization steps, are presented and discussed in this thesis.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Andreasen, S. Z. (Intern), Boisen, A. (Intern), Emnéus, J. (Intern), Zor, K. (Intern)
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Towards a fully automated lab-on-a-disc system integrating sample enrichment and detection of analytes from complex matrices
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Wireless, smartphone controlled potentiostat integrated with lab-on-disc platform
A smartphone controlled wireless data transmitting and inductive powering Power Lab-on-disc (PLoD) platform is developed based on 2.4 GHz Bluetooth and 205 kHz Qi techniques, respectively. A potentiostat is integrated on the PLoD platform, and amperometric measurements are performed. The wireless potentiostat can provide -3~3 V with 14-bit resolution for amperometry in a range of -300~300 μA with a readout noise floor of 1.2 μA (p-p) in a static condition. A 0~3000 rpm spinning test shows that a phosphate buffer saline (400 mV potential) baseline noise is proportional to spinning acceleration and deceleration.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, National Taiwan Ocean University, National Taiwan University, Technical University of Denmark
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Number of pages: 2
Publication date: 2017
Main Research Area: Technical/natural sciences

A substrate and a method of using it
A substrate for a plurality of different measurement set-ups such as SERS, SPR and LSPR which substrate has a base and a plurality of elongate elements with metallic tips. A metallic layer is present on the base surface between the elongate elements and gaps or cavities exist between the layer and the tips or elongate elements. When the elongate elements and the base are transparent, transmission measurement set-ups are also possible.

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Organisations: Department of Micro- and Nanotechnology, Department of Physics, Experimental Surface and Nanomaterials Physics, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Thilsted, A. H. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern)
Publication date: 5 Oct 2016

A Centrifugal Microfluidic Platform Using SLM Extraction: for combined sample clean-up and enrichment of trace analytes
Here we present a pump-less microfluidic platform which performs sample clean-up and enrichment in a single step, by integrating Supported Liquid Membrane (SLM) extraction. Our platform offers a simple, yet very efficient, method for achieving sample pre-treatment and enrichment of rare analytes, in an easy to use and highly efficient device.
A comprehensive investigation of copper binding properties of metformin using on-disc magnetic microbead agglomeration with real-time analysis

Analyzing Engineered Nanoparticles using Photothermal Infrared Spectroscopy

Nanoparticles, particles having one or more dimensions smaller than 100 nm, show novel properties and functions that differ significantly from those of their corresponding bulk counterpart. Due to their small size and large surface to volume ratio they can e.g. diffuse easily and be highly reactive. To facilitate occupational safety and health there is a need to develop instruments to monitor and analyze nanoparticles in the industry, research and urban environments. The aim of this Ph.D. project was to develop new sensors that can analyze engineered nanoparticles. Two sensors were studied: (i) a miniaturized toxicity sensor based on electrochemistry and (ii) a photothermal spectrometer based on tensile-stressed mechanical resonators (string resonators).

Miniaturization of toxicity sensor targeting engineered nanoparticles was explored. This concept was based on the results of the biodurability test using redox activity measurements. With a new setup adapted to miniaturization, stable pH was achieved, platinum was found to be more suitable than gold for open circuit potential-time measurements, miniaturized platinum working electrodes and quasi silver/silver chloride reference electrodes were fabricated, and Gambles solution with dispersed iron oxide nanoparticles showed lowered potential as expected. Despite the potential of this concept instability and lack of reproducibility continued to be an unneglectable issue. The concept of utilizing string resonators for photothermal spectroscopy was, for the first time, studied in details both theoretically and experimentally. The string-based photothermal spectrometer consists of a string resonator on which an analyte is collected. Wavelength-dependent absorption by the analyte leads to heating of the string which is reflected in its resonance frequency. This setup allows for spectroscopic measurement of the analyte. An analytical model describing the resonance frequency of a string resonator locally heated was developed. The developed model was in agreement with FEM simulations and experimental results. Theoretical and experimental work lead to a set of design rules for the responsivity of the string-based photothermal spectrometer. Responsivity is maximized for a thin, narrow and long string irradiated by high power radiation. Various types of nanoparticles and binary mixtures of them were successfully detected and analyzed. Detection of copper-chelation of the antidiabetic drug metformin was demonstrated as well. The estimated detection limit for the developed system is an analyte with a mass of ~150 ag (1 ag = 10^-18 g). In short, it has been demonstrated that the string-based photothermal spectrometer is a promising technique for nanoparticle detection and analysis.
We report fabrication of nanostructured, laser-doped selective emitter (LDSE) silicon solar cells with power conversion efficiency of 18.1% and a fill factor (FF) of 80.1%. The nanostructured solar cells were realized through a single step, mask-less, scalable reactive ion etch (RIE) texturing of the surface. The selective emitter was formed by means of laser doping using a continuous wave (CW) laser and subsequent contact formation using light-induced plating of Ni and Cu. The combination of RIE-texturing and a LDSE cell design has to our knowledge not been demonstrated previously. The resulting efficiency indicates a promising potential, especially considering that the cell reported in this work is the first proof-of-concept and that the fabricated cell is not fully optimized in terms of plating, emitter sheet resistance and surface passivation. Due to the scalable nature and simplicity of RIE-texturing as well as the LDSE process, we consider this specific combination a promising candidate for a cost-efficient process for future Si solar cells.
This paper describes an aptamer-based optomagnetic biosensor for detection of a small molecule based on target binding-induced inhibition of magnetic nanoparticle (MNP) clustering. For the detection of a target small molecule, two mutually exclusive binding reactions (aptamer-target binding and aptamer-DNA linker hybridization) are designed. An aptamer specific to the target and a DNA linker complementary to a part of the aptamer sequence are immobilized onto separate MNPs. Hybridization of the DNA linker and the aptamer induces formation of MNP clusters. The target-to-aptamer binding on MNPs prior to the addition of linker-functionalized MNPs significantly hinders the hybridization reaction, thus reducing the degree of MNP clustering. The clustering state, which is thus related to the target concentration, is then quantitatively determined by an optomagnetic readout technique that provides the hydrodynamic size distribution of MNPs and their clusters. A commercial Blu-ray optical pickup unit is used for optical signal acquisition, which enables the establishment of a low-cost and miniaturized biosensing platform. Experimental results show that the degree of MNP clustering correlates well with the concentration of a target small molecule, adenosine triphosphate (ATP) in this work, in the range between 10µM and 10mM. This successful proof-of-concept indicates that our optomagnetic aptasensor can be further developed as a low-cost biosensing platform for detection of small molecule biomarkers in an out-of-lab setting.
Click chemistry based biomolecular conjugation monitoring using surface-enhanced Raman spectroscopy mapping

We describe here a novel surface-enhanced Raman spectroscopy (SERS) based technique for monitoring the conjugation of small molecules by the well-known click reaction between an alkyne and azido moiety on the partner molecules. The monitoring principle is based on the loss of the characteristic alkyne/azide Raman signal with triazole formation in the reaction as a function of time. Since these universal Raman reporter groups are specific for click reactions, this method may facilitate a broad range of applications for monitoring the conjugation efficiency of molecules in diverse areas such as bioconjugation, material science or drug discovery. Additionally, as an attractive advantage of this technique, no significant background signal is expected during the measurements, since these signals reside in a Raman silent region of 2000–2300 cm⁻¹, where virtually all biological molecules are transparent.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing using Microcontainers and Nanomechanics, Columbia University
Authors: Palla, M. (Ekstern), Kumar, S. (Ekstern), Li, Z. (Ekstern), Jockusch, S. (Ekstern), Russo, J. J. (Ekstern), Ju, J. (Ekstern), Bosco, F. (Intern), Rindzvečius, T. (Intern), Alstrøm, T. S. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern)
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Detection methods for centrifugal microfluidic platforms

Centrifugal microfluidics has attracted much interest from academia as well as industry, since it potentially offers solutions for affordable, user-friendly and portable biosensing. A wide range of so-called fluidic unit operations, e.g. mixing, metering, liquid routing, and particle separation, have been developed and allow automation and integration of complex assay protocols in lab-on-a-disc systems. Besides liquid handling, the detection strategy for reading out the assay is crucial for developing a fully integrated system. In this review, we focus on biosensors and readout methods for the centrifugal microfluidics platform and cover optical as well as mechanical and electrical detection principles.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing using Microcontainers and Nanomechanics
Authors: Burger, R. (Intern), Amato, L. (Intern), Boisen, A. (Intern)
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Detection of nerve gases using surface-enhanced Raman scattering substrates with high droplet adhesion

Threats from chemical warfare agents, commonly known as nerve gases, constitute a serious security issue of increasing global concern because of surging terrorist activity worldwide. However, nerve gases are difficult to detect using current analytical tools and outside dedicated laboratories. Here we demonstrate that surface-enhanced Raman scattering (SERS) can be used for sensitive detection of femtomol quantities of two nerve gases, VX and Tabun, using a handheld Raman device and SERS substrates consisting of flexible gold-covered Si nanopillars. The substrate surface exhibits high droplet adhesion and nanopillar clustering due to elasto-capillary forces, resulting in enrichment of target molecules in plasmonic hot-spots with high Raman enhancement. The results may pave the way for strategic life-saving SERS detection of chemical warfare agents in the field.
Electrospraying Chitosan Particles for Oral Vaccine Delivery

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, National Food Institute, Research Group for Nano-Bio Science
Authors: Nielsen, L. H. (Intern), Sevilla Moreno, J. A. (Intern), Boutrup Stephansen, K. (Intern), Chronakis, I. S. (Intern), Boisen, A. (Intern)
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Event: Abstract from 2016 AAPS Annual Meeting and Exposition, Denver, CO, United States.
Main Research Area: Technical/natural sciences

Electrospraying particles for loading into microcontainers for drug delivery

General information
State: Published
Organisations: National Food Institute, Research Group for Nano-Bio Science, Department of Micro- and Nanotechnology, Nanoprobes
Authors: Sevilla Moreno, J. A. (Intern), Boutrup Stephansen, K. (Intern), Nielsen, L. H. (Intern), Chronakis, I. S. (Intern), Boisen, A. (Intern)
Publication date: 2016
Event: Abstract from 42nd International conference on Micro and Nano Engineering, Vienna, Austria.
Main Research Area: Technical/natural sciences

Engineering Plasmonic Nanopillar Arrays for Surface-enhanced Raman Spectroscopy
This Ph.D. thesis presents (i) an in-depth understanding of the localized surface plasmon resonances (LSPRs) in the nanopillar arrays (NPs) for surface-enhanced Raman spectroscopy (SERS), and (ii) systematic ways of optimizing the fabrication process of NPs to improve their SERS efficiencies. This Ph.D. project is part of the NAPLAS - NAnoPLAsmonic Sensors project, funded by The Danish Council for Independent Research. LSPRs in silver capped silicon NPs are studied using numerical simulations and dark-field scattering microscopy. Simulations show that a standalone NP supports two LSPR modes, i.e., the particle mode and the cavity mode. The particle mode can be hybridized via leaning of pillars. The LSPR wavelength of the cavity mode is dominant only by the diameter of the Si pillar. The presence of a substrate dramatically changes the intensities of these two LSPR modes, by introducing constructive and destructive interference patterns with the excitation fields. Experimental scattering spectra can be interpreted using theoretical simulations. The processes, which affect the SERS efficiencies of the silver NPs, are systematically evaluated. Short exposures to the O₂-plasma and the use of 1-3 nm Cr adhesion layers are advantageous for reducing the SERS background signals. Influence
of the NP height and silver deposition thickness on SERS intensities is also investigated. Using an optimized recipe, the measured SERS enhancement factor (EF) reaches 108, and the SERS signal intensity exhibits a standard deviation of ~14% (660 data points) across a 5 x 5 mm² surface area. Lastly, a further improved process shows that high-density NPs exhibit unrivalled macroscale SERS uniformities (RSD: ~2.5% in mm scale, ~7% in inch scale) and SERS reproducibilities (RSD: ~1.5% across three wafers), while at the same time displaying a very large average SERS EF of >108. From a practical point of view, the developed SERS substrates are particularly interesting, since they are easy to handle and store and the fabrication is scalable, facilitating a wide and simple use of SERS in sensing applications.

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Wu, K. (Intern), Boisen, A. (Intern), Rindzevicius, T. (Intern), Schmidt, M. S. (Intern)
Number of pages: 152
Publication date: 2016

Experimentation and numerical modeling of cyclic voltammetry for electrochemical micro-sized sensors under the influence of electrolyte flow
In this study, we perform experimental studies as well as simulations for cyclic voltammetry (CV) of the redox couple FeIII(CN)63-/FeII(CN)64- on a gold plated ECC biosensor encapsulated by a microfluidic system. We examine the effect of flow rate, scan rate, varying supporting electrolyte, exchange current density and the position of electrode on the CV measurements. The results show that at a relatively high flow (250 μL) and low scan rates (50 - 200 mV/s), the current response is limited by the convection due to quick supply of fresh ions at the electrode surface which leads to fading hysteresis of the recorded CV. However, at high scan rates (250 mV/s) and slow flow rates (50 - 200 μL), peak currents are recorded which means that mass transport is dominated by the diffusion mechanism and a quasi-steady state of CV is recorded. In the case of insufficient supporting electrolyte, the excess charges generated during scan will lead to ohmic distortion of the electrolyte solution and consequently result into a ramping effect of the recorded CV. However, for sufficient amount of supporting electrolyte (200 mM), the simulation results show good agreement with the experimental data. In addition, the results also show that a decrease in exchange current density leads to a shift in the peak current of the recorded CV. Finally, the results also demonstrate that the working electrode at the center of the fluidic cell records accurate measurement than placing the electrode at the bottom of the cell. The numerical results and the experimental data show both qualitative good agreement and quantitative good agreement.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, Norwegian University of Science and Technology
Authors: Adesokan, B. J. (Intern), Quan, X. (Intern), Evgrafov, A. (Ekstern), Heiskanen, A. (Intern), Boisen, A. (Intern), Sørensen, M. P. (Intern)
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Cyclic voltammetry, Microelectrode location, Nernst–Planck, Navier–Stokes, Finite element method

Fabrication and characterization of Au dimer antennas on glass pillars with enhanced plasmonic response
Fabrication and characterization of pyrolytic carbon string resonators

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Nguyen, Q. L. (Intern), Kurek, M. (Intern), Larsen, P. E. (Intern), Schmid, S. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
Publication date: 2016
Event: Abstract from 42nd International conference on Micro and Nano Engineering, Vienna, Austria.
Main Research Area: Technical/natural sciences
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Geometric Optimization of Microcontainers for Oral Drug Delivery

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Jensen, K. E. (Intern), Vaut, L. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2016
Event: Abstract from Modelling and experiments in drug delivery systems, Coimbra, Portugal.
Main Research Area: Technical/natural sciences
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Activities:
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Gold Nanoparticle Aggregations on Recyclable Hierarchical Nanotrays for Surface-enhanced Raman Spectroscopy with Macroscale Uniformity

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Self-Organized Nanoporous Materials
Authors: Wu, K. (Intern), Li, T. (Intern), Schmidt, M. S. (Intern), Wang, Z. (Intern), Rindzevicius, T. (Intern), Ndoni, S. (Intern), Boisen, A. (Intern)
Publication date: 2016
Event: Abstract from XXV International Conference on Raman Spectroscopy, Eusébio, Brazil.
Main Research Area: Technical/natural sciences
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Hollow MEMS: An Integrated Sensor for Combined Density, Viscosity, Buoyant Mass and IR Absorption Spectrometry

Miniaturization of electro mechanical sensor systems to the micro range and beyond has shown impressive sensitivities measuring sample properties like mass, viscosity, acceleration, pressure and force just to name a few applications. In order to enable these kinds of measurements on liquid samples a hollow MEMS sensor has been designed, fabricated and tested. Combined density, viscosity, buoyant mass spectrometry and IR absorption spectroscopy are possible on liquid samples and micron sized suspended particles (e.g. single cells). Measurements are based on changes in the resonant behavior of these sensors.

Optimization of the microfabrication process has led to a process yield of almost 100%. This is achieved despite the fact, that the process still offers a high degree of flexibility. By simple modifications the Sensor shape can be optimized for different size ranges and sensitivities.

Microfluidic interfacing has been realized using high throughput and low cost technologies such as injection molding and ultra-sonic welding. Standard fluidic LUER connections were used that are widely applied in other micro fluidic projects at DTU Nanotech to enable future interfacing of the system with other technologies and pre-concentration approaches.

A thorough theoretical analysis of the expected sensor responsivity and sensitivity is performed. Predictions made are confirmed by finite element simulations. Using these tools the sensor geometry is optimized for ideal performance in both mass density and IR spectroscopy measurements of samples, the size of single yeast cells (≈ 5 μm). A relative frequency shift of 69 ppm/single cell buoyant mass in case of the mass spectroscopy measurements and 40 ppm/μW in case of the IR absorption spectroscopy measurements are calculated and confirmed by FE simulations for the sensor geometry fabricated.

In order to verify sufficient frequency stability, Allan Deviation measurements are performed on the fabricated sensors. In combination with the calculated responsivities these measurements confirm that the sensor sensitivity will enable single cell measurements.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Larsen, P. E. (Intern), Boisen, A. (Intern), Schmid, S. (Intern)
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Lab-on-a-disc agglutination assay for protein detection by optomagnetic readout and optical imaging using nano- and micro-sized magnetic beads

We present a biosensing platform for the detection of proteins based on agglutination of aptamer coated magnetic nano- or microbeads. The assay, from sample to answer, is integrated on an automated, low-cost microfluidic disc platform. This ensures fast and reliable results due to a minimum of manual steps involved. The detection of the target protein was achieved in two ways: (1) optomagnetic readout using magnetic nanobeads (MNBs); (2) optical imaging using magnetic microbeads (MMBs). The optomagnetic readout of agglutination is based on optical measurement of the dynamics of MNB aggregates whereas the imaging method is based on direct visualization and quantification of the average size of MMB aggregates. By enhancing magnetic particle agglutination via application of strong magnetic field pulses, we obtained identical limits of detection of 25 pM with the same sample-to-answer time (15 min 30 s) using the two differently sized beads for the two detection methods. In both cases a sample volume of only 10 μl is required. The demonstrated automation, low sample-to-answer time and portability of both detection instruments as well as integration of the assay on a low-cost disc are important steps for the implementation of these as portable tools in an out-of-lab setting.
Lab-on-a-disc device for screening of genetically engineered E. coli cells

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factory Optimization, Research Groups
Authors: Sanger, K. (Intern), Zor, K. (Intern), Jendresen, C. B. (Intern), Amato, L. (Intern), Burger, R. (Intern), Boisen, A. (Intern), Nielsen, A. T. (Intern)
Number of pages: 1
Publication date: 2016
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Lab-on-a-disc agglutination assay for protein detection by optomagnetic readout method

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Lithography-Free Fabrication of Silica Nanocylinders with Suspended Gold Nanorings for LSPR-Based Sensing

Tunable plasmonic platforms are important for a variety of applications such as photovoltaics, LED's, optoelectronics, medical research, and biosensors. In particular, development of label-free plasmonic biosensors is one of the key research areas that utilizes plasmonic nanostructures for detection of biologically relevant molecules at low concentrations. The authors have developed a cost-effective, fast, and lithography-free method to fabricate transparent fused silica nanocylinders. The technique allows tuning of nanocylinder height, diameter, and density and can be scaled to large surface areas, such as 8 in. wafers. The authors demonstrate that gold coated nanocylinders support localized surface plasmon resonances (LSPR) from visible to near infrared wavelengths. The plasmonic platform can be characterized as suspended gold nanorings and exhibits a sensitivity of 658 nm RIU⁻¹ with a figure-of-merit of 10, comparable to other state-of-the-art LSPR sensing platforms that utilize more complex nanofabrication pathways. It was observed that the LSPR peak positions can be controlled by varying the geometry of the nanocylinders. The authors illustrate surface functionalization, biosensing, and surface regeneration properties of the platform using thiols and detection of bovine serum albumin (BSA). The observed LSPR shifts for 11-mercaptoundecanoic acid and BSA was 12 and 26 nm, respectively.

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Main Research Area: Technical/natural sciences
Macroscale SERS Uniformity and Reproducibility Using Densely Clustered Nanopillars

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Microcontainers - an oral drug delivery system for poorly soluble drugs

In oral delivery, it can sometimes be necessary to employ drug delivery systems to achieve targeted delivery to the intestine. Microcontainers are polymeric, cylindrical devices in the micrometer size range (Figure 1), and are suggested as a promising oral drug delivery system [1],[2]. The purpose of these studies was to fabricate microcontainers in either SU-8 or biodegradable poly-L-lactic acid (PLLA), and fill the microcontainers with poorly soluble drugs. Furthermore, the application of the microcontainers as an oral drug delivery system was investigated in terms of release, in situ intestinal perfusion and oral bioavailability. SU-8 microcontainers were fabricated using lithography resulting in microcontainers with an inner diameter of 220 μm. The PLLA microcontainers were prepared by hot embossing with inner diameter of 240 μm (Figure 1). In terms of drug filling, the SU-8 microcontainers were filled with polyvinylpyrrolidone (PVP) by inkjet printing followed by supercritical CO2 impregnation of ketoprofen into the PVP matrix. As an alternative filling method, the powder of amorphous sodium salt of furosemide, (ASSF) was filled into the SU-8 microcontainers. The PLLA microcontainers were filled with drug formulation by embossing the microcontainers into a polycaprolactone (PCL) and furosemide (4:1 w/w) layer. For the ASSF-filled microcontainers, an enteric-resistant lid of Eudragit L100 was spray coated onto the cavity of the microcontainers. From coated ASSF-filled microcontainers, a fast release in simulated intestinal medium at pH 6.5 was observed. In situ intestinal perfusions were performed in rats of the Eudragit-coated ASSF-filled microcontainers and compared to a furosemide solution. For the in vivo studies, the rats were dosed orally with capsules containing ASSF-filled microcontainers coated with Eudragit L100. As control, capsules were filled with the powder of ASSF and the capsules were coated with Eudragit L100. The oral bioavailability study showed that the relative oral bioavailability of ASSF in microcontainers is 220±43% when compared to drug-filled capsules coated with Eudragit.
Microcontainers as an oral drug delivery system

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Microcontainers as an Oral Drug Delivery System

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Microcontainers as effective drug delivery vehicles: advances in the drug loading

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Technical University of Denmark
Authors: Marizza, P. (Intern), Leonardi, L. (Ekstern), Mazzoni, C. (Intern), Tentor, F. (Intern), Petersen, R. S. (Intern), Abid, Z. (Intern), Boisen, A. (Intern)
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Microcontainers for Intestinal Drug Delivery
Among all the drug administration routes, the oral one is the most preferred by the patients being less invasive, faster and easier.
Oral drug delivery systems designed to target the intestine are produced by powder technology and capsule formulations. Those systems including micro- and nano-particulate systems (i.e. vesicles, polymer nanoparticles, dendrimers etc.) suffer the non-unidirectional release of the drug to the epithelium of the intestine, which entails an inevitable loss in the lumen and, therefore, the reduction of the drug delivered to the intestinal epithelium. A new promising approach focuses on reservoir based microdevices serving as carriers for poorly soluble drugs, hereby called microcontainers (1).
Microcontainers have a cylindrical geometry and provide a unidirectional release due to their design meanwhile protecting the drug formulation from the low gastric pH and the enzymatic degradation. Here, we present the preparation of microcontainers with enteric coating (2) efficiently loaded with drug and able to target the intestine as a multi-particulate system.

Nanomechanical IR spectroscopy for fast analysis of liquid-dispersed engineered nanomaterials
The proliferated use of engineered nanomaterials (ENMs), e.g. in nanomedicine, calls for novel techniques allowing for fast and sensitive analysis of minute samples. Here we present nanomechanical IR spectroscopy (NAM-IR) for chemical analysis of picograms of ENMs. ENMs are nebulized directly from dispersion and efficiently collected on nanomechanical string resonators through a non-diffusion limited sampling method. Even very small amounts of sample can convert absorbed IR light into a measurable frequency detuning of the string through photothermal heating. An IR absorption spectrum is thus readily obtained by recording this detuning of the resonator over a range of IR wavelengths. Results recorded using NAM-IR agree well with corresponding results obtained through ATR-FTIR, and remarkably, measurement including sample preparation takes only a few minutes, compared to ~2 days sample preparation for ATR-FTIR.
Resonator dimensions play an important role in NAM-IR, a relationship which will be elaborated here.

**General information**

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Colloids and Biological Interfaces, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics

Authors: Andersen, A. J. (Intern), Yamada, S. (Intern), Ek, P. K. (Intern), Andresen, T. L. (Intern), Boisen, A. (Intern), Schmid, S. (Intern)

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- Scopus rating (2015): SJR 1.225 SNIP 1.484 CiteScore 4.84
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- Scopus rating (2014): SJR 1.229 SNIP 1.658 CiteScore 4.37
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- BFI (2010): BFI-level 1
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- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
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- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 1.448 SNIP 1.566
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- Scopus rating (2006): SJR 1.359 SNIP 1.535
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Nanomechanical Pyrolytic Carbon Resonators: Novel Fabrication Method and Characterization of Mechanical Properties

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Authors: Kurek, M. (Intern), Larsen, F. K. (Ekstern), Larsen, P. E. (Intern), Schmid, S. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
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Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 0.707 SNIP 1.796 CiteScore 2.4
Web of Science (2014): Indexed yes
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Web of Science (2013): Indexed yes
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Nanostructuring of Solar Cell Surfaces

Solar energy is by far the most abundant renewable energy source available, but the levelized cost of solar energy is still not competitive with that of fossil fuels. Therefore there is a need to improve the power conversion efficiency of solar cells without adding to the production cost.

The main objective of this PhD thesis is to develop nanostructured silicon (Si) solar cells with higher power conversion efficiency using only scalable and cost-efficient production methods. The nanostructures, known as ‘black silicon’, are fabricated by single-step, maskless reactive ion etching and used as front texturing of different Si solar cells. Theoretically the nanostructure topology may be described as a graded refractive index in a mean-field approximation between air and Si. The optical properties of the developed black Si were simulated and experimentally measured. Total AM1.5G-weighted average reflectance well below 1% was measured for different crystalline grades of Si. Furthermore, the reflectance of RIE-textured Si remains below that of KOH-textured Si at all incident angles below 70°. RIE- and conventionally textured, screen-printed Si solar cells were fabricated on 156x156 mm² CZ Si wafers and characterized for comparison. Power conversion efficiency of 16.5% was obtained for this batch of RIE-textured Si solar cells. The efficiency of the KOH-textured reference cell was 17.8%. Quantum Efficiency measurements and carrier loss analysis show that the lower efficiency of the RIE-textured cells is primarily due to increased emitter and surface recombination. The large-area screen-printed solar cells were furthermore characterized at varying incident angles. The angle-dependent analysis shows that RIE-textured cells have a higher normalized power output averaged over the range of incident angles between 0 and 90. This result indicates the potential of improved cell performance and higher output power at diffuse light conditions and during daily and yearly operation. A second batch of RIE-textured solar cells with laser-doped selective emitters (LDSE) was fabricated. A power conversion efficiency of 18.1% and a fill factor of 80.1% were obtained by laser doping and subsequent Ni/Cu plating in combination with RIE-texturing. This result shows the potential of improved efficiency of RIE-textured compared to conventionally textured cells, especially when laser doping on black Si is combined with improved surface passivation schemes such as atomic layer deposition (ALD) of Al₂O₃, ALD Al₂O₃ passivation on black Si yields surface recombination velocity (SRV) below 80 cm/s and implied open-circuit voltage (iVOC) of 680 mV. Surface recombination velocity of 20 cm/s and implied open-circuit voltage of 695 mV is obtained for black Si passivated by doped poly-Si and a tunnel oxide.

General information
Nonlinear optomechanical measurement of mechanical motion

Precision measurement of nonlinear observables is an important goal in all facets of quantum optics. This allows measurement-based non-classical state preparation, which has been applied to great success in various physical systems, and provides a route for quantum information processing with otherwise linear interactions. In cavity optomechanics much progress has been made using linear interactions and measurement, but observation of nonlinear mechanical degrees-of-freedom remains outstanding. Here we report the observation of displacement-squared thermal motion of a micro-mechanical resonator by exploiting the intrinsic nonlinearity of the radiation-pressure interaction. Using this measurement we generate bimodal mechanical states of motion with separations and feature sizes well below 100 pm. Future improvements to this approach will allow the preparation of quantum superposition states, which can be used to experimentally explore collapse models of the wavefunction and the potential for mechanical-resonator-based quantum information and metrology applications.
Orientation of Pterin-6-Carboxylic Acid on Gold Capped Silicon Nanopillars Platforms: Surface Enhanced Raman Spectroscopy and Density Functional Theory Studies

The orientation of pterin-6-carboxylic acid on gold nanopillars was investigated by surface enhanced Raman spectroscopy and density functional theory methods. The experimentally vibrations from pterin-6-COOH free and attached to the Au surface display vibration features indicating chemical interaction of the pterin with the metal surface. The spectral feature evidenced that the pterin would adsorb on gold surface with a "lying down" configuration through the high intensity vibration of NH scissoring and rocking OH modes. The orientation study of pterins on gold nanopillars presented herein is believed to lead to new applications in biosensing field for detecting pterins of physiological importance.
Perforated SiN membrane resonators for nanomechanical IR spectroscopy poster

Constant progress in micro- and nanofabrication provides a great opportunity in development of micro- and nanomechanical resonators that can be used for sensing purposes. These sensors usually consist of singly-clamped cantilever beams, doubly-clamped bridges or membranes that exhibit resonant behavior. The principle of operation is based on the monitoring of the resonance frequency shift due to various external factors such as change of temperature. It has been shown that photothermal infrared (IR) spectroscopy based on nanomechanical silicon nitride (SiN) string resonators (NAM-IR) enables the exceptionally fast chemical analysis of pictograms of analytes directly from liquid solution in only a few minutes [1]. However in this technique the coupling of the IR laser beam to the nanometer-wide string resonators is difficult and inefficient. Therefore perforated SiN membranes with thickness of 100 nm, lateral dimension of 1×1 mm² and 2 µm perforation grid pitch were used instead of strings which makes the IR beam alignment significantly simpler while maintaining similar sampling efficiency and photothermal IR absorption sensitivity.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Technical University of Denmark
Authors: Kurek, M. (Intern), Carnoy, M. (Ekstern), Boisen, A. (Intern), Schmid, S. (Intern)
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Plasmonic nanopillar structures for surface-enhanced raman scattering applications

Noble metal nanostructures support localized surface plasmon (LSPR) resonances that depend on their dimensions, shapes and compositions. Particle LSPR's can be used to spatially confine the incident light and produce enormous electromagnetic (EM) field enhancement spots, i.e. hot spots. Hot spots have been utilized in surface-enhanced Raman spectroscopy (SERS) for biological and chemical sensing. We present Au nanopillar (NP) SERS structures that are excellent for molecular detection. The NP structures can be fabricated using a simple two-step process. We analyze NP
optical properties experimentally and theoretically. Simulations show that a single Ag-coated NP supports two LSPR modes, i.e. the particle mode and the Ag cap resonant cavity mode. The Ag cap resonant cavity mode contributes most to the enhancement of the Raman scattering signal. The electric field distribution calculations show that the EM hot spots are located at the bottom of the Ag cap which is important observation for practical SERS sensing. Reproducible and repeatable SERS signal intensities can be obtained across large surface areas (>mm²). Application examples include detection of TAMRA-labeled vasopressin and cyanide (KCN).

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Polymeric microcontainers improve oral bioavailability of furosemide
Microcontainers with an inner diameter of 223μm are fabricated using the polymer SU-8, and evaluated in vitro, in situ and in vivo for their application as an advanced oral drug delivery system for the poorly water soluble drug furosemide. An amorphous sodium salt of furosemide (ASSF) is filled into the microcontainers followed by applying a lid using Eudragit L100. It is possible to control the drug release in vitro, and in vitro absorption studies show that the microcontainers are not a hindrance for absorption of ASSF. In situ perfusion studies in rats are performed with ASSF-filled microcontainers coated with Eudragit and compared to a furosemide solution. The absorption rate constant of ASSF confined in microcontainers is found to be significantly different from the solution, and by light microscopy, it is observed that the microcontainers are engulfed by the intestinal mucus. An oral bioavailability study in rats is performed with ASSF confined in microcontainers coated with Eudragit and a control group with ASSF in Eudragit-coated capsules. A relative bioavailability of 220% for the ASSF in microcontainers compared to ASSF in capsules is found. These studies indicate that the microcontainers could serve as a promising oral drug delivery system.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, University of Valencia, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Melero, A. (Ekstern), Keller, S. S. (Intern), Jacobsen, J. (Ekstern), Garrigues, T. (Ekstern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
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Cystic fibrosis (CF) is the most frequently inherited disease in the Western world, and also the one with the highest morbidity and mortality. The main reason is chronic lung infections caused by the pathogenic bacterium Pseudomonas aeruginosa, which is well-adapted to the thick and dehydrated mucous in the CF airways. Established methods to detect P. aeruginosa in young CF children are invasive and lack sensitivity, which is why novel approaches are being investigated. P. aeruginosa emits hydrogen cyanide (HCN) gas, which can possibly be used as a biomarker for early P. aeruginosa colonisation, if it can be detected in the breath. It was investigated if a nanopillar substrate for surface-enhanced Raman spectroscopy (SERS), developed in the Nanoprobes group, could be optimised for gas phase detection of HCN. The project consisted of 3 steps, of which the first was to establish a chemical method to detect cyanide on the
substrate in relevant concentrations, preferably in gas. Step I was split up into two parts; one for HCN detection in the gas phase, and one for detection of potassium cyanide (KCN) in serial dilutions to reach sufficiently low CN concentrations and verify the limit of detection. Once this was done, Step II was to measure HCN(g) from emissions of P. aeruginosa; first from the established reference strain, the wild type PAO1. Secondly, it was relevant to study clinical P. aeruginosa strains, isolated for the first time from CF children (the wild type-like strains), and then compare to SERS measurements on later strains, isolated from the same patients after their infection became chronic and the P. aeruginosa had mutated in the lasR gene, which is essential to HCN production. Step III was a clinical trial, where children with CF would blow into a bag containing the SERS substrate, which was then measured, to see if HCN was detected when a new P. aeruginosa colonisation occurred; and data was correlated to culturing of sputum from the patient’s lungs. The SERS substrate was optimised, and setups were developed for HCN(g) detection, for SERS detection of HCN from bacterial volatiles, and for collection and SERS substrate exposure to human breath. Five ppm HCN was successfully detected in gas phase, and KCN was detected down to 10^-6 M. HCN detection was demonstrated from cultures of P. aeruginosa wild types, starting from the end of exponential / beginning of stationary growth phase. HCN was also detected from lasR mutated clinical P. aeruginosa strains isolated from the airways of children with CF, when the mutation was located at the 5’ terminal (downstream) of the gene. P. aeruginosa isolates with a mutation at the 3’ terminal of the lasR gene (upstream) did not emit detectable HCN. Application for ethics’ committee was submitted and permission granted to conduct a 4 months’ clinical pilot study at Rigshospitalet, including 50 CF patients aged 5-17 years and 19 age-matched control subjects. One CF patient had a new P. aeruginosa lung colonisation during the trial, and it was probably detected on the SERS substrate, which had an increased HCN signal compared to the patient’s other visits. Additional cases of increased SERS cyanide signal were seen in the breath of some of the children, and it was speculated if they could come from prolonged exposure time or from children being exposed to passive smoking at home. The SERS substrate has a background peak in the Raman spectrum, which needs to be addressed, because it is located very close to the cyanide peak.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk AS
Authors: Lauridsen, R. K. (Intern), Boisen, A. (Intern), Rindzevicius, T. (Intern), Molin, S. (Ekstern)
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Spray Drying of Cubosomes for Oral Vaccine Delivery

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Supercritical impregnation of polymer matrices spatially confined in microcontainers for oral drug delivery: Effect of temperature, pressure and time
The present study is aimed to enhance the oral bioavailability of ketoprofen by inserting it into the matrix of poly(vinylpyrrolidone) (PVP) K10 spatially confined into microcontainers, by means of supercritical CO2-aided impregnation. Microcontainers are cylindrical reservoirs, with typical sizes in the micrometer range, with a cavity open on one side, where the drug formulation is loaded. Differently to traditional tablets, microcontainers have a higher surface area per unit volume, and release the drug only in one direction. This design is meant to enhance the absorption of problematic drugs, like those with poor solubility in water. In a previous study we introduced a novel technique for drug loading of microcontainers, based on inkjet printing and supercritical impregnation (SCI). We showed that SCI produces accurate and reproducible drug loading for large arrays of microcontainers. In the attempt of enhancing the throughput of the loading methods, we propose the replacement of polymer inkjet printing with an easier manual compression of the PVP powder into the microcontainers. As the second step, the polymer powder-filled microcontainers were submitted to SCI. The separate role of different impregnation parameters (temperature, pressure, time, drug concentration in the supercritical phase) was elucidated with respect to the loading capacity. The microcontainer filling was observed by means of optical macroimaging, X-ray microtomography and scanning electron microscopy. The physical state of the drug was investigated by means of Raman spectroscopy and compared with selected representative PVP-ketoprofen physical mixtures. Finally, the drug loading was estimated by means of in vitro dissolution tests. The characterization study shows that the present loading method is a valuable alternative to the one previously described. The drug loading can be controlled with high accuracy and reproducibility and the impregnated drug is in amorphous state. These results demonstrate that SCI can be used as a high-throughput loading technique for microfabricated devices for oral drug delivery.
Surface-enhanced Raman spectroscopic study of DNA and 6-mercapto-1-hexanol interactions using large area mapping

The emergence of 2D SERS substrates with large areas of hot spots has enabled data to be gathered at large scale. This work presents a statistical tool for analysing large amounts of SERS data by utilizing a peak-fitting model in a specific spectral range. By analysing the distributions of Raman intensities and peak positions it is possible to directly inspect the interplay between DNA and 6-mercaptop-1-hexanol on gold covered nanopillars. It is demonstrated that optimised functionalization parameters can be extracted from the Raman spectra directly. Using the peak-fitting approach it is possible to avoid mis-interpretation of intensity histograms, where contamination might contribute with an enhanced background and not a peak.

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Authors: Frøhling, K. B. (Intern), Alstrøm, T. S. (Intern), Bache, M. (Intern), Schmidt, M. S. (Intern), Schmidt, M. N. (Intern), Larsen, J. (Intern), Jakobsen, M. H. (Intern), Boisen, A. (Intern)
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Surface Enhanced Raman Spectroscopy detection of p-coumaric acid from cell supernatant using gold-capped silicon nanopillar substrates

A standard protocol for analysis of microbial factories requires the screening of several populations in order to find the best performing ones. This is done with standard analytical methods (e.g. HPLC) with an expensive and time-consuming process. Surface Enhanced Raman Spectroscopy (SERS) is a highly sensitive spectroscopic technique which only requires drying a small volume of solution on an active substrate, with an analysis time of few minutes. Here we demonstrate the use of SERS to discriminate between two different bacterial populations based on detection of p-coumaric acid (pHCA) in cell supernatant. pHCA is a valuable secondary metabolite of genetically modified E. coli[1]. It is produced through deamination of tyrosine, and it has strong Raman and SERS activity[2],[3]. Gold capped silicon nanopillars were used as sensing substrates[4]. At first, they were successfully used to detect pHCA spiked in culture medium, in the same concentration range (10^{-4} – 10^{-5} M) commonly found in cell supernatant. For supernatant analysis, triplicate cultures of FjTAL modified (P strains) and control (C strains) E.coli strains were carried out according to the
methods described by[5] and shown in Fig.1. Samples of cell supernatant were extracted from each culture at 0, 3, 24 and 48 h post seeding and their pHCA content was measured with HPLC[5]. For SERS analysis, aliquots of supernatant were diluted 10-fold with MilliQ water, and 1 μL droplets were dried on the SERS substrates. A MatLab analysis was performed to extract the height of the significant peak at 1169 cm⁻¹, with the results shown in Fig.2. The amplitude of the peak shows a different trend for P and C strains. A similar trend is obtained from HPLC. These promising results open up new possibilities for the use of SERS for high-throughput and automated evaluation of bacterial factories, allowing parallel analysis and discrimination of different strains.

Surface Enhanced Raman Spectroscopy detection of p-coumaric acid from cell supernatant using gold-capped silicon nanopillar substrates

The purpose of the project is to use Surface Enhanced Raman Spectroscopy (SERS) to discriminate between two different bacterial populations, based on their p-coumaric acid (pHCA) production. The pHCA concentration is measured in a droplet of the supernatant dried on the SERS substrates, using a Raman microscope. By analyzing the SERS signal of pHCA from the supernatant, considering the peak height at the characteristic frequency (1169 cm⁻¹) it is possible to distinguish between a producing and control strain, as also confirmed by HPLC analysis.

Synthesis and characterization of UV photocrosslinkable hydrogels with poly(N-vinyl-2-pyrrolidone): Determination of the network mesh size distribution

Hydrogels of poly(N-vinyl-2-pyrrolidone) were produced by UV irradiation of aqueous solutions of the polymer in the presence of hydrogen peroxide, used as initiator. The mechanical and the nanostructural properties of the gels were characterized by a combination of experimental techniques including rheology, low field nuclear magnetic resonance spectroscopy (LF-NMR), and small angle X-ray scattering. Different irradiation doses as well as polymer and initiator concentrations were tested in the characterization. The study elucidates the relationship between different methods to estimate the mesh size of the gel polymeric network. Moreover, a novel correlation model was developed based on Chui and Scherer theories for the interpretation of LF-NMR dataset of polymer solutions and networks.
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Web of Science (2016): Indexed yes
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Scopus rating (2014): SJR 0.79 SNIP 1.113 CiteScore 2.78
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.827 SNIP 1.167 CiteScore 2.41
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.695 SNIP 1.038 CiteScore 1.62
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.374 SNIP 0.854 CiteScore 1.03
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.261 SNIP 0.469
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.289 SNIP 0.419
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.22 SNIP 0.497
Scopus rating (2007): SJR 0.197 SNIP 0.403
Scopus rating (2006): SJR 0.216 SNIP 0.347
Scopus rating (2005): SJR 0.265 SNIP 0.465
Scopus rating (2004): SJR 0.228 SNIP 0.42
Scopus rating (2003): SJR 0.24 SNIP 0.33
Scopus rating (2002): SJR 0.184 SNIP 0.28
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.207 SNIP 0.376
Scopus rating (2000): SJR 0.233 SNIP 0.323
Scopus rating (1999): SJR 0.206 SNIP 0.327
Original language: English
Hydrogels, Drug delivery, Photocrosslinking, Polymer network morphology, Rheology, Modeling
Electronic versions:
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Source: FindIt
Source-ID: 2303405233
Publication: Research - peer-review › Journal article – Annual report year: 2016
Transparent Substrates for Plasmonic Sensing by Lithography-Free Fabrication

This Ph.D. thesis presents fabrication and optimization of transparent plasmonic substrates that can be used for biological and chemical sensing by surface enhanced Raman spectroscopy (SERS) sensing and localized surface plasmon resonance refractive index (LSPR RI) sensing. These substrates are: glass nanopillars with gold caps for SERS sensing; polymer nanopillars with gold caps for SERS sensing; transferred gold nanocaps to polymer foil for SERS sensing; and glass hollow-core nanocylinders with gold nanorings for LSPR RI sensing.

These substrates were achieved using lithography-free fabrication methods, and resulted in large-area, high throughput and low cost production techniques. The fabrication techniques consisted of using aluminum patterned areas and reactive ion etching (RIE) to achieve nanopillars or nanocylinders in glass; using RIE to achieve nanopillars in silicon as a mould for polymer injection; and using RIE and imprinting to transfer gold nanocaps to a polymer foil. The SERS substrates showed a 91%, a 94% and 8% Raman signal intensity compared to gold-capped silicon nanopillars for the glass nanopillars, the polymer injected nanopillars and the transferred gold nanocaps, respectively. As the substrates were transparent, measurements from the backside were possible, showing a 44%, 1.7% and 71% Raman signal intensity in comparison to the measurements from the front, for the glass nanopillars, the polymer injected nanopillars and the transferred metal nanocaps, respectively.

For LSPR, the glass hollow-core nanocylinders with suspended gold nanorings showed a sensitivity of 658 nm RIU with a gure-of-merit of 10. The LSPR wavelengths could be shifted by tuning the plasma etching parameters.

Due to the low electrical conductivity of glass substrates, electrodes could be incorporated onto the glass nanopillars, resulting in a device that could be used for both electrochemistry and SERS measurements. The polymer injected nanopillars used an industrial high throughput and robust fabrication technique. The substrate was integrated into high throughput fluidic devices for in-situ SERS measurements. The fabrication methods presented in this Ph.D. thesis are scalable, high throughput and low cost, and result in high performance plasmonic surfaces for sensing.
Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes, Helmholtz Centre for Infection Research (HZI), Saarland University, University of Copenhagen, Monash University
Authors: Nielsen, L. H. (Intern), De Rossi, C. (Ekstern), Lehr, C. (Ekstern), Rades, T. (Ekstern), Boyd, B. (Ekstern), Boisen, A. (Intern), Gordon, S. (Ekstern)
Number of pages: 1
Publication date: 2016
Event: Poster session presented at BioBarriers 2016, Saarbrücken, Germany.
Main Research Area: Technical/natural sciences
Electronic versions:
BB2016_cell_model.pdf

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Triple co-culture cell model as an in vitro model for oral particulate vaccine systems

General information
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Organisations: Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Department of Micro- and Nanotechnology, Nanoprobes, Helmholtz Centre for Infection Research (HZI), University of Copenhagen, Monash University
Authors: Nielsen, L. H. (Intern), De Rossi, C. (Ekstern), Lehr, C. (Ekstern), Rades, T. (Ekstern), Boyd, B. (Ekstern), Boisen, A. (Intern), Gordon, S. (Ekstern)
Number of pages: 1
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Event: Poster session presented at 10th World Meeting on Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology, Glasgow, United Kingdom.
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Triple co-culture cell model as an in vitro model for oral particulate vaccine systems

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Authors: Nielsen, L. H. (Intern), De Rossi, C. (Ekstern), Lehr, C. (Ekstern), Rades, T. (Ekstern), Boyd, B. (Ekstern), Boisen, A. (Intern), Gordon, S. (Ekstern)
Publication date: 2016
Event: Abstract from BioBarriers 2016, Saarbrücken, Germany.
Main Research Area: Technical/natural sciences
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Wafer-Scale Nanopillars Derived from Block Copolymer Lithography for Surface-Enhanced Raman Spectroscopy
We report a novel nanofabrication process via block copolymer lithography using solvent vapor annealing. The nanolithography process is facile and scalable, enabling fabrication of highly ordered periodic patterns over entire wafers
as substrates for surface-enhanced Raman spectroscopy (SERS). Direct silicon etching with high aspect ratio templated by the block copolymer mask is realized without any intermediate layer or external precursors. Uniquely, an atomic layer deposition (ALD)-assisted method is introduced to allow reversing of the morphology relative to the initial pattern. As a result, highly ordered silicon nanopillar arrays are fabricated with controlled aspect ratios. After metallization, the resulting nanopillar arrays are suitable for SERS applications. These structures readily exhibit an average SERS enhancement factor of above $10^{10}$, SERS uniformities of 8.5% relative standard deviation across 4 cm, and 6.5% relative standard deviation over $5 \times 5$ mm$^2$ surface area, as well as a very low SERS background. The as-prepared SERS substrate, with a good enhancement and large-area uniformity, is promising for practical SERS sensing applications.

General information
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Organisations: Department of Micro- and Nanotechnology, Self-Organized Nanoporous Materials, Nanoprobes, Center for Nanostructured Graphene, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Li, T. (Intern), Wu, K. (Intern), Rindzevicius, T. (Intern), Wang, Z. (Intern), Schulte, L. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Ndoni, S. (Intern)
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 8.15 SJR 2.784 SNIP 1.543
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.6 SJR 2.561 SNIP 1.536
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.262 SNIP 1.555 CiteScore 7.38
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.125 SNIP 1.636 CiteScore 6.88
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.992 SNIP 1.548 CiteScore 6.05
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.199 SNIP 1.327 CiteScore 4.94
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.046 SNIP 1.404 CiteScore 4.41
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 1.597 SNIP 0.944
Web of Science (2010): Indexed yes
Web of Science (2009): Indexed yes
Original language: English
SERS uniformity, block copolymer lithography, nanofabrication, plasmonic nanomaterials, surface-enhanced Raman spectroscopy
DOIs:
A method for the chemical modification of polychlorinated biphenyls for improved affinity towards noble metal surfaces.

The present application discloses a method for the modification and analysis of a field sample suspected of containing contaminant(s) like polychlorinated biphenyls (PCBs). The invention also relates to a corresponding kit for the modification of samples suspected of containing such contaminant(s).

Adsorption and Vibrational Study of Folic Acid on Gold Nanopillar Structures Using Surface-enhanced Raman Scattering Spectroscopy

This paper presents a study of adsorption and vibrational features of folic acid, using surface-enhanced Raman scattering (SERS). A gold-capped silicon nanopillar (Au NP) with a height of 600 nm and a width of 120 nm was utilized to study the vibrational features of FA molecules adsorbed on the nanopillars within the high electromagnetic field areas. The adsorption behaviour of folic acid and the band assignment of the main vibrations together with the optimized geometry of folic acid and folic acid in the presence of a cluster of 10 gold atoms were assessed using the density functional theory (B3LYP(6-31G(d))) and the scalar relativistic effective core potential with a double-zeta basis set (LANL2DZ). The vibrations obtained from the solid-state folic acid and the folic acid on a gold cluster were in accordance with those observed experimentally. The analysis of the main vibrations indicated that the interaction of folic acid with the Au NP occurred primarily through the nitrogen atoms, from their pteridine ring. Finally, the obtained adsorption isotherm for folic acid was deduced from the analysis of the SERS spectra and it followed a negative cooperative binding model.
A Lab-on-a-Disc Platform for Trapping of Cell Population, Monitoring of Cell growth and Evaluation of Redox Metabolism

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, Technical University of Denmark
Authors: Amato, L. (Intern), Tehrani, S. E. (Ekstern), Sanger, K. (Ekstern), Burger, R. (Intern), Andreasen, S. Z. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Event: Abstract from XXIII International Symposium on Bioelectrochemistry and Bioenergetics, Malmö, Sweden.
Main Research Area: Technical/natural sciences
Links:
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2015

A Lab-on-a-disc platform for trapping of cells, monitoring of cell behaviour and evaluation of redox metabolism
In this work, we demonstrate an integrated electrochemical system on a centrifugal microfluidic platform for cell studies by combining electrochemical impedance spectroscopy and amperometry, and comparison of different cleaning protocols for gold electrodes on plastic substrate.

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State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems, Bioanalytics, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Amato, L. (Intern), Kuldeep, K. (Intern), Esmail Tehrani, S. (Intern), Burger, R. (Intern), Caviglia, C. (Intern), Andreasen, S. Z. (Intern), Heiskanen, A. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern)
Pages: 1299-1301
Publication date: 2015
Host publication information
Title of host publication: Proceedings MicroTAS 2015
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 128950322
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Angle resolved characterization of nanostructured and conventionally textured silicon solar cells
We report angle resolved characterization of nanostructured and conventionally textured silicon solar cells. The nanostructured solar cells are realized through a single step, mask-less, scalable reactive ion etching (RIE) texturing of the surface. Photovoltaic properties including short circuit current, open circuit voltage, fill factor (FF) and power conversion efficiency are each measured as function of the relative incident angle between the solar cell and the light source. The relative incident angle is varied from 0° to 90° in steps of 10° in orthogonal axes, such that each solar cell is characterized
at 100 different angle combinations. The angle resolved photovoltaic properties are summarized in terms of the average, angle-dependent electrical power output normalized to the power output at normal incidence and differently textured cells on different silicon substrates are compared in terms of angle resolved performance. The results show a 3% point improvement in average electrical power output normalized with respect to normal incidence power output of RIE textured, multicrystalline Si cells compared to conventional multicrystalline Si cells and above 1% point improvement of RIE textured monocrystalline Si cells compared to conventional monocrystalline Si cells.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology, Nanoprobes, Department of Physics, Experimental Surface and Nanomaterials Physics, Technical University of Denmark, Institute for Energy Technology
Authors: Davidsen, R. S. (Intern), Ormstrup, J. (Ekstern), Ommen, M. L. (Ekstern), Larsen, P. E. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Nordseth, Ø. (Ekstern), Hansen, O. (Intern)
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- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 4.83 SJR 1.459 SNIP 1.532
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 4.97 SJR 1.599 SNIP 1.71
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 1.8 SNIP 1.851 CiteScore 5.16
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 2.19 SNIP 2.348 CiteScore 5.87
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 2.179 SNIP 2.529 CiteScore 5.58
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 2.441 SNIP 2.654 CiteScore 5.25
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 2.182 SNIP 2.577 CiteScore 5.16
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 2.494 SNIP 2.105
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.942 SNIP 1.957
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 1.626 SNIP 1.449
- Web of Science (2008): Indexed yes
General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Andreasen, S. Z. (Intern), Burger, R. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:
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Source: PublicationPreSubmission
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2015

Centrifugal Microfluidic Platform Using Supported Liquid Membrane Extraction for Combined Sample Clean-Up and Enrichment of Trace Analytes

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics
Authors: Andreasen, S. Z. (Intern), Burger, R. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Event: Poster session presented at Microfluidics Congress 2015, London, United Kingdom.
Main Research Area: Technical/natural sciences
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Source-ID: 118025081
Degradation studies of spray coated polymer films using cantilever sensors

General information
State: Published
Organisations: Center for Nanostructured Graphene, Department of Micro- and Nanotechnology, Amphiphilic Polymers in Biological Sensing, Nanoprobes, Biomaterial Microsystems, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Almdal, K. (Intern), Bose, S. (Intern), Keller, S. S. (Intern), Alstrøm, T. S. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Event: Poster session presented at Fourth International Symposium Frontiers in Polymer Science, Riva del Garda, Italy.
Main Research Area: Technical/natural sciences
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Detection of bacterial metabolites through dynamic acquisition from surface enhanced raman spectroscopy substrates integrated in a centrifugal microfluidic platform
In this work we present a novel technology that combines the advantages of centrifugal microfluidics with dynamic in-situ Surface Enhanced Raman Spectroscopy (SERS) sensing. Our technology is based on an automated readout system that allows on-line SERS acquisition on a rotating centrifugal microfluidic platform with embedded gold nanopillar substrates. While spinning, the disc platform enables dynamic SERS acquisition of multiple chips, significantly reducing time-to-result and improving the reproducibility of the acquired spectra, reducing the fluctuation by a factor of 2.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Durucan, O. (Intern), Morelli, L. (Intern), Schmidt, M. S. (Intern), Burger, R. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern)
Number of pages: 3
Pages: 1831-1833
Publication date: 2015

Development of a SERS aptasensor for detection of medical residues
Low levels of medical residues in environmental, industrial and domestic water systems is a growing concern. The biosensor industry is trying to accommodate the need of sensitive and specific sensor systems capable of ultra-low level detection of medical residues. In this PhD project a surface enhanced Raman spectroscopy (SERS) sensor for the female sexhormone 17β-estradiol was attempted. It is commonly used in contraceptive pills from where it find its way through waste water treatment plants and into the environment. The SERS substrate was fabricated in a cleanroom facility using techniques well known from the electronics industry. The substrate consisted of silver or gold covered silicon nanopillars. The nanopillars were chemically functionalised with a DNA aptamer specific towards 17β-estradiol using thiol chemistry. At first, an entire functionalisation protocol was carried out to detect Estradiol Glow, which is fluorescently labelled 17β-estradiol. It was shown that Estradiol Glow exhibit very strong Raman activity and was such ideal for initial test. Since a large amount of data was gathered for this experiment it was necessary to develop an algorithm capable of analysing large data sets. Non-negative Matrix Factorization (NMF) was utilised to effectively improve the detection limit of the system by one order of magnitude.
Due to issues relating to the functionalisation protocol it was secondly investigated whether the aptamer was properly immobilised on the nanopillar surface. By hybridisation to a labelled complementary strand it was proven that aptamer was
indeed immobilised. It was also found that stronger binding to the gold covered nanopillars could be obtained by a short treatment in reactive O₂ plasma. Likewise it was found that the addition of a detergent to the washing buffer had a great influence on the unspecific binding to the nanopillars.

A thorough study of the parameters influencing the degree of functionalisation was then conducted. By utilizing a developed peak-fitting model it was possible to directly inspect the interplay between DNA aptamer and 6-mercapto-1-hexanol (MCH) used for blocking unspecific binding to gold. By inspecting the spectra of the molecules and their combination it was possible to observe attachment of DNA aptamer and MCH. Displacement/removal of DNA aptamer was also observed for high concentrations of MCH.

The final study was an attempt to detect pure 17β-estradiol using the developed functionalisation parameters. Unfortunately the inherent weak Raman signal of 17β-estradiol proved to faint for direct detection. Therefore Estradiol Glow was employed, however without success. Despite several attempts with varying degree of stringency successful detection was never accomplished.

In conclusion, this PhD project successfully characterised the chemical functionalisation parameters needed for generic SERS aptasensor development using only the Raman signals of the molecules. The SERS substrate was successfully fabricated repeatedly and showed great enhancement of Raman signals. Two analysis methods (NMF and peak-fitting) was developed in collaboration with DTU Compute in order to accommodate for the large amount of data gathered throughout the project. This work displays the complexity in SERS aptasensor development, which is needed for sensitive and selective capture of medical residues.
and unidirectional drug release. Most of these devices have been fabricated using microfabrication methods with materials such as Si and photoresists. However, there is a need to shift from these materials towards biocompatible and biodegradable polymers such as poly-l-lactic acid (PLLA) or poly-e-caprolactone (PCL). Hot embossing is one of the most viable and matured methods to fabricate microstructures in such biopolymers. However, hot embossing is unable to produce discrete 3D microdevices due to the inherent problem of a residual layer that connects all the microdevices to each other. Therefore, hot punching which is combination of hot embossing and mechanical punching has been developed in this project. This process utilizes a stamp in connection with the ability to apply heat and pressure to transfer the stamp pattern to a film. Processes have been optimized for fabrication of nickel stamps with two layered, high aspect ratio microstructures. Bosch deep reactive ion etching of Silicon producing sloped sidewalls required for stamp production has been developed. The sloped sidewalls ensure a successful separation of stamp and film after patterning. High aspect ratio, 3D, discrete microcontainers in PLLA and PCL are fabricated using hot punching. High throughput and replication fidelity is achieved. Characterization of spin coating of drug-polymer films is thoroughly performed using microscopy, profilometry, differential scanning calorimetry, Raman spectroscopy, X-ray diffraction and microdissolution release tests. These films are applied for loading of microcontainers. Furosemide which is an important loop diuretic drug with low solubility and permeability is used as a model drug and embedded in a PCL matrix. The crystallinity of the drug is tailored by the process parameters of spin coating. Release profiles ranging from rapid burst release to sustained zero-order release are obtained by tuning spin coating. The hot punching technique is then applied for loading of microcontainers with the spin coated drug-polymer matrix. It has been demonstrated that hot punching is a fast, parallel, single step process that can load containers with high yield. Furthermore, the drug-polymer matrix loaded in the containers is characterized using the above mentioned techniques. Finally, zero-order sustained release of furosemide drug from microcontainers is successfully demonstrated.

Fabrication and loading of oral drug delivery microcontainers using hot punching
In this paper, poly-l-lactic acid (PLLA) solution is spin coated to achieve a PLLA layer of 55 μm thickness. Hot punching with a Ni stamp is optimized to fabricate microcontainers in PLLA. Process optimization of thermal bonding of the microcontainers to a poly acrylic acid (PAA) layer is performed by modifying sample preparation and varying temperature. The fabricated microcontainers are loaded by hot punching in a spin coated drug polymer film of furosemide and poly-e-caprolactone (PCL).
Fabrication of Ni stamp with high aspect ratio, two-leveled, cylindrical microstructures using dry etching and electroplating:

**Paper**

We describe a process for the fabrication of a Ni stamp that is applied to the microstructuring of polymers by hot embossing. The target devices are microcontainers that have a potential application in oral drug delivery. Each container is a 3D, cylindrical, high aspect ratio microstructure obtained by defining a reservoir and a separating trench with different depths of 65 and 125 μm, respectively, in a single embossing step. The fabrication of the required two leveled stamp is done using a modified DEEMO (dry etching, electroplating and molding) process. Dry etching using the Bosch process and electroplating are optimized to obtain a stamp with smooth stamp surfaces and a positive sidewall profile. Using this stamp, hot embossing is performed successfully with excellent yield and high replication fidelity.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Individual Nanoparticle Functionality, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Petersen, R. S. (Intern), Keller, S. S. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Number of pages: 12
Publication date: 2015
Main Research Area: Technical/natural sciences

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- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.013 SNIP 1.637
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.144 SNIP 1.5
Hot embossing and mechanical punching of biodegradable microcontainers for oral drug delivery

A process has been developed to fabricate discrete three-dimensional microcontainers for oral drug delivery application in Poly-L-Lactic Acid (PLLA) polymer. The method combines hot embossing for the definition of holes in a PLLA film and mechanical punching to penetrate the polymer layer around the holes, after filling them with drug. Here, we demonstrate the fabrication of microcontainers with a diameter of 340 lm and a height of 50 lm. The process is temperature benign so that the compositional integrity of the drug is preserved. It also provides a good flexibility for creating different sizes and shapes of microcontainers. Finally, the process is compatible with roll-to-roll processing that could lead to low cost high volume production. © 2014 Elsevier B.V. All rights reserved.
Hot punching of high-aspect-ratio 3D polymeric microstructures for drug delivery

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Petersen, R. S. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern)
Number of pages: 4
Pages: 2576-2579
Publication date: 2015
Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 6.05 SJR 2.158 SNIP 1.586
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.98 SJR 2.162 SNIP 1.569
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.239 SNIP 1.721 CiteScore 5.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.555 SNIP 1.797 CiteScore 5.6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.397 SNIP 1.693 CiteScore 5.9
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.405 SNIP 1.731 CiteScore 5.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.54 SNIP 1.788 CiteScore 5.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.718 SNIP 1.876
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.673 SNIP 2.164
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.833 SNIP 1.849
Web of Science (2008): Indexed yes
We investigate the effect of flow rate on the electrical current response to the applied voltage in a micro electrochemical system. To accomplish this, we considered an ion-transport model that is governed by the Nernst-Planck equation coupled to the Navier-Stokes equations for hydrodynamics. The Butler-Volmer relation provides the boundary conditions, which represent reaction kinetics at the electrode-electrolyte interface. The result shows that convection drastically affects the rate of surface kinetics. At a physically sufficient high flow rates and lower scan rates, the current response is limited by the convection due to fresh ions being brought to the electrode surface and immediately taken away before any surface reaction. However, at high flow and scan rates, the Faradaic current overrides current due to convection. The model also allows predicting the effect of varying electrolyte concentration and scan rates respectively.
Integrating Electrochemical Detection with Centrifugal Microfluidics for Real-Time and Fully Automated Sample Testing

Here we present a robust, stable and low-noise experimental set-up for performing electrochemical detection on a centrifugal microfluidic platform. By using a low-noise electronic component (electrical slip-ring) it is possible to achieve continuous, on-line monitoring of electrochemical experiments, even when the microfluidic disc is spinning at high velocities. Automated sample handling is achieved by designing a microfluidic system to release analyte sequentially, utilizing on-disc passive valving. In addition, the microfluidic system is designed to trap and keep the liquid sample stationary during analysis. In this way it is possible to perform cyclic voltammetry (CV) measurements at varying spin speeds, without altering the electrochemical response. This greatly simplifies the interpretation and quantification of data. Finally, real-time and continuous monitoring of an entire electrochemical experiment, including all intermediate sample handling steps, is demonstrated by amperometric detection of on-disc mixing of analytes (PBS and ferricyanide).

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Andreasen, S. Z. (Intern), Kwasny, D. (Intern), Amato, L. (Intern), Brøgger, A. L. (Intern), Bosco, F. (Intern), Andersen, K. B. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 17187–17193
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: R S C Advances
Volume: 5
ISSN (Print): 2046-2069
We present a novel strategy for thrombin detection by combining a magnetic bead based agglutination assay and low-cost microfluidic disc. The detection method is based on an optomagnetic readout system implemented using a Blu-ray optical pickup unit (OPU) as main optoelectronic component. The assay, from sample to answer, is fully integrated on a microfluidic disc which embeds on-disc mixing ensuring full automation of the assay along with less sample-to-answer time compared to similar methods. Moreover, we compare the optomagnetic readout to the cluster size distribution determined using a commercial optical scanning imaging instrument.

**Integration of agglutination assay for protein detection in microfluidic disc using Blu-ray optical pickup unit and optical fluid scanning**

We present a novel strategy for thrombin detection by combining a magnetic bead based agglutination assay and low-cost microfluidic disc. The detection method is based on an optomagnetic readout system implemented using a Blu-ray optical pickup unit (OPU) as main optoelectronic component. The assay, from sample to answer, is fully integrated on a microfluidic disc which embeds on-disc mixing ensuring full automation of the assay along with less sample-to-answer time compared to similar methods. Moreover, we compare the optomagnetic readout to the cluster size distribution determined using a commercial optical scanning imaging instrument.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Magnetic Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Uddin, R. (Intern), Burger, R. (Intern), Donolato, M. (Intern), Fock, J. (Intern), Creagh, M. (Intern), Hansen, M. F. (Intern), Boisen, A. (Intern)
Number of pages: 3
Pages: 1807-1809
Publication date: 2015

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Title of host publication: Proceedings of MicroTAS 2015
Main Research Area: Technical/natural sciences
Agglutination assay, Aptamer, Magnetic beads, Centrifugal Microfluidics, Thrombin, Microfluidic disc
Electronic versions:
Integration_of_agglutination_assay.pdf
Source: PublicationPreSubmission
Maskless Nanostructure Definition of Submicron Rear Contact Areas for Advanced Solar Cell Designs

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology, Nanoprobes
Authors: Davidsen, R. S. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Hansen, O. (Intern)
Number of pages: 1
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:
Poster_MNE15_draft.pdf
Source: PublicationPreSubmission
Source-ID: 117836776
Publication: Research - peer-review › Poster – Annual report year: 2015

Mathematical model for biomolecular quantification using large-area surface-enhanced Raman spectroscopy mapping

Surface-enhanced Raman spectroscopy (SERS) based on nanostructured platforms is a promising technique for quantitative and highly sensitive detection of biomolecules in the field of analytical biochemistry. Here, we report a mathematical model to predict experimental SERS signal (or hotspot) intensity distributions of target molecules on receptor-functionalized nanopillar substrates for biomolecular quantification. We demonstrate that by utilizing only a small set of empirically determined parameters, our general theoretical framework agrees with the experimental data particularly well in the picomolar concentration regimes. This developed model may be generally used for biomolecular quantification using Raman mapping on SERS substrates with planar geometries, in which the hotspots are approximated as electromagnetic enhancement fields generated by closely spaced dimers. Lastly, we also show that the detection limit of a specific target molecule, TAMRA-labeled vasopressin, approaches the single molecule level, thus opening up an exciting new chapter in the field of SERS quantification.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Harvard University, Columbia University
Authors: Palla, M. (Ekstern), Bosco, F. (Intern), Yang, J. (Ekstern), Rindzevicius, T. (Intern), Alstrøm, T. S. (Intern), Schmidt, M. S. (Intern), Lin, Q. (Ekstern), Ju, J. (Ekstern), Boisen, A. (Intern)
Pages: 85845-85853
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: RSC Advances
Volume: 5
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.01 SJR 0.863 SNIP 0.736
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.06 SJR 0.889 SNIP 0.757
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.947 SNIP 0.834 CiteScore 3.42
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
This paper presents the development of a novel statistical method for quantifying trace amounts of biomolecules by surface-enhanced Raman spectroscopy (SERS) using a rigorous, single molecule (SM) theory based mathematical derivation. Our quantification framework could be generalized for planar SERS substrates, in which the nanostructured features can be approximated as a closely spaced electromagnetic dimer problem. The potential for SM detection was also shown, which opens up an exciting opportunity in the field of SERS quantification.

Method for manufacturing carrier containing e.g. proteins for human during oral drug delivery operation for food and drug administration application in pharmaceutical industry, involves providing active ingredient to core layer

NOVELTY - The method involves preparing a multi-layered film comprising a core layer and a barrier layer, where the core layer comprises active ingredient. The multi-layered film is subjected to a hot embossing step using an embossing stamp including protrusions that allows for generation of the micro-containers containing an active ingredient or containing a core layer that is configured to accept the active ingredient such that the barrier layer partially encloses the core layer. The active ingredient is provided to the core layer when the core layer is configured to accept the active ingredient.

USE - Method for manufacturing a multi-layered micro-container i.e. carrier, containing an active ingredient e.g. small organic molecules, proteins, peptides, vitamins, antibodies, antibody fragments, vaccines, RNA, DNA and antibiotics, for a patient e.g. human and animal, during an oral drug delivery operation for a food and drug administration (FDA) application in a pharmaceutical industry.

ADVANTAGE - The method enables allowing an individual micro-structure stuck in an embossing stamp to be demolded under the conditions such that demolding operation is done by treating elastically or plastically deformable layer to
increase stiction of the release layer. The method enables manufacturing the micro-container including an outer diameter of 200-500 pm and a height of 2-70 pm such that wall thickness is larger than 5 m to increase geometrical stability and reduce buckling. The method enables manufacturing a multi-layered micro-container to enable unidirectional release at a site of absorption, thus increasing bioavailability of drugs.

DETAILED DESCRIPTION - The barrier layer is made out of polycaprolactone (PCL), polylactic acid (PLA), polyglycolic acid (PGA), hydroxypropylmethyl cellulose (HPMC), polymethacrylate (PMMA), Eudragits Poly-methacrylic acid-co-methyl methacrylate, ethyl cellulose (EC), polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), polyethylene glycol (PEG), polyethylene glycol methacrylate (PEGMA), polyethylene glycol dimethacrylate (PEGDMA), poly-lactic-co-glycolic acid (PGLA), polyacrylic acid (PAA) and copolymer. An INDEPENDENT CLAIM is also included for a micro-container.

Microcantilever sensors for fast analysis of enzymatic degradation of poly (D, L-lactide)

In this work we have performed a detailed analysis of enzymatic degradation of amorphous poly (d, l-lactide) (PDLLA) by measuring the resonance frequencies of polymer coated microcantilevers before and after degradation. The miniaturized cantilever system provides a fast analysis of the biodegradation rate of PDLLA with a minute amount of sample and without the need of thermal and chemical acceleration. The degradation rate of the polymer has been estimated by multilayer cantilever theory and model simulation. A bulk degradation rate of 0.24 μg mm^{-2} hour^{-1} is estimated which agrees well with values reported in literature. The role of enzyme concentrations, pre-hydration in buffer, surface morphologies of PDLLA films and adsorption time of enzymes on the rate of degradation has been investigated. An increase in degradation rate is observed with an increase in enzyme concentration and after pre-hydration in buffer. A polymer film with a non-uniform surface degrades faster than the uniform one due to the preference of enzyme attack at film defects. A threshold time of around 3 h is estimated for irreversible enzyme adsorption on the polymer surface after which degradation can proceed even in buffer solution in the absence of enzyme.
Microcontainers - an oral drug delivery system for poorly soluble drugs

**General information**

State: Published

Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Valencia, University of Copenhagen

Authors: Nielsen, L. H. (Intern), Petersen, R. S. (Intern), Marizza, P. (Intern), Keller, S. S. (Intern), Melero, A. (Ekstern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)

Number of pages: 2

Publication date: 2015

**Abstract**

Enzymatic degradation PDLLA, Microcantilevers, Resonance frequency, Spray coating

**Keywords**

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Microcontainers as an oral drug delivery system

**General information**
State: Published
Organisations: Biomaterial Microsystems, Department of Micro- and Nanotechnology, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Nanoprobes, University of Copenhagen
Authors: Petersen, R. S. (Intern), Nielsen, L. H. (Intern), Marizza, P. (Intern), Keller, S. S. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 1
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Title of host publication: Book of Abstracts. DTU's Sustain Conference 2015
Place of publication: Lyngby
Publisher: Technical University of Denmark (DTU)
Article number: Q-5
Main Research Area: Technical/natural sciences
Conference: DTU Sustain Conference 2015, Lyngby, Denmark, 17/12/2015 - 17/12/2015
Electronic versions: Q5_DTU_Sustain_2015.pdf
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Microcontainers improve oral bioavailability of furosemide

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Biomaterial Microsystems, University of Valencia, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Melero, A. (Ekstern), Keller, S. S. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Event: Poster session presented at 1st European Conference on Pharmaceutics, Reims, France.
Main Research Area: Technical/natural sciences
Electronic versions: Poster_Reims_2015_LHN.pdf
Source: PublicationPreSubmission
Source-ID: 110810681
Publication: Research - peer-review › Poster – Annual report year: 2015

Microcontainers improve oral bioavailability of furosemide

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Valencia, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Melero, A. (Ekstern), Keller, S. S. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Event: Abstract from CRS Nordic Chapter, Edinburgh, United Kingdom.
Main Research Area: Technical/natural sciences
Electronic versions:
Micromechanical Fast Quasi-Static Detection of α and β Relaxations with Nanograms of Polymer

Micromechanical string resonators are used as a highly sensitive tool for the detection of glass transition (Tg or α relaxation) and sub-Tg (β relaxation) temperatures of polystyrene (PS) and poly (methyl methacrylate) (PMMA). The characterization technique allows for a fast detection of mechanical relaxations of polymers with only few nanograms of sample in a quasi-static condition. The polymers are spray coated on one side of silicon nitride (SiN) microstrings. These are pre-stressed suspended structures clamped on both ends to a silicon frame. The resonance frequency of the microstrings is then monitored as a function of increasing temperature. α and β relaxations in the polymer affect the net static tensile stress of the microstring and result in measurable local frequency slope maxima. Tg of PS and PMMA is detected at 91 ±2°C and 114 ±2°C, respectively. The results match well with the glass transition values of 93.6°C and 114.5°C obtained from differential scanning calorimetry of PS and PMMA, respectively. The β relaxation temperatures are detected at 30±2°C and 33±2°C for PS and PMMA which is in accordance with values reported in literature.
Parallelized system for biopolymer degradation studies through automated microresonator measurement in liquid flow

In this work we present a novel automated system which allows the study of enzymatic degradation of biopolymer films coated on micromechanical resonators. The system combines an optical readout based on Blu-Ray technology with a software-controlled scanning mechanism. Integrated with a microfluidic setup unit, the system allows high-throughput measurements of resonance frequency over microresonator arrays under controlled flow conditions. We here demonstrate the acquisition of statistical data on biopolymer films degradation under enzymatic reaction over a large sample of micromechanical resonators. The system has been proved to be able to perform measurements both in air and in liquid environment.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Academia Sinica Taiwan
Authors: Casci Ceccacci, A. (Intern), Morelli, L. (Intern), Bosco, F. (Intern), Burger, R. (Intern), Chen, C. H. (Ekstern), Hwu, E. T. (Ekstern), Boisen, A. (Intern)
Number of pages: 3
Pages: 1870-1872
Publication date: 2015

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Title of host publication: 19th International Conference on Miniaturized Systems for Chemistry and Life Sciences, MicroTAS 2015
Publisher: Chemical and Biological Microsystems Society
ISBN (Electronic): 9780979806483
Main Research Area: Technical/natural sciences
Control and Systems Engineering, Automation, Biomolecules, Resonators, Blu-ray technology, Enzymatic Degradation, Enzymatic reaction, High-throughput measurements, Liquid environment, Micro-resonator arrays, Resonance frequencies, Scanning mechanisms, Micromechanical resonators
Source: FindIt
Source-ID: 2342835041
pH-triggered drug release from biodegradable microwells for oral drug delivery

Microwells fabricated from poly-L-lactic acid (PLLA) were evaluated for their application as an oral drug delivery system using the amorphous sodium salt of furosemide (ASSF) as a model drug. Hot embossing of PLLA resulted in fabrication of microwells with an inner diameter of 240 μm and a height of 100 μm. The microwells were filled with ASSF using a modified screen printing technique, followed by coating of the microwell cavities with a gastroresistant lid of Eudragit® L100. The release behavior of ASSF from the coated microwells was investigated using a μ-Diss profiler and a UV imaging system, and under conditions simulating the changing environment of the gastrointestinal tract. Biorelevant gastric medium (pH 1.6) was employed, after which a change to biorelevant intestinal release medium (pH 6.5) was carried out. Both μ-Diss profiler and UV imaging release experiments showed that sealing of microwell cavities with an Eudragit® layer prevented drug release in biorelevant gastric medium. An immediate release of the ASSF from coated microwells was observed in the intestinal medium. This pH-triggered release behavior demonstrates the future potential of PLLA microwells as a site-specific oral drug delivery system.

General information

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Saarland University, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Nagstrup, J. (Intern), Gordon, S. (Ekstern), Keller, S. S. (Intern), Østergaard, J. (Ekstern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 7
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Main Research Area: Technical/natural sciences

Publication information

Journal: Biomedical Microdevices
Volume: 17
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.639 SJR 0.538 CiteScore 2.07
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.29 SJR 0.606 SNIP 0.743
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.768 SNIP 0.903 CiteScore 2.68
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.961 SNIP 1.158 CiteScore 2.98
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.882 SNIP 0.99 CiteScore 3.01
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.991 SNIP 1.098 CiteScore 3.12
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.151 SNIP 1.107 CiteScore 3.45
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.284 SNIP 1.232
Plasmon resonances of Ag capped Si nanopillars fabricated using mask-less lithography.
Localized surface plasmon resonances (LSPR) and plasmon couplings in Ag capped Si Nanopillar (Ag NP) structures are studied using 3D FEM simulations and dark-field scattering microscopy. Simulations show that a standalone Ag NP supports two LSPR modes, i.e. the particle mode and the cavity mode. The LSPR peak position of the particle mode can be tuned by changing the size of the Ag cap, and can be hybridized by leaning of pillars. The resonance position of the cavity resonance mode can be tuned primarily via the diameter of the Si pillar, and cannot be tuned via leaning of Ag NPs. The presence of a substrate dramatically changes the intensity of these two LSPR modes by introducing constructive and destructive interference patterns with incident and reflected fields. Experimental scattering spectra can be interpreted using theoretical simulations. The Ag NP substrate displays a broad plasmonic resonance band due to the contribution from both the hybridized particle LSPR and the cavity LSPR modes.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Photonics Engineering, Structured Electromagnetic Materials, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Authors: Wu, K. (Intern), Rindzevicius, T. (Intern), Schmidt, M. S. (Intern), Mogensen, K. B. (Intern), Xiao, S. (Intern), Boisen, A. (Intern)
Pages: 12965-12978
Publication date: 2015
Main Research Area: Technical/natural sciences

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Journal: Optics Express
Volume: 23
Issue number: 10
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.91 SNIP 1.674 CiteScore 3.78
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.313 SNIP 2.124 CiteScore 4.18
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.337 SNIP 2.196 CiteScore 4.38
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.562 SNIP 2.108 CiteScore 3.85
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.58 SNIP 2.572 CiteScore 4.04
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.204 SNIP 2.423
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.284 SNIP 2.11
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.313 SNIP 2.336
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.819 SNIP 2.472
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.669 SNIP 2.217
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.745 SNIP 1.748
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.496 SNIP 1.42
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.98 SNIP 0.761
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.442 SNIP 0.843
Original language: English
Electronic versions:
oe_23_10_12965.pdf
DOIs:
10.1364/OE.23.012965
Publication: Research - peer-review › Journal article – Annual report year: 2015
Polymeric microcontainers improve oral bioavailability of a poorly soluble drug

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Valencia, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Melero, A. (Ekstern), Keller, S. S. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:
Polymeric_microcontainers_improve_oral_bioavailability_of_a_poorly_soluble_drug.pdf

Quantification of NS1 dengue biomarker in serum via optomagnetic nanocluster detection
Dengue is a tropical vector-borne disease without cure or vaccine that progressively spreads into regions with temperate climates. Diagnostic tools amenable to resource-limited settings would be highly valuable for epidemiologic control and containment during outbreaks. Here, we present a novel low-cost automated biosensing platform for detection of dengue fever biomarker NS1 and demonstrate it on NS1 spiked in human serum. Magnetic nanoparticles (MNPs) are coated with high-affinity monoclonal antibodies against NS1 via bio-orthogonal Cu-free 'click' chemistry on an anti-fouling surface molecular architecture. The presence of the target antigen NS1 triggers MNP agglutination and the formation of nanoclusters with rapid kinetics enhanced by external magnetic actuation. The amount and size of the nanoclusters correlate with the target concentration and can be quantified using an optomagnetic readout method. The resulting automated dengue fever assay takes just 8 minutes, requires 6 μL of serum sample and shows a limit of detection of 25 ng/mL with an upper detection range of 20000 ng/mL. The technology holds a great potential to be applied to NS1 detection in patient samples. As the assay is implemented on a low-cost microfluidic disc the platform is suited for further expansion to multiplexed detection of a wide panel of biomarkers.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Magnetic Systems, University of Queensland
Authors: Antunes, P. S. M. (Intern), Watterson, D. (Ekstern), Parmvi, M. (Intern), Burger, R. (Intern), Boisen, A. (Intern), Young, P. (Ekstern), Cooper, M. A. (Ekstern), Hansen, M. F. (Intern), Ranzoni, A. (Ekstern), Donolato, M. (Intern)
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Main Research Area: Technical/natural sciences

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Volume: 5
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.36 SJR 1.533 SNIP 1.245
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.63 SJR 1.692 SNIP 1.354
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.034 SNIP 1.597 CiteScore 5.3
Web of Science (2015): Indexed yes
We present the first implementation of a Blu-ray optical pickup unit (OPU) for the high-performance low-cost readout of a homogeneous assay in a multichamber microfluidic disc with a chamber thickness of 600 μm. The assay relies on optical measurements of the dynamics of magnetic nanobeads in an oscillating magnetic field applied along the light propagation direction. The laser light provided by the OPU is transmitted through the sample chamber and reflected back onto the photo detector array of the OPU via a mirror. Spectra of the 2nd harmonic photo detector signal vs. the frequency of the applied magnetic field show a characteristic peak due to freely rotating magnetic nanobeads. Beads bound to ~1 μm coils of DNA formed off-chip by padlock probe recognition and rolling circle amplification show a different dynamics and the intensity of the characteristic peak decreases. We have determined the optimum magnetic bead concentration to 0.1 mg/mL and have measured the response vs. concentration of DNA coils formed from Escherichia Coli. We have found a limit of detection of 10 pM and a dynamic range of about two orders of magnitude, which is comparable to the performance obtained using costly and bulky laboratory equipment. The presented device leverages on the advanced but low-cost technology of Blu-ray OPUs to provide a low-cost and high-performance magnetic bead-based readout of homogeneous bioassays. The device is highly flexible and we have demonstrated its use on microfluidic chambers in a disc with a thickness compatible with current optical media mass-production facilities.
Reduction of thermal budget in the solar industry

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology, Nanoprobes, Experimental Surface and Nanomaterials Physics

Magnetic biosensing, Molecular diagnostics, Optical scattering, DNA amplifications, Lab-on-a-chip

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Source-ID: 102456345
Publication: Research - peer-review › Journal article – Annual report year: 2014
Scalable DNA-Based Magnetic Nanoparticle Agglutination Assay for Bacterial Detection in Patient Samples

We demonstrate a nanoparticle-based assay for the detection of bacteria causing urinary tract infections in patient samples with a total assay time of 4 h. This time is significantly shorter than the current gold standard, plate culture, which can take several days depending on the pathogen. The assay is based on padlock probe recognition followed by two cycles of rolling circle amplification (RCA) to form DNA coils corresponding to the target bacterial DNA. The readout of the RCA products is based on optomagnetic measurements of the specific agglutination of DNA-bound magnetic nanoparticles (MNPs) using low-cost optoelectronic components from Blu-ray drives. We implement a detection approach, which relies on the monomerization of the RCA products, the use of the monomers to link and agglutinate two populations of MNPs functionalized with universal nontarget specific detection probes and on the introduction of a magnetic incubation scheme. This enables multiplex detection of Escherichia coli, Proteus mirabilis and Pseudomonas aeruginosa at clinically relevant concentrations, demonstrating a factor of 30 improvement in sensitivity compared to previous MNP-based detection schemes. Thanks to the universal probes, the same set of functionalized MNPs can be used to read out products from a multitude of RCA targets, making the approach truly scalable for parallel detection of multiple bacteria in a future integrated point of care molecular diagnostics system.
SERS sensors for DVD platform

This Ph.D. thesis explores the engineering of a portable sensor system for detection of rare and small molecules. The Ph.D. project is part of the research project 'Multi-Sensor DVD platform' (MUSE), aiming to integrate different sensors on a rotating disc. The sensors are chosen to complement each other, creating more reliable and stable results for the end user. The rotating disc comprises microfluidic channels, which can be utilized for handling and manipulating liquid samples such as blood or water.

The focus of this Ph.D. thesis, is on the integration of one specific sensor on a rotating disc. The sensor is based upon surface enhanced Raman spectroscopy (SERS), which detects molecular vibrations. The aim of this thesis is to cover the different aspects of the sensor system.

SERS substrates, consisting of nanopillars with gold or silver caps on top, have been fabricated by standard micro and nano fabrication techniques. These substrates possess plasmonic properties and can therefore enhance Raman signals from even small molecules in close proximity to the surface of the caps. By introducing high temperature annealing to the fabrication process, the SERS background signal, originating from etch residues, has been reduced, further improving the SERS signal.

Microuidic sample handling are, in combination with the SERS sensor, to be used with the DVD system. Nanoparticles has been investigated as a mean to capture and handle the target molecules. This enables the use of sandwich assays between the substrate and nanoparticles for biodetection. It is demonstrated that the SERS substrate maintains its enhancing properties when the nanoparticles are immobilized on the surface. By introducing a dynamic measuring method called DynaSERS it is demonstrated how the stability of the Raman signal can be improved. Additionally, the assignment of vibrational modes is made easier, as the peak width is reduced and the peak position is shifted.

Finally, the instrumentation for a portable sensor system has been investigated and SERS measurements on a rotating microfluidic disc has been demonstrated.
Silver-capped silicon nanopillar platforms for adsorption studies of folic acid using surface enhanced Raman spectroscopy and density functional theory

The study of the interactions of folic acid (FA) with surface enhanced Raman scattering substrates is relevant for understanding its adsorption mechanism and for fabricating analytical devices for detection of malignant cells over-expressing folate receptors. This paper presents a study of the adsorption of FA on silver-capped silicon nanopillar substrates employing surface enhanced Raman scattering spectroscopy and density functional theory calculations. The experimentally observed vibrations from free FA and FA bound to the Ag surface display different vibrational spectra indicating chemical interaction of the molecule with the metal surface. Density functional theory calculations show that the Ag–FA interaction is primarily through the nitrogen from the pteridine ring anchoring to the Ag metal surface. To investigate the Ag–FA binding behavior further, the adsorption isotherm of FA on the silver-capped silicon nanopillar surface is estimated. The results show a positive cooperative Ag–FA binding mechanism. That is, adsorbed FA increases the affinity of new incoming FA molecules.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, Universidad Santo Tomas
Authors: Castillo, J. (Intern), Rindzevicius, T. (Intern), Wu, K. (Intern), Rozo, C. E. (Ekstern), Schmidt, M. S. (Intern), Boisen, A. (Intern)
Pages: 1087-1094
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Raman Spectroscopy
Volume: 46
Issue number: 11
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.05 SJR 0.888 CiteScore 2.58
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.71 SJR 0.926 SNIP 1.115
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.02 SNIP 0.891 CiteScore 2.25
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.15 SNIP 1.071 CiteScore 2.53
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.029 SNIP 1.073 CiteScore 2.49
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.288 SNIP 1.086 CiteScore 2.63
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.262 SNIP 1.109 CiteScore 2.73
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Silver Capped Silicon Nanopillars as Surface Enhanced Raman Spectroscopy Substrates

General Information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Wu, K. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015

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Title of host publication: Proceedings of the 36th Progress In Electromagnetics Research Symposium
Main Research Area: Technical/natural sciences
Conference: 36th Progress In Electromagnetics Research Symposium, Prague, Czech Republic, 06/07/2015 - 06/07/2015
Electronic versions:
150416025429_abstract.pdf
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Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Simple electrodynamic transduction scheme for micromechanical resonators

General Information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Kurek, M. (Intern), Larsen, P. E. (Intern), Schmid, S. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2015
Main Research Area: Technical/natural sciences
Electronic versions:
Simple_electrodynamic_transduction_scheme_for_micromechanical_resonators_poster_2.pdf
Simulation and Measurement of Angle Resolved Reflectance from Black Si Surfaces

In this work angle-resolved reflectance from nanostructured Si surfaces realized by maskless RIE texturing has been simulated and measured. The simulation and experimental measurement data show the same trend. Experimentally a total reflectance below 1% for incident angles below 30° and specular reflectance below 0.1% at incident angles below 70° is seen. In both simulation and experiment the specular reflectance is below 10% at incident angles below 65° and below 1% at incident angles below 45° in the case of non-linear graded refractive index. From the simulation results the non-linear graded refractive index yields lower reflectance than the linearly graded refractive index.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology, Nanoprobes
Authors: Davidsen, R. S. (Intern), Wu, K. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Hansen, O. (Intern)
Number of pages: 3
Publication date: 2015

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Title of host publication: Proceedings of the 31st European Photovoltaic Solar Energy Conference and Exhibition
Series: EU PVSEC Proceedings
ISSN: 2196-100X
Main Research Area: Technical/natural sciences
Black silicon, Reactive ion etching, Angle dependence, Reflectance, Nanostructures
Electronic versions:
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Simulation and Measurement of Angle Resolved Reflectance from Black Si Surfaces

General information
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Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology, Nanoprobes
Authors: Davidsen, R. S. (Intern), Wu, K. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Hansen, O. (Intern)
Number of pages: 1
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Main Research Area: Technical/natural sciences
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Source-ID: 117670617
Publication: Research - peer-review › Poster – Annual report year: 2015

Statistical analysis of large areas of Raman mapped DNA functionalized gold coated silicon nanopillar SERS substrates

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Surface Engineering, Department of Applied Mathematics and Computer Science, Cognitive Systems, Nanoprobes
Authors: Frøhling, K. B. (Intern), Alstrøm, T. S. (Intern), Bache, M. (Intern), Schmidt, M. S. (Intern), Schmidt, M. N. (Intern), Larsen, J. (Intern), Jakobsen, M. H. (Intern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2015
Event: Abstract from 8th International Conference on Advanced Vibrational Spectroscopy, Vienna, Austria
Main Research Area: Technical/natural sciences
SERS, Area map, Peak fitting, Statistics, Sensor
The copper binding properties of metformin - QCM-D, XPS and nanobead agglomeration

Study of the copper binding properties of metformin is important for revealing its mechanism of action as a first-line type-2 diabetes drug. A quantitative investigation of interactions between metformin and l-cysteine-copper complexes was performed. The results suggest that metformin could interact with biological copper, which plays a key role in mitochondrial function.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, DTU Danchip, Magnetic Systems, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, University of Dundee
Authors: Quan, X. (Intern), Uddin, R. (Intern), Heiskanen, A. (Intern), Parmvi, M. (Intern), Nilson, K. (Intern), Donolato, M. (Intern), Hansen, M. F. (Intern), Rena, G. (Ekstern), Boisen, A. (Intern)
Pages: 17313-17316
Publication date: 2015
Main Research Area: Technical/natural sciences

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.03 SJR 2.555 SNIP 1.127
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.06 SJR 2.538 SNIP 1.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.601 SNIP 1.295 CiteScore 6.7
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.692 SNIP 1.436 CiteScore 6.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.752 SNIP 1.372 CiteScore 6.73
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.118 SNIP 1.35 CiteScore 6.21
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.889 SNIP 1.323 CiteScore 5.96
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Towards quantitative SERS detection of hydrogen cyanide at ppb level for human breath analysis

Lung infections with Pseudomonas aeruginosa (PA) is the most common cause of morbidity and mortality in cystic fibrosis (CF) patients. Due to its ready adaptation to the dehydrated mucosa of CF airways, PA infections tend to become chronic, eventually killing the patient. Hydrogen cyanide (HCN) at ppb level has been reported to be a PA biomarker. For early PA detection in CF children not yet chronically lung infected a non-invasive Surface-Enhanced Raman Spectroscopy (SERS)-based breath nanosensor is being developed. The triple bond between C and N in cyanide, with its characteristic band at $\sim2133$ cm$^{-1}$, is an excellent case for the SERS-based detection due to the infrequent occurrence of triple bonds in nature.

For demonstration of direct HCN detection in the gas phase, a gold-coated silicon nanopillar substrate was exposed to 5 ppm HCN in N$_2$. Results showed that HCN adsorbed on the SERS substrate can be consistently detected under different experimental conditions and up to 9 days after exposure. For detection of lower cyanide concentrations serial dilution experiments using potassium cyanide (KCN) demonstrated cyanide quantification down to 1 $\mu$M in solution (corresponding to 18 ppb). Lower KCN concentrations of 10 and 100 nM (corresponding to 0.18 and 1.8 ppb) produced SERS intensities that were relatively similar to the reference signal. Since HCN concentration in the breath of PA colonized CF children is reported to be $\sim13.5$ ppb, the detection of cyanide is within the required range.

General information

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Novo Nordisk Foundation Center for Biosustainability, Bacterial Cell Factories, Department of Chemistry, Department of Applied Mathematics and Computer Science, Cognitive Systems, Amphiphilic Polymers in Biological Sensing, Department of Environmental Engineering, Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Number of pages: 6
Pages: 84-89
Wafer-Scale Leaning Silver Nanopillars for Molecular Detection at Ultra-Low Concentrations

Wafer-scale surface-enhanced Raman scattering (SERS) substrates fabricated using maskless lithography are important for scalable production targets. Large-area, leaning silver-capped silicon nanopillar (Ag NP) structures suitable for SERS molecular detection at extremely low analyte concentrations are investigated. Theoretical results show that isolated Ag NPs essentially support two localized surface plasmon (LSP) modes. The most prominent LSP resonance is observed in the near-infrared region (∼800 nm) and can be tuned by changing the diameter of the silicon nanopillars (Si NPs). The corresponding electric field distribution maps indicate that the maximum E-field enhancement is found at the Ag cavity, i.e., the bottom part of the Ag cap. We argue that the plasmon coupling between the resonant Ag cap cavities contributes most to the enhancement of the Raman signal. We experimentally evaluate these findings and show that by exposing Si NPs to an O₂-plasma the average Ag NP cluster size, and thus the overall interpillar coupling, can be systematically reduced. We show that deposition of Cr adhesion layers on Si NPs (>3 nm) introduces plasmon coupling loss to the Ag NP LSP cavity mode that significantly reduces the SERS intensity. Results also show that short exposures to the O₂-plasma and the use of 1−3 nm Cr adhesion layers are advantageous for reducing the signal background noise from Ag NPs. In addition, the influence of the Ag NP height and Ag metal thickness on SERS intensities is investigated and optimal fabrication process parameters are evaluated. Finally, the SERS spectrum from 100 pM trans-1,2-bis(4-pyridyl) ethylene (BPE) is recorded, showing distinct characteristic Raman vibrational modes. The calculated enhancement factor is of the order of 10⁸, and the SERS signal intensity exhibits a standard deviation of around 14% (660 data points) across a 5 × 5 mm² surface area.
Biosensor based on the measurements of clustering dynamics of magnetic particles using a double pass setup

Disclosed herein is a biosensor for optical detection of Brownian relaxation dynamics of magnetic particles measured by light transmission. The magnetic particles can be functionalized with biological ligands for the detection of target analytes in a sample. The setup may be implemented in a disc and optical pick-up head configuration.
A Centrifugal Microfluidic Platform for Biomarker Detection in Blood using BluRay Technology

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Magnetic Systems, Department of Applied Mathematics and Computer Science, Cognitive Systems, Copenhagen University Hospital
Publication date: 2014
Event: Poster session presented at 24th Anniversary World Congress on Biosensors, Melbourne, Australia.
Main Research Area: Technical/natural sciences
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Source-ID: 92650093
Publication: Research - peer-review › Poster – Annual report year: 2014

A magnetic nanoparticle-clustering biosensor for blu-ray based optical detection of small-molecules

In magnetic nanoparticle (MNP)-clustering assays, a target molecule is bound to multiple receptors tethered onto MNPs, triggering MNP-clustering and leading to changes in the size of clusters. However, sandwich-type clustering requires multiple binding-sites on a target molecule, which is often unavailable for small-molecules. Furthermore, measuring magnetic properties as signals is not intrinsically selective regarding MNP-cluster size. Thus, the detection of few MNP-clusters is readily interfered by background signals from predominantly-existing single MNPs. Additionally, bulky and high-cost instruments limit the advancement of MNP-based assays. We report here a novel MNP-clustering small-molecule assay on an optical readout platform to overcome the limitations aforementioned with the following improvements. First, a facile MNP-clustering assay applicable to diverse small-molecules was realized by adopting an inhibition mechanism. Next, frequency-dependent optical measurements enabled us to resolve signals depending on the cluster size. Lastly, a low-cost and miniaturized optical readout setup was established by implementing a Blu-ray pickup head. Consequently, our low-cost optical biosensor using MNP-clustering facilitates high-resolution small-molecule assays.

For experiments, aptamer-functionalized MNPs (Apt-MNPs) were first incubated with adenosine-5'-triphosphate (ATP) followed by adding MNPs with linker strands (linker-MNPs). The linker hybridizes with a region of aptamer sequences in the absence of ATP, forming MNP-clusters. Conversely, when aptamers are preoccupied by ATP inhibiting the hybridization, the cluster formation is hindered (Fig. 1). Consequently, higher ATP-concentrations result in smaller and fewer cluster formations. Blu-ray optical transmission measurements through an MNP-solution (Fig. 2) reveal that the 2nd harmonic component of the signal is related to the frequency of Brownian relaxation dynamics of MNPs induced by alternating magnetic field. Following measurement characterization (Fig. 3) and analyte-control experiments (Fig. 4), we demonstrated the ATP concentration dependent behavior of signals in micromolar ranges (Fig. 5). These results support that our MNP-clustering optical biosensor is capable of specific and quantitative detection of small-molecules.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Magnetic Systems, Nanoprobes, Columbia University, CIC nanoGUNE Consolider, Academia Sinica Taiwan
Authors: Yang, J. (Ekstern), Donolato, M. (Intern), Antunes, P. S. M. (Intern), Pinto, A. (Ekstern), Bosco, F. (Intern), Hwu, E. (Ekstern), Chen, C. (Ekstern), Vavassori, P. (Ekstern), Boisen, A. (Intern), Hansen, M. F. (Intern), Ling, Q. (Ekstern)
Publication date: 2014
Can engineering solutions really provide a sustainable future?
Sustainability is a word which is very often (mis)used in various public debates. In engineering, however, it is perhaps easier to define the term, then in other academic fields. We advocate the principle that only those activities, which can be sustained for at least a few centuries using known technology and resources, should be called sustainable. Using this definition of sustainability one particularly big challenge field is energy supply, but the importance of the issue - "The energy problem" - is clear.
To illustrate one central aspect of the energy problem we introduce the "1 TW benchmark". On this backdrop we proceed to discuss the practical availability of chemical elements for energy technologies and the implications this has for industrial scalability. The issue will be exemplified by how some, otherwise promising, emerging technologies are limited in ultimate scale by scarcity of key elements. Finally, we discuss a few specific recent research highlights from DTU-Physics within the field of energy harvesting and conversion.

Characterization of Electromechanical Behavior of an Electrochemical Cantilever System

Characterization of the time-evolving bending profile of micro-cantilevers
Conducting 3D-carbon scaffolds induce spontaneous differentiation of human neural stem cells and measure neurotransmitter release in real-time

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Self-Organized Nanoporous Materials, Bioanalytics
Authors: Amato, L. (Intern), Schulte, L. (Intern), Heiskanen, A. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern), Ndoni, S. (Intern), Emnéus, J. (Intern)
Number of pages: 1
Publication date: 2014

**Host publication information**
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Main Research Area: Technical/natural sciences
Electronic versions: Amato_ESEAC2014.pdf

**Bibliographical note**
For oral presentation
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Source-ID: 103224953
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Development of an electrochemical cantilever platform

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, McGill University, Lund University
Authors: Quan, X. (Intern), Heiskanen, A. (Intern), Grütter, P. (Ekstern), Tenje, M. (Ekstern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2014

**Host publication information**
Title of host publication: Proceedings of the 11th Nanomechanical Sensing Workshop
Main Research Area: Technical/natural sciences
Conference: 11th Annual International Workshop on Nanomechanical Sensing, Madrid, Spain, 30/04/2014 - 30/04/2014
Electronic versions: nmc2014_Xueling_Quan.pdf
Source: PublicationPreSubmission
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Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Electrochemistry in a centrifugal microfluidic system: Towards a novel point-of-care technology platform

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems, Bioanalytics
Authors: Andreasen, S. Z. (Intern), Kwasny, D. (Intern), Bregger, A. L. (Intern), Bosco, F. (Intern), Andersen, K. B. (Intern), Svendsen, W. E. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern)
Fabrication and Process Optimization of Wafer-scale Silicon Nanopillar SERS Substates

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Wu, K. (Intern), Schmidt, M. S. (Intern), Rindzевичius, T. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014
Event: Poster session presented at 40th International Conference on Micro and Nano Engineering, Lausanne, Switzerland.
Main Research Area: Technical/natural sciences
Electronic versions:
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Fabrication of drug-laden poly(vinylpyrrolidone)(PVP) microgels by UV-photolithography and supercritical impregnation

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Polymer Microsystems for Cell Processing, Center for Electron Nanoscopy, University of Copenhagen
Authors: Marizza, P. (Intern), Keller, S. S. (Intern), Faralli, A. (Intern), Mateiu, R. V. (Intern), Müllertz, A. (Ekstern), Larsen, N. B. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014

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Main Research Area: Technical/natural sciences
Electronic versions:
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Source: PublicationPreSubmission
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Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Hollow micro string based calorimeter device
The present invention relates to a micron-scale calorimeter and a calorimetry method utilizing the micron-scale calorimeter. In accordance with the invention, there is provided a micron-scale calorimeter comprising a micro-channel string, being restrained at at least two longitudinally distanced positions so as to form a free released double clamped string in-between said two longitudinally distanced positions said micro-channel string comprising a microfluidic channel having a closed cross section and extending in the longitudinal direction of the hollow string, acoustical means adapted to oscillate the string at different frequencies by emitting sound waves towards the string, optical means adapted to detect oscillating frequencies of the string, and controlling means controlling the strength and frequency of the sound wave emitted by the acoustical means and receiving a signal from the optical means representing the detected oscillating frequencies.
Imaging based agglutination measurement of magnetic micro-particles on a Lab-on-a-Disc platform

In this work we present a magnetic micro beads based agglutination assay on a centrifugal microfluidic platform. An imaging based method is used to quantify bead agglutination and measure the concentration of antibodies or C-reactive protein in solution.

Imaging based agglutination measurement of magnetic micro-particles on a lab-on-a-disk platform

In this work we present a magnetic micro beads based agglutination assay on a centrifugal microfluidic platform. An imaging based method is used to quantify bead agglutination and measure the concentration of antibodies or C-reactive protein in solution.
Improvement of Infrared Detectors for Tissue Oximetry using Black Silicon Nanostructures

We present a nanostructured surface, made of dry etched black silicon, which lowers the reflectance for light incident at all angles. This surface is fabricated on infrared detectors used for tissue oximetry, where the detection of weak diffuse light signals is important. Monte Carlo simulations performed on a model of a neonatal head shows that approximately 60% of the injected light will be diffuse reflected. However, the change in diffuse reflected light due to the change in cerebral oxygenation is very low and the light will be completely isotropic scattered. The reflectance of the black silicon surface was measured for different angles of incident and was found to be below 10% for angles of incident up to 70°. The quantum efficiency of detectors with the black silicon nanostructures was measured and compared to detectors with a simple anti-reflection coating. The result was an improvement in quantum efficiency for both normal incident light and light incident at 38°.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, MEMS-AppliedSensors, Silicon Microtechnology, Nanoprobes
Authors: Petersen, S. D. (Intern), Davidsen, R. S. (Intern), Alcala, L. R. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Hansen, O. (Intern), Thomsen, E. V. (Intern)
Number of pages: 4
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 0.74
Scopus rating (2015): CiteScore 0.56
Scopus rating (2014): CiteScore 0.53
Scopus rating (2013): CiteScore 0.4
ISI indexed (2013): ISI indexed no
Scopus rating (2012): CiteScore 0.28
ISI indexed (2012): ISI indexed no
Scopus rating (2011): CiteScore 0.45
ISI indexed (2011): ISI indexed no
Web of Science (2010): Indexed yes
Original language: English
Tissue oximetry, Infrared detectors, Black detectors, Black silicon, Quantum efficiency, Diffuse reflected light
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procedia_engineering_eurosensors2014_petersen.pdf
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Publication: Research - peer-review › Conference article – Annual report year: 2014

Improving spectral resolution of SERS using moving Ag nanopillar substrate

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Brøgger, A. L. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2014

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Improving spectral resolution of SERS using moving AG nanopillar substrate

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Brøgger, A. L. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Alstrøm, T. S. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014
Event: Poster session presented at 24th International Conference on Raman Spectroscopy, Jena, Germany.
Main Research Area: Technical/natural sciences

Improving the robustness of Surface Enhanced Raman Spectroscopy based sensors by Bayesian Non-negative Matrix Factorization

Due to applications in areas such as diagnostics and environmental safety, detection of molecules at very low concentrations has attracted recent attention. A powerful tool for this is Surface Enhanced Raman Spectroscopy (SERS) where substrates form localized areas of electromagnetic “hot spots” where the signal-to-noise (SNR) ratio is greatly amplified. However, at low concentrations hot spots with target molecules bound are rare. Furthermore, traditional detection relies on having uncontaminated sensor readings which is unrealistic in a real world detection setting. In this paper, we propose a Bayesian Non-negative Matrix Factorization (NMF) approach to identify locations of target molecules. The proposed method is able to successfully analyze the spectra and extract the target spectrum. A visualization of the loadings of the basis vector is created and the results show a clear SNR enhancement. Compared to traditional data processing, the NMF approach enables a more reproducible and sensitive sensor.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Department of Micro- and Nanotechnology, Surface Engineering, Nanoprobes
Authors: Alstrøm, T. S. (Intern), Frøhling, K. B. (Intern), Larsen, J. (Intern), Schmidt, M. N. (Intern), Bache, M. (Intern), Schmidt, M. S. (Intern), Jakobsen, M. H. (Intern), Boisen, A. (Intern)
Number of pages: 6
Publication date: 2014

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Title of host publication: Proceedings of the 2014 IEEE International Workshop on Machine Learning for Signal Processing (MLSP)
Publisher: IEEE
Editors: Mboup, M., Adali, T., Moreau, É., Larsen, J.
ISBN (Print): 978-1-4799-3694-6
Main Research Area: Technical/natural sciences
DOIs: 10.1109/MLSP.2014.6958925
Source: FindIt
Source-ID: 272797661
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014
In-situ monitoring of potential enhanced DNA related processes using electrochemical quartz crystal microbalance with dissipation (EQCM-D)

The effect of applied potential pulses on DNA functionalization (thiolated single stranded DNA) and hybridization processes has been monitored in-situ on gold surfaces using electrochemical quartz crystal microbalance with dissipation (EQCM-D). The applied potentials were chosen with respect to the potential of zero charge ($E_{pzC}$) of the gold surfaces: a positive potential to attract the negatively charged DNA molecules and a negative potential to enhance the vertical alignment due to electrostatic repulsion. The obtained results clearly show that both DNA modification and hybridization are strongly enhanced by applying potential pulses. Based on the EQCM-D results, we present a model to explain the influence of the potential pulsing. Aside from the effect of applied potentials on DNA related processes, this work also demonstrates the versatility of the combination of electrochemistry and quartz crystal microbalance with dissipation in facilitating real-time in situ monitoring of such processes.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, Lund University
Authors: Quan, X. (Intern), Heiskanen, A. (Intern), Tenje, M. (Ekstern), Boisen, A. (Intern)
Number of pages: 4
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Volume: 48
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BFI (2017): BFI-level 1
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.53 SJR 1.626 SNIP 1.086
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.628 SNIP 1.176 CiteScore 4.77
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.832 SNIP 1.342 CiteScore 5.16
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.808 SNIP 1.422 CiteScore 4.97
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.316 SNIP 1.554 CiteScore 4.98
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.137 SNIP 1.604 CiteScore 5.14
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.179 SNIP 1.549
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 2.062 SNIP 1.546
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.257 SNIP 1.534
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Potential pulse assisted functionalization, Thiolated DNA functionalization, DNA hybridization, Vertically aligned DNA conformation, EQCM-D

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Integrated cantilever-based flow sensors with tunable sensitivity for in-line monitoring of flow fluctuations in microfluidic systems

For devices such as bio-/chemical sensors in microfluidic systems, flow fluctuations result in noise in the sensor output. Here, we demonstrate in-line monitoring of flow fluctuations with a cantilever-like sensor integrated in a microfluidic channel. The cantilevers are fabricated in different materials (SU-8 and SiN) and with different thicknesses. The integration of arrays of holes with different hole size and number of holes allows the modification of device sensitivity, theoretical detection limit and measurement range. For an average flow in the microliter range, the cantilever deflection is directly proportional to the flow rate fluctuations in the microfluidic channel. The SiN cantilevers show a detection limit below 1 nL/min and the thinnest SU-8 cantilevers a detection limit below 5 nL/min. Finally, the sensor is applied for in-line monitoring of flow fluctuations generated by external pumps connected to the microfluidic system. © 2013 by the authors; licensee MDPI, Basel, Switzerland.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Noeth, N. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern)
Pages: 229-244
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Main Research Area: Technical/natural sciences

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Journal: Sensors
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.23 SJR 0.584 SNIP 1.55
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.78 SJR 0.623 SNIP 1.614
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.647 SNIP 1.643 CiteScore 2.21
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.707 SNIP 1.796 CiteScore 2.4
In vitro characterization of microcontainers as an oral drug delivery system.

We here present in vitro studies showing the promise of microcontainers (fabricated in either SU-8 or Poly(lactic acid) (PLLA)) as an oral drug delivery system for the poorly watersoluble drug, furosemide.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Petersen, R. S. (Intern), Jacobsen, J. (Ekstern), Boisen, A. (Intern), Müllertz, A. (Ekstern)
Publication date: 2014
Event: Abstract from 41th Annual Meeting and Exposition of the Controlled Release Society, Chicago, United States.
Main Research Area: Technical/natural sciences
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Conference poster contribution: 41st Annual Meeting & Exposition of the Controlled Release Society, Chicago, USA, July 2014
In vitro characterization of microcontainers as an oral drug delivery system.

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State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Jacobsen, J. (Ekstern), Boisen, A. (Intern), Müllertz, A. (Ekstern)
Publication date: 2014
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Lab-on-Blu-ray: Low-cost analyte detection on a disk

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Magnetic Systems, Nanoprobes, Technical University of Denmark, Columbia University, Academia Sinica Taiwan
Authors: Donolato, M. (Intern), Antunes, P. S. M. (Intern), Burger, R. (Intern), Bosco, F. (Intern), Olsson, M. (Ekstern), Yang, J. (Ekstern), Chen, C. (Ekstern), Lin, Q. (Ekstern), Hwu, E. T. (Ekstern), Boisen, A. (Intern), Hansen, M. F. (Intern)
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Conference: 18th International Conference on Miniaturized Systems for Chemistry and Life Sciences, San Antonio, United States, 26/10/2014 - 26/10/2014
Electronic versions:
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Poster abstract
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Lab-on-Blu-ray: Low-cost analyte detection on a disk

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Magnetic Systems, Nanoprobes, Technical University of Denmark, Columbia University, Academia Sinica Taiwan
Authors: Donolato, M. (Intern), Antunes, P. S. M. (Intern), Burger, R. (Intern), Bosco, F. (Intern), Olsson, M. (Ekstern), Yang, J. (Ekstern), Chen, C. (Ekstern), Lin, Q. (Ekstern), Hwu, E. T. (Ekstern), Boisen, A. (Intern), Hansen, M. F. (Intern)
Number of pages: 2
Publication date: 2014

Host publication information
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Main Research Area: Technical/natural sciences
Electronic versions:
BluRayDiagnostics.pdf

Bibliographical note
For oral presentation
Source: PublicationPreSubmission
Lab-on-Blu-ray: Low-cost analyte detection on a disk
In this work, we present for the first time a centrifugal microfluidic system for the detection of analytes in blood using a low cost (< 10$) blu-ray pickup head for detection. The microfluidic operations are carried out on a disk, while the detection method is based on optical measurements of the rotation dynamics of functionalized magnetic nanobeads (MNBs) in an oscillating uniaxial magnetic field.

Loading of microcontainers for oral drug delivery
The pharmaceutical research is facing several obstacles in the development of drug products for the oral delivery. The main problem deals with the intrinsic chemical nature of the new drug candidates, which are often poorly soluble and barely absorbed in the gastro-intestinal tract. Furthermore, they are usually degraded before they are absorbed. These combined factors considerably reduce the bioavailability of many active ingredients. Several strategies have been developed to overcome these challenges. One of them are microfabricated drug delivery devices. Microreservoir based-systems are characterized by small dimensions (100-500 μm), mucoadhesive properties, asymmetric geometry and unidirectional drug release. In the fabrication of these microcontainers, an important task is the drug loading. The state of the art in this field is based on traditional methods used in microtechnology, which for this application in most cases are cost ineffective and unsuitable for large scale production.

The goal of this project was to develop novel techniques for loading of poorly soluble drugs and macromolecules in microcontainers. The research focused on simple and cost effective methods, suitable for a large group of drugs and with the perspective of mass production.

In a first instance, the suitability of inkjet printing as filling method was elucidated. Solutions containing furosemide and lipid based formulations of insulin were dispensed into microcontainers. Secondly, this technique was successfully utilized for the deposition of polymer matrices in microcontainers, which afterwards were loaded with the drug. For this purpose, inkjet printing of solutions of poly(vinylpyrrolidone) was developed. The polymer deposition was homogeneous and reproducible, which demonstrated that inkjet printing is a valuable technology to dispense controlled amounts of polymer into microcontainers. Subsequently, polymer filled-containers were loaded with drug. To achieve this, supercritical impregnation technology was successfully employed. Furthermore, in vitro drug dissolution studies showed that the loading yields and the release properties of the microdevices can be tuned. The effect of different impregnation process parameters on the loading yields was studied, and the drug-polymer interactions were characterized with various spectroscopic techniques. This technique allowed loading of large arrays of the microcontainers in one single operation with high accuracy and repeatability. Furthermore, the combination of inkjet printing and supercritical impregnation allows to minimize the waste of possibly expensive active ingredients.

A successful process for the definition of micropatterns of poly(vinylpyrrolidone) hydrogel by means of UV photolithography was developed. The fabrication of polymer patterns was optimized and loading with both small hydrophobic drugs and proteins was demonstrated. Finally, structural properties of hydrogels were elucidated by rheology and NMR with the perspective of controlling the drug release. The loading techniques developed in this thesis represent a novelty in the field of microfabricated drug delivery devices. The methods utilized in this research work are potentially integrated in the fabrication process of biopolymer microcontainers.
Low-Power Photothermal Probing of Single Plasmonic Nanostructures with Nanomechanical String Resonators

We demonstrate the direct photothermal probing and mapping of single plasmonic nanostructures via the temperature-induced detuning of nanomechanical string resonators. Single Au nanoslits and nanorods are illuminated with a partially polarized focused laser beam (\(\lambda = 633\) nm) with irradiances in the range of 0.26–38 \(\mu\)W/\(\mu\)m\(^2\). Photothermal heating maps with a resolution of \(\sim 375\) nm are obtained by scanning the laser over the nanostructures. Based on the string sensitivities, absorption efficiencies of 2.3 ± 0.3 and 1.1 ± 0.7 are extracted for a single nanoslit (53 nm × 1 \(\mu\)m) and nanorod (75 nm × 185 nm). Our results show that nanomechanical resonators are a unique and robust analysis tool for the low-power investigation of thermoplasmonic effects in plasmonic hot spots.
Micro and nano structures for biosensing and oral drug delivery

The optics and mechanics from a DVD player can be used to realize compact and sensitive sensor systems. By rotating a disc with integrated microfluidic channels it is possible to manipulate liquid samples such as blood – performing crucial operations like separation, valving and mixing. We integrate sensors such as cantilevers, nanoparticles and resonating strings with centrifugal microfluidics. The sensors are read out by a DVD pick-up head which can perform transmission/absorption measurements and which can detect nm deflections. Also, electrodes are integrated on a disc platform, facilitating electrochemical measurements. In cantilever-based sensing, micrometer sized cantilevers are functionalized on one side with probe molecules. As target analytes bind to the probe molecules the cantilever deflects due to changes in surface stress. This deflection is typically in the nm range and normally only a few cantilevers can be read-out simultaneously. Using a rotating disc system hundreds of cantilevers can be read-out in one second. We will demonstrate how this approach can be used for detection of biomarkers. Hollow cantilevers will be briefly discussed as a new way of performing IR spectroscopy on picoliter amount of sample. Vibrating micrometer sized strings can be used for efficient and sensitive mass detection and for chemical analysis of single nanoparticles. We will show examples from drug characterization and illustrate how the strings can be read-out using blu-ray optics. Finally, we will show how agglutination based assays can be handled and read-out using the disc platform – here targeting biomarkers for rapid diagnostics and prognostics. Micrometer sized containers can be used for oral drug delivery. The hypothesis is that oral drug delivery can be improved significantly by utilizing micrometer sized containers loaded with drug(s) and sealed by intelligent lids that open at specific locations in the body. The containers will, among other features, protect active pharmaceutical ingredients (APIs) during the passage through the stomach and facilitate adhesion to the wall of the intestine for controlled and unidirectional release, followed by absorption through the intestinal wall. We will show our recent findings and results.
Microcontainers, an innovative oral drug delivery system for poorly soluble drugs

General information
State: Published
Organisations: Nanoprobes, Department of Micro- and Nanotechnology, University of Copenhagen, Saarland University
Authors: Nielsen, L. H. (Intern), Nagstrup, J. (Intern), Keller, S. S. (Intern), Gordon, S. (Ekstern), Østergaard, J. (Ekstern), Rades, T. (Ekstern), Boisen, A. (Intern), Müllertz, A. (Ekstern)
Number of pages: 2
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Microcontainers as an oral drug delivery system.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Jacobsen, J. (Ekstern), Rades, T. (Ekstern), Boisen, A. (Intern), Müllertz, A. (Ekstern)
Publication date: 2014
Event: Abstract from Globalization of Pharmaceutics Education Network biennial meeting, Helsinki, Finland.
Main Research Area: Technical/natural sciences
Electronic versions:
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Microcontainers as an oral drug delivery system.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Rønholt, S. (Ekstern), Nielsen, L. H. (Intern), Davidsen, A. B. (Ekstern), Keller, S. S. (Intern), Müllertz, A. (Ekstern)
Publication date: 2014
Event: Poster session presented at 2014 AAPS Annual Meeting and Exposition, San Diego, CA, United States.
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Microcontainers as oral drug delivery systems for small molecules and proteins

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Rønholt, S. (Ekstern), Nielsen, L. H. (Intern), Davidsen, A. B. (Ekstern), Keller, S. S. (Intern), Müllertz, A. (Ekstern), Boisen, A. (Intern), Nielsen, H. M. (Ekstern)
Publication date: 2014
Event: Poster session presented at 2014 AAPS Annual Meeting and Exposition, San Diego, CA, United States.
Main Research Area: Technical/natural sciences
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Microcontainers for Unidirectional Release in the Upper Intestine

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Marizza, P. (Intern), Keller, S. S. (Intern), Nielsen, L. H. (Intern), Petersen, R. S. (Intern), Nagstrup, J. (Intern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Publication date: 2014

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Main Research Area: Technical/natural sciences
Conference: 13th European Symposium on Controlled Drug Delivery, Egmond aan Zee, Netherlands, 16/04/2014 - 16/04/2014
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Microfabricated containers for oral drug delivery

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Keller, S. S. (Intern), Nielsen, L. H. (Intern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 1
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Drug delivery, Microcontainers, Spray coating
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Microfabricated containers for pH-triggered drug release in the upper intestine

General information
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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Keller, S. S. (Intern), Nielsen, L. H. (Ekstern), Marizza, P. (Intern), Petersen, R. S. (Intern), Nagstrup, J. (Intern), Müllertz, A. (Ekstern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014

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Main Research Area: Technical/natural sciences
Conference: 10th International Conference and Workshop on Biological Barriers, Saarbrücken, Germany, 16/02/2014 - 16/02/2014
Micromechanical photothermal analyser of microfluidic samples.
The present invention relates to a micromechanical photothermal analyser of microfluidic samples comprising an oblong micro-channel extending longitudinally from a support element, the micro-channel is made from at least two materials with different thermal expansion coefficients, wherein the materials are arranged relatively to each other so that heating of the micro-channel results in a bending of the micro-channel, the first material has a first thermal expansion coefficient and is made from an light-specific transparent penetrable material so that when exposed to ultraviolet, visible, or infrared light, the specific light radiates into the channel through said light transparent material, the second material has a second thermal expansion coefficient being different from the first thermal expansion coefficient. The micromechanical photothermal analyser also comprises an irradiation source being adapted to controlled radiate ultraviolet, visible, or infrared light towards and through the transparent micro-channel, and a deflection detector being adapted to detect the amount of deflection of the micro-channel. The wavelength-deflection plot provides a spectrum of an analyte inside the oblong microchannel. To characterize the analyte the plot is compared with the standard database of spectroscopy.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Alberta
Authors: Khan Muhammad, F. (Ekstern), Schmid, S. (Intern), Boisen, A. (Intern), Kim, S. (Ekstern), Thundat, T. (Ekstern)
Publication date: 2014

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Main Research Area: Technical/natural sciences
Publication: Research › Patent – Annual report year: 2015

Micromechanical resonators as a tool for polymer characterization
The aim of this Ph.D. project was the evaluation of micromechanical resonators like cantilevers and strings as analytical tools for characterization of polymers. Spray coating was used as the technique to coat one side of the micromechanical resonators with polymer. Process optimization of different spray coating parameters was carried out with two polymer-solvent systems to obtain homogeneous films with uniform thickness and low roughness. Full factorial experimental design was employed to identify the most important parameter among the crucial parameters of spray coating such as nozzle-substrate distance, the temperature of the substrate and the speed of the spraying nozzle. Micromechanical string resonators were successfully developed as an analytical tool for sensitive and fast thermal characterization of polymers with only a few nanograms of sample. Both the glass transition (Tg) and sub-Tg transition of different polymers were detected and confirmed by conventional thermal polymer characterization techniques. An analytical model was derived to validate the resonance frequency response of the polymer coated microstrings during heating cycles. The resonance frequency change provided the quasi-static Tg of polymers while the quality factor change provided the frequency dependent shift of Tg to higher temperature. Microcantilevers were successfully employed as a platform for fast estimation of polymer degradation rate with minute amount of sample compared to conventional techniques. A detailed investigation of enzymatic degradation of poly (D, L-lactide) was done in buffered proteinase K solution. The influence of concentration of the enzyme solution, pre-hydration in buffer, surface morphology and adsorption time of enzymes on the rate of degradation was studied. The bulk degradation rate estimated from the experimental results and model simulation of multilayered cantilever structures matched well with values reported in literature. The basic understanding of the spray coating process and the newly developed approaches of microstrings and microcantilevers as analytical tools show promising potential for investigation of different polymers and pharmaceutical systems.

General information
State: Published
Micromechanical String Resonators: Analytical Tool for Thermal Characterization of Polymers

Resonant microstrings show promise as a new analytical tool for thermal characterization of polymers with only few nanograms of sample. The detection of the glass transition temperature (Tg) of an amorphous poly(d,l-lactide) (PDLLA) and a semicrystalline poly(l-lactide) (PLLA) is investigated. The polymers are spray coated on one side of the resonating microstrings. The resonance frequency and quality factor (Q) are measured simultaneously as a function of temperature. Change in the resonance frequency reflects a change in static tensile stress, which yields information about the Young’s modulus of the polymer, and a change in Q reflects the change in damping of the polymer-coated string. The frequency response of the microstring is validated with an analytical model. From the frequency independent tensile stress change, static Tg values of 40.6 and 57.6 °C were measured for PDLLA and PLLA, respectively. The frequency-dependent damping from Q indicates higher Tg values of 62.6 and 88.8 °C for PDLLA and PLLA, respectively, at ∼105 Hz. Resonant microstrings facilitate thermal analysis of nanogram polymer samples measuring the static and a dynamic glass transition temperature simultaneously.
Molecular diagnostics based on magnetic nanobead clustering dynamics monitored using a Blu-ray optomagnetic readout system

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Magnetic Systems, Nanoprobes, Uppsala University, Stockholm University, Academia Sinica Taiwan, CIC nanoGUNE Consolider
Number of pages: 1
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Main Research Area: Technical/natural sciences

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Alberta
Authors: Khan, F. (Intern), Kim, S. (Ekstern), Lee, D. (Ekstern), Schmid, S. (Intern), Boisen, A. (Intern), Thundat, T. (Ekstern)
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Nanomechanical identification of liquid reagents in a microfluidic channel
Integration of promising technologies that can enhance sensitivity, selectivity, and throughput into micro total analysis systems (μTAS) are important in making them useful in precise screening of reaction byproducts in analytical chemistry, cellular biology and pharmaceutical industries. But unfortunately so far a method to precisely determine molecular signatures of reagents is missing in μTAS. We have developed a technique whereby molecular signatures of 50 pL of liquid reagents confined within a bimetallic microchannel cantilever can be obtained. This is achieved using wavelength dependent mechanical bending of the cantilever under infrared (IR) radiation. This technique also allows simultaneous physical characterization of the liquid reagent using variations in resonance frequency. It is useful in lab-on-a-chip devices and has a myriad of applications in drug screening, bioreactor monitoring, and petrochemical analysis.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Alberta
Authors: Khan, F. (Intern), Kim, S. (Ekstern), Lee, D. (Ekstern), Schmid, S. (Intern), Boisen, A. (Intern), Thundat, T. (Ekstern)
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Main Research Area: Technical/natural sciences

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.98 SJR 2.162 SNIP 1.569
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.239 SNIP 1.721 CiteScore 5.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Nanomechanical IR Spectroscopy for the fast analysis of picogram samples of engineered nanomaterials

The proliferation of engineered nanomaterials (ENMs), e.g. in nanomedicine, demands for novel sensitive techniques allowing for the analysis of minute samples. We present nanoelectromechanical system-based IR spectroscopy (NEMS-IR) of picograms of polymeric micelles. The micelles are nebulized with electrospray directly from dispersion and then efficiently collected on the sensor, which detects the IR-wavelength-dependent photothermal sample heating. Only 10 nL of sample (~0.1 mg/mL) is required for the acquisition of an IR spectrum. Measurement, including sample preparation, takes only a few minutes, compared to 2 days for analysis by ATR-FT-IR. NEMS-IR constitutes a promising technique for the fast analysis of ENMs.

General information
State: Published
Optical, Nanomechanical and Electrochemical Sensing on a DVD Disc

Our vision is to create a platform where optical, nanomecanical and electrochemical sensors can be integrated and read-out using the mechanics and the optics from DVDs and Blu-Rays. Integrating sensors on a disc allows us to use centrifugal microfluidics which has been developed for more than 50 years and which has proven to be a simple and powerful way to manipulate liquid samples without the need of external pumps [1]. As an example, serum can be separated from a whole blood sample in a few minutes by simply spinning the disc and allowing the cellular components to sediment. Cantilever-like sensors have been integrated on a disc [2] and we now have a method of obtaining large amount of data – allowing us to do statistics on the measurements. Currently, we are studying the specific detection of biomarkers, such as suPAR [3]. Additionally, we try to implement optical microscopy on the spinning platform in order to study and count larger objects such as cells. In this way it will be possible to analyze a given sample for several parameters simultaneously. Electrodes can also be integrated on the spinning platform [4] and hereby it is possible to perform electrochemical measurements at the same time as having the benefit of the centrifugal liquid handling. As an example it is simple to measure in flow conditions and to perform continuous cyclic voltammograms in different concentrations of electrolytes using built-in valves. In conclusion, the merger of sensors and centrifugal microfluidics combined with sensitive and compact read-out possibilities from optical pick-up heads makes it possible to realize full sample pretreatment and read-out in a both fast and compact manner.

References:
2. F.G Bosco et al., High throughput label-free platform for statistical bio-molecular sensing, Lab on a Chip, 11(14) 2411-2416, 2011
3. M. Bache et al., Nanomechanical recognition of prognostic biomarker suPAR with DVD-ROM optical technology, Nanotechnology 24 (44), 444011, 2013
4. A.L. Brøgger et al., Centrifugal microfluidic platform with real-time electrochemical detection, 224th Electrochemical Society Meeting, 2013

Optimizing Signal-to-Noise Ratio of SERS Ag Capped Si Nanopillars

Our vision is to create a platform where optical, nanomechanical and electrochemical sensors can be integrated and read-out using the mechanics and the optics from DVDs and Blu-Rays. Integrating sensors on a disc allows us to use centrifugal microfluidics which has been developed for more than 50 years and which has proven to be a simple and powerful way to manipulate liquid samples without the need of external pumps [1]. As an example, serum can be separated from a whole blood sample in a few minutes by simply spinning the disc and allowing the cellular components to sediment. Cantilever-like sensors have been integrated on a disc [2] and we now have a method of obtaining large amount of data – allowing us to do statistics on the measurements. Currently, we are studying the specific detection of biomarkers, such as suPAR [3]. Additionally, we try to implement optical microscopy on the spinning platform in order to study and count larger objects such as cells. In this way it will be possible to analyze a given sample for several parameters simultaneously. Electrodes can also be integrated on the spinning platform [4] and hereby it is possible to perform electrochemical measurements at the same time as having the benefit of the centrifugal liquid handling. As an example it is simple to measure in flow conditions and to perform continuous cyclic voltammograms in different concentrations of electrolytes using built-in valves. In conclusion, the merger of sensors and centrifugal microfluidics combined with sensitive and compact read-out possibilities from optical pick-up heads makes it possible to realize full sample pretreatment and read-out in a both fast and compact manner.

References:
2. F.G Bosco et al., High throughput label-free platform for statistical bio-molecular sensing, Lab on a Chip, 11(14) 2411-2416, 2011
3. M. Bache et al., Nanomechanical recognition of prognostic biomarker suPAR with DVD-ROM optical technology, Nanotechnology 24 (44), 444011, 2013
4. A.L. Brøgger et al., Centrifugal microfluidic platform with real-time electrochemical detection, 224th Electrochemical Society Meeting, 2013
Photothermal probing of plasmonic hotspots with nanomechanical resonator

Plasmonic nanostructures (hotspots) are key components e.g. in plasmon-enhanced spectroscopy, plasmonic solar cells, or as nano heat sources. The characterization of single hotspots is still challenging due to a lack of experimental tools. We present the direct photothermal probing and mapping of single plasmonic nanoslits via the thermally induced detuning of nanomechanical string resonators. A maximum relative frequency detuning of 0.5 % was measured for a single plasmonic nanoslit for a perpendicularly polarized laser with a power of 1350 nW. Finally, we show the photothermal scan over a nanoslit array.

Photothermal resonance

The present invention relates to a method for detecting photo-thermal absorbance of a material utilising a mechanically temperature sensitive resonator (20) and a sample being arrange in thermal communication with the temperature sensitive resonator. The present invention further relates to an apparatus for detecting photo-thermal absorbance of a sample.

Photothermal probing of plasmonic hotspots with nanomechanical resonator

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Photothermal resonance

The present invention relates to a method for detecting photo-thermal absorbance of a material utilising a mechanically temperature sensitive resonator (20) and a sample being arrange in thermal communication with the temperature sensitive resonator. The present invention further relates to an apparatus for detecting photo-thermal absorbance of a sample.
Physical characterization of photocrosslinked poly(vinyl pyrrolidone) (PVP) hydrogels for drug delivery

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Department of Chemical and Biochemical Engineering, The Danish Polymer Centre, University of Trieste, University of Copenhagen
Number of pages: 2
Publication date: 2014

Host publication information
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Main Research Area: Technical/natural sciences
Electronic versions:
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Bibliographical note
8th Symposium of The Pharmaceutical Solid State Research Cluster (PSSRC), Ljubljana, Slovenia, September 16-18 2014,
Source: PublicationPreSubmission
Source-ID: 103224915
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Polymer drug matrix loading in micro-containers using hot punching

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Petersen, R. S. (Intern), Nagstrup, J. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern)
Number of pages: 1
Publication date: 2014

Host publication information
Title of host publication: Proceedings of the 40th International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Hot embossing, Microcontainers, Oral drug delivery, SU-8, Photolithography
Electronic versions:
Petersen_MNE2014.pdf

Bibliographical note
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Source: PublicationPreSubmission
Source-ID: 103224970
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Polymer-filled microcontainers for oral delivery loaded using supercritical impregnation
In the last years a large variety of drug delivery systems have been developed to improve bioavailability of therapeutics in oral administration. An increasing interest has arisen in reservoir-based microdevices designed for active ingredients like water insoluble compounds and fragile biomolecules. Such microdevices are designed to protect the active ingredient against degradation and deactivation, and to allow cytoadhesion and unidirectional drug release. There are few works which optimize the drug loading step and often therapeutics are dosed in the microdevices through laborious and time consuming procedures. This work proposes an effective loading technique for a poorly soluble model drug in microcontainers, by combining inkjet printing and supercritical fluid impregnation. Well defined quantities of poly(vinyl pyrrolidone) (PVP) solutions are dispensed into microcontainers by inkjet printing with a quasi-no-waste performance. Then ketoprofen is impregnated in the polymer matrix by using supercritical carbon dioxide (scCO₂) as loading medium. The amount of polymer is controlled by the volume and the number of droplets of dispersed polymer and drug loading is tuned by varying the impregnation parameters. Compared to solid dispersions of the same drug and polymer, scCO₂-impregnated microcontainers exhibit a more reproducible drug loading and a faster dissolution rate of the active compound which allows drug release to be modulated. The combination of these loading techniques potentially allows the high throughput fabrication of microdevices for oral drug delivery with a safe and solvent-free solution. © 2013 Published by Elsevier B.V.
Quadratic measurement and conditional state preparation in an optomechanical system

We experimentally demonstrate, for the first time, quadratic measurement of mechanical motion in an optomechanical system. We use this nonlinear measurement to conditionally prepare classical non-Gaussian states of motion of a micromechanical oscillator.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Queensland
Authors: A. Brawley, G. (Ekstern), Vanner, M. A. (Ekstern), Bowen, W. P. (Ekstern), Schmid, S. (Intern), Boisen, A. (Intern)
Number of pages: 3
Publication date: 2014
Sensitive Blu-ray detection of clustered rolling circle products for molecular diagnostics

In this paper we present a method for low cost and rapid sensing of nucleic acids (NA) for infectious diagnostics, where isothermal rolling circle amplification (RCA) products, specifically generated by the presence of the human pathogen Pseudomonas aeruginosa (PA), are bound to magnetic nanoparticles (MNP). Samples are injected into a microfluidic disc chip and analyzed on a novel magneto-optical platform. The sensing approach is based on the clustering pattern of MNP in a magnetic field and measures the effect of cluster formation on transmitted light using a standard Blu-Ray pickup head. The concentration of DNA target is correlated with an increase of clustered particles.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Magnetic Systems, Nanoprobes, Silicon Microtechnology, Stockholm University
Pages: 24-26
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Title of host publication: Proceedings of the 18th International Conference on Miniaturized Systems for Chemistry and Life Sciences
Publisher: Chemical and Biological Microsystems Society
ISBN (Print): 978-0-9798064-7-6
Main Research Area: Technical/natural sciences
Conference: 18th International Conference on Miniaturized Systems for Chemistry and Life Sciences, San Antonio, United States, 26/10/2014 - 26/10/2014
Molecular diagnostics, Magnetic biosensing, Optical scattering, DNA amplifications, Lab-on-a-chip
Source: PublicationPreSubmission
Source-ID: 102496141
Publication: Research - peer-review › Article in proceedings – Annual report year: 2014

Single-layer graphene on silicon nitride micromembrane resonators
Due to their low mass, high quality factor, and good optical properties, silicon nitride (SiN) micromembrane resonators are widely used in force and mass sensing applications, particularly in optomechanics. The metallization of such membranes would enable an electronic integration with the prospect for exciting new devices, such as optoelectromechanical transducers. Here, we add a single-layer graphene on SiN micromembranes and compare electromechanical coupling and mechanical properties to bare dielectric membranes and to membranes metallized with an aluminium layer. The electrostatic coupling of graphene covered membranes is found to be equal to a perfectly conductive membrane, without significantly adding mass, decreasing the superior mechanical quality factor or affecting the optical properties of pure SiN micromembranes. The concept of graphene-SiN resonators allows a broad range of new experiments both in applied physics and fundamental basic research, e.g., for the mechanical, electrical, or optical characterization of graphene.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, National Institute of Standards and Technology, Harvard University, Technical University of Denmark, Massachusetts Institute of Technology, University of Copenhagen
Authors: Schmid, S. (Intern), Bagci, T. (Forskerdatabase), Zeuthen, E. (Forskerdatabase), Taylor, J. M. (Ekstern), Herring, P. K. (Ekstern), Cassidy, M. C. (Ekstern), Marcus, C. M. (Ekstern), Villanueva Torrijo, L. G. (Intern), Armato, B. (Ekstern), Boisen, A. (Intern), Shin, Y. C. (Ekstern), Kong, J. (Ekstern), Sørensen, A. S. (Ekstern), Usami, K. (Ekstern), Polzik, E. S. (Ekstern)
Pages: 054513
Publication date: 2014
Main Research Area: Technical/natural sciences
Synthesis and characterization of covalent diphenylalanine nanotube-folic acid conjugates

Herein, we describe the synthesis and characterization of a covalent nanoscale assembly formed between diphenylalanine micro/nanotubes (PNT) and folic acid (FA). The conjugate was obtained via chemical functionalization through coupling of amine groups of PNTs and carboxylic groups of FA. The surface analysis of PNT-FA indicated the presence of FA aggregates on the surface of PNTs. The covalent interaction between FA and self-assembled PNTs was further investigated using fluorescence microscopy, Raman and surface-enhanced Raman scattering (SERS) spectroscopies. The SERS experiments were performed on a large area silver-capped (diameter of 62 nm) silicon nanopillars with an approximate height of 400 nm and a width of 200 nm. The results showed that the PNT-FA synthesis procedure preserves the molecular structure of FA. The PNT-FA conjugate presented in this study is a promising candidate for applications in the detection and diagnosis of cancer or tropical diseases such as leishmaniasis and as a carrier nanosystem delivering drugs to malignant tumors that overexpress folate receptors.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Center for Electron Nanoscopy, Nano Bio Integrated Systems, Polymer Microsystems for Medical Diagnostics
Authors: León, J. J. C. (Intern), Rindzevicius, T. (Intern), Wu, K. (Intern), Schmidt, M. S. (Intern), Janik, K. A. (Intern), Boisen, A. (Intern), Svendsen, W. E. (Intern), Rozlosnik, N. (Intern), Castillo, J. (Intern)
Number of pages: 8
Publication date: 2014
Main Research Area: Technical/natural sciences

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Volume: 16
Issue number: 7
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.93 SJR 0.528 SNIP 0.603
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.496 SNIP 0.557
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.568 SNIP 0.696 CiteScore 1.97
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.672 SNIP 0.861 CiteScore 2.17
Tailoring the structure and the properties of pyrolysed carbon electrodes

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Self-Organized Nanoporous Materials, Bioanalytics
Authors: Amato, L. (Intern), Schulte, L. (Intern), Heiskanen, A. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern), Ndoni, S. (Intern), Emnéus, J. (Intern)
Number of pages: 1
Publication date: 2014
Main Research Area: Technical/natural sciences
Electronic versions: posterESEAC2014_for_Tine.pdf
Source: PublicationPreSubmission
Source-ID: 99690332
Publication: Research - peer-review → Journal article – Annual report year: 2014

A microfluidic surface enhanced Raman spectroscopic biosensor using aptamer functionalized nanopillars
This paper presents a microchip incorporating an aptamer-functionalized nanopillar substrate, enabling the specific detection of low-abundance biomolecules using surface enhanced Raman spectroscopy (SERS). In a temperature controlled microchamber, aptamers immobilized on the nanostructure surface specifically recognize target molecules.
Raman-tagged biomolecules trapped within a cluster of leaning nanopillars report greatly enhanced Raman signals due to the coupling effect of localized surface plasmons. It was demonstrated that integrated intensities of spatially collected Raman responses are linearly proportional to analyte concentrations in the low picomolar regime (10/50/100/200 pM), showing the capability of our device for sensitive and quantitative detection of analyte molecules.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Columbia University
Authors: Yang, J. (Ekstern), Palla, M. (Ekstern), Bosco, F. G. (Intern), Schmidt, M. S. (Intern), Rindzevicius, T. (Intern), Boisen, A. (Intern), Ju, J. (Ekstern), Lin, Q. (Ekstern)
Pages: 1799-1802
Publication date: 2013

Host publication information
Title of host publication: Proceedings of the The 17th International Conference on Solid-State Sensors, Actuators and Microsystems
Publisher: IEEE
ISBN (Print): 9781467359832
Main Research Area: Technical/natural sciences
Conference: 17th International Conference on Solid-State Sensors, Actuators and Microsystems, Barcelona, Spain, 16/06/2013 - 16/06/2013
bioMEMS, biosensors, microfluidics, microsensors, molecular biophysics, nanobiotechnology, nanosensors, optical sensors, Raman spectroscopy, surface enhanced Raman scattering, surface plasmons, Computing and Processing, Engineering Profession, General Topics for Engineers, Geoscience, Nuclear Engineering
DOIs: 10.1109/Transducers.2013.6627138
Source: dtu
Source-ID: n::oai:DTIC-ART:iel/409255442::36273
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

A slow cooling rate of indomethacin melt spatially confined in microcontainers increases the physical stability of the amorphous drug without influencing its biorelevant dissolution behaviour
Amorphous indomethacin was prepared by melting the γ-form of indomethacin, spatially confined within microcontainers (inner diameter of 223 μm), followed by cooling of the melt at a rate of 14, 23 or 36 K/min. The physical stability of the amorphous indomethacin within microcontainers was investigated using Raman microscopy. Furthermore, the dissolution behaviour of confined amorphous indomethacin was evaluated in biorelevant intestinal media at pH 6.5. After 30 days of storage, 10.3±1.2 % of the amorphous indomethacin cooled at 14 K/min and confined within microcontainers was found to be crystalline. When the melt of indomethacin was cooled at 23 or 36 K/min, 20.7±1.5 and 31.0±2.6% of the indomethacin were found to be crystalline after storage for 30 days. Scanning electron microscopy showed a smooth surface of amorphous indomethacin within the microcontainers when cooling the melt at 14 K/min, whereas cracks and an uneven surface were observed when cooling at rates of 23 and 36 K/min. The uneven surface is hypothesised to be the main reason for the lower physical stability, as the cracks could act as nucleation sites for crystal growth. The rate of cooling was not seen to have any effect on the dissolution of amorphous indomethacin from the microcontainers.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern), Müllertz, A. (Ekstern), Rades, T. (Ekstern)
Pages: 268-274
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Drug Delivery and Translational Research
Volume: 4
Issue number: 3
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Scopus rating (2017): SNIP 0.832 SJR 0.944 CiteScore 3.1
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Scopus rating (2016): SJR 0.976 SNIP 0.71 CiteScore 2.76
Biodegradable microcontainers as an oral drug delivery system for poorly soluble drugs.

PURPOSE: To fabricate microcontainers in biodegradable poly(lactic acid) (PLLA) polymer films using hot embossing, and investigate the application of fabricated microcontainers as an oral drug delivery system for a poorly soluble drug.

METHODS: For fabrication of the PLLA microcontainers, a film of PLLA was produced by spin coating. The film was heated above the polymer glass transition temperature (Tg), and a stamp was forced into the film. Following cooling of the film the stamp was removed, exposing the formed microcontainers. Microcontainers were filled with amorphous furosemide sodium salt (produced by spray drying) using a simplified version of a screen printing technique. An enteric-resistant lid of Eudragit L-100 was subsequently spray coated onto the cavity of the microcontainers. Release of amorphous furosemide salt from the coated microcontainers was investigated using a μ-Diss profiler. Release experiments were carried out in biorelevant gastric medium (pH 1.6) for 2 h, followed by 3 h in a biorelevant intestinal medium (pH 6.5). Moreover, biorelevant flow through dissolution was also carried out in conjunction with UV imaging to visualize the release of amorphous furosemide salt from the coated microcontainers.

RESULTS: Fabricated PLLA microcontainers had an inner diameter of 220 μm and a height of 100 μm. The screen printing technique was shown to be an optimized set-up to fill the microcontainers with drug. From the release experiments it was observed that the Eudragit layer prevented drug release in biorelevant gastric medium, while an immediate release of the amorphous furosemide salt was seen in the biorelevant intestinal medium. The same trend was observed in the UV imaging experiments –negligible drug release was observed in gastric medium, whereas following re-equilibration of the dissolution cell with the intestinal medium, a release of furosemide was observed after 1 min with an increased release after 5 min of dissolution.

CONCLUSIONS: Biodegradable microcontainers were successfully fabricated and loaded with drug. Coating with Eudragit L-100 proved to be useful for protecting drug release from microcontainers in gastric medium, and facilitated an immediate release in the intestinal medium. The fabricated microcontainers therefore show considerable future potential as oral drug delivery systems.
the nanograss substrates is presented with discussion of their morphology, diameter distribution, and catalyst thickness influence.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Molecular Windows, Nanointegration, Imperial College London
Authors: Wierzbicki, R. (Intern), Schmidt, M. S. (Intern), Boisen, A. (Intern), Engstrøm, D. (Ekstern), Melhave, K. (Intern), Bøggild, P. (Intern)
Pages: 110-113
Publication date: 2013
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Microelectronic Engineering
Volume: 104
ISSN (Print): 0167-9317
Ratings:
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- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 1.67 SJR 0.604 SNIP 0.937
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 0.934 SNIP 1.093
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 0.834 SNIP 1.098
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 1.027 SNIP 1.06
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 1.045 SNIP 1.138
- Web of Science (2007): Indexed yes
- Scopus rating (2006): SJR 0.966 SNIP 1.093
- Web of Science (2006): Indexed yes
Centrifugal microfluidic platform with real-time electrochemical detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems
Authors: Brøgger, A. L. (Intern), Andreasen, S. Z. (Intern), Bosco, F. (Intern), Andersen, K. B. (Intern), Kwasny, D. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 202768
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Electrochemical Society. Meeting Abstracts (Online)
Volume: MA2013-02
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Source: dtu
Source-ID: u::9890
Publication: Research - peer-review › Conference abstract in journal – Annual report year: 2013

Compact MEMS/NEMS characterization platform using a DVD optical pick-up unit with optical imaging function

In this work, we present a compact, simple and efficient platform for Micro-electromechanical systems (MEMS)/Nano-electromechanical systems (NEMS) characterization. In this platform, a CCD camera is combined with a DVD optical pick-up unit (OPU). The CCD camera captures optical image of MEMS/NEMS samples and detection laser spot, which makes laser alignment on measurement target easier. The DVD OPU is used for detection of resonant frequency measurements of the samples. Working bandwidth and noise level of the OPU are 100 MHz and 1.3 pmHz−2, respectively. Furthermore, the OPU has a laser spot size of 560 μm (full width at half maximum, FWHM), which is capable of measuring cantilevers and strings with sub-micron width. A homemade nano-scale resolution X-Y-Z positioner with working distances of 12, 12, 5 mm is responsible for laser-sample alignment. Both thermal and excited resonant frequencies of MEMS/NEMS cantilevers and strings are characterized.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Pages: 485-488
Publication date: 2013

Host publication information
Computational and experimental studies of the interaction between single-walled carbon nanotubes and folic acid

This work involved the preparation of a conjugate between single-walled carbon nanotubes and folic acid that was obtained without covalent chemical functionalization using a simple “one pot” synthesis method. Subsequently, the conjugate was investigated by a computational hybrid method: our own Nlayered Integrated Molecular Orbital and Molecular Mechanics (B3LYP(6–31G(d):UFF)). The results confirmed that the interaction occurred via hydrogen bonding between protons of the glutamic moiety from folic acid and π electrons from the carbon nanotubes. The single-walled carbon nanotube-folic acid conjugate presented herein is believed to lead the way to new potential applications as carbon nanotube-based drug delivery systems.
Conducting pyrolysed carbon scaffold for tissue engineering

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, BioLabChip, Nanoprobes, Bioanalytics, Fluidic Array Systems and Technology
Authors: Mohanty, S. (Intern), Amato, L. (Intern), Heiskanen, A. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern), Dufva, M. (Intern), Emnéus, J. (Intern)
Publication date: 2013

Host publication information
Title of host publication: Proceedings of the 39th International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Electronic versions:
prod11389012046900.Conducting_pyrolysed_carbon_scaffold_for_tissue_engineering.pdf
Source: dtu
Source-ID: u::10308
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2013

Detection of Airborne Nanoparticles with Mechanical Systems

General information
State: Published
Development of Electrochemical Cantilever Sensors for DNA Applications

In this work, we develop a generic DNA based sensing platform used for characterizing surface functionalization and detecting DNA hybridization. Silicon nitride cantilever sensors are fabricated with an integrated three-electrode system and integrated in a microfluidic chip. Cantilevers with gold electrodes are functionalized with thiol-modified single stranded DNA (ssDNA) probes to detect target DNA. During functionalization and hybridization, information related to nanomechanical changes on the surface are obtained by optical measurements of changes in cantilever deflection. Simultaneously, the process is monitored electrochemically. The results clearly indicate that the electrochemical cantilever sensor is very sensitive for detecting DNA hybridization at the cantilever surface.

General information

State: Published
Organisations: Nanoprobes, Department of Micro- and Nanotechnology, Bioanalytics, BioLabChip, Lund University, McGill University
Authors: Quan, X. (Intern), Heiskanen, A. (Intern), Yi, S. (Intern), Labuda, A. (Ekstern), Wolff, A. (Intern), Dulanto, J. (Ekstern), Grutter, P. (Ekstern), Tenje, M. (Ekstern), Boisen, A. (Intern)
Pages: 2077-81
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information

Journal: E C S Transactions
Volume: 50
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Scopus rating (2017): CiteScore 0.44 SJR 0.225 SNIP 0.252
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.4 SJR 0.228 SNIP 0.253
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.211 SNIP 0.244 CiteScore 0.36
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.212 SNIP 0.234 CiteScore 0.36
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.192 SNIP 0.231 CiteScore 0.27
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.241 SNIP 0.26 CiteScore 0.29
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.261 SNIP 0.28 CiteScore 0.36
DNA hybridization sensing for cytogenetic analysis
Cytogenetic analysis focuses on studying the cell structure, mainly in respect to chromosome content and their structure. Chromosome abnormalities, such as translocations may cause various genetic disorders, but are also associated with haematological malignancies. Chromosome translocations are rearrangements between two chromosome arms that results in two derivative chromosomes having a mixed DNA sequence. The current detection method is a Fluorescent In situ Hybridization, which requires a use of expensive, fluorescently labeled probes that target the DNA sequences of two chromosomes involved in the translocation (Kwasny et al., 2012).

We have developed a new double hybridization assay that allows for sorting of the DNA chromosomal fragments into separate compartment, moreover allowing for detection of the translocation. To detect the translocation it is necessary to determine that the two DNA sequences forming a derivative chromosome are connected, which is achieved by two subsequent hybridization steps. The first example of the translocation detection was presented on lab-on-a-disc using fluorescently labeled DNA fragments, representing the derivative chromosome (Bregger et al., 2012). To allow for cheaper detection a label-free approach has been investigated using electrochemical impedance spectroscopy as a sensing method. We present here our recent results in regards to DNA sensing on metallic and conductive polymer electrodes for translocation detection. Our sensors are inexpensive and can be successfully applied in cytogenetic analysis as a replacement of standard techniques.

Drug-polymer filled micro-containers for oral delivery loaded using supercritical CO2 aided-impregnation
In this work we present an effective loading technique of micro-containers for oral drug delivery of a poorly water soluble drug in a solid dispersion with polymer. By combining inkjet printing and supercritical CO2 impregnation we load ketoprofen in a solid dispersion with poly(vinylpyrrolidone) (PVP) into cylindrical micro-containers providing unidirectional release. Both the printing and the impregnation step can be tuned in order to control drug loading with accuracy in the range of micro-grams.
Enhanced Light–Matter Interactions in Graphene-Covered Gold Nanovoid Arrays

The combination of graphene with noble-metal nanostructures is currently being explored for strong light–graphene interactions enhanced by plasmons. We introduce a novel hybrid graphene–metal system for studying light–matter interactions with gold-void nanostructures exhibiting resonances in the visible range. Enhanced coupling of graphene to the plasmon modes of the nanovoid arrays results in significant frequency shifts of the underlying plasmon resonances, enabling 30% enhanced absolute light absorption by adding a monolayer graphene and up to 700-fold enhancement of the Raman response of the graphene. These new perspectives enable us to verify the presence of graphene on gold-void arrays, and the enhancement even allows us to accurately quantify the number of layers. Experimental observations are further supported by numerical simulations and perturbation-theory analysis. The graphene gold-void platform is beneficial for sensing of molecules and placing Rhodamine 6G (R6G) dye molecules on top of the graphene; we observe a strong enhancement of the R6G Raman fingerprints. These results pave the way toward advanced substrates for surface-enhanced Raman scattering (SERS) with potential for unambiguous single-molecule detection on the atomically well-defined layer of graphene.
Ferromagnetic shadow mask for spray coating of polymer patterns

We present the fabrication of a wafer-scale shadow mask with arrays of circular holes with diameters of 150–400 μm. Standard UV photolithography is used to define 700 μm thick SU-8 structures followed by electroplating of nickel and etching of the template. The ferromagnetic properties of the shadow mask allow magnetic clamping to the substrate and spray coating of well defined polymer patterns.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Keller, S. S. (Intern), Bosco, F. (Intern), Boisen, A. (Intern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Graphene-on-dielectric micromembrane for optoelectromechanical hybrid devices

Due to their exceptional mechanical and optical properties, dielectric silicon nitride (SiN) micromembranes have become the centerpiece of many optomechanical experiments. Efficient capacitive coupling of the membrane to an electrical system would facilitate exciting hybrid optoelectromechanical devices. However, capacitive coupling of such SiN membranes is rather weak. Here we add a single layer of graphene on SiN micromembranes (SiN-G) and compare the
electromechanical coupling and mechanical properties to bare SiN membranes and to membranes coated with an aluminium layer (SiN-Al). The electrostatic force to external coplanar electrodes of SiN-G membranes is found to be equal to that of the SiN-Al membranes and corresponds to the theoretical value calculated for a perfectly conductive membrane coating. Our results show that a single layer of graphene substantially enhances the electromechanical capacitive coupling of a SiN membrane without significantly adding mass, decreasing the mechanical quality factor or affecting the optical properties.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, National Institute of Standards and Technology, Harvard University, Technical University of Denmark, Massachusetts Institute of Technology, University of Copenhagen
Authors: Schmid, S. (Intern), Bagci, T. (Forskerdatabase), Zeuthen, E. (Forskerdatabase), Taylor, J. M. (Ekstern), Herring, P. K. (Ekstern), Cassidy, M. C. (Ekstern), Marcus, C. M. (Forskerdatabase), Villanueva Torrijo, L. G. (Intern), Amato, B. (Ekstern), Boisen, A. (Intern), Shin, Y. C. (Ekstern), Kong, J. (Ekstern), Sørensen, A. S. (Forskerdatabase), Usami, K. (Forskerdatabase), Polzik, E. S. (Forskerdatabase)
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Main Research Area: Technical/natural sciences

High-performance spinning device for DVD-based micromechanical signal transduction
Here we report a high-throughput spinning device for nanometric scale measurements of microstructures with instrumentation details and experimental results. The readout technology implemented in the designed disc-like device is based on a DVD data storage optical pick-up unit (OPU). With a spinning mechanism, this device can simultaneously measure surface topography, mechanical deflections and resonance frequencies of several microfabricated beams at a high speed. In biochemical sensing applications, the OPU can measure bending changes of functionalized microcantilevers, providing a statistically robust and label-free bio-detection analysis of multiple compounds. The signal-to-noise ratio (S/N) is demonstrated from statistical measurements as 1.2 with arginine detection at 750 nM concentration. Practically, the OPU can measure up to 480 individual cantilever sensors per second with nanometer resolution. The optomechanical optimization of the device design and settings for biochemical detection are described.

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Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Academia Sinica Taiwan, National Taiwan University
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Hot punching of individual biopolymer microcontainers for oral drug delivery
Imaging interferometry to measure surface rotation field

This paper describes a polarized-light imaging interferometer to measure the rotation field of reflecting surfaces. This setup is based on a homemade prism featuring a birefringence gradient. The arrangement is presented before focusing on the homemade prism and its manufacturing process. The dependence of the measured optical phase on the rotation of the surface is derived, thus highlighting the key parameters driving the sensitivity. The system’s capabilities are illustrated by imaging the rotation field at the surface of a tip-loaded polymer specimen.
Inkjet printing as a technique for filling of micro-wells with biocompatible polymers

We present an innovative technique to dispense precise amounts of polymer solutions into large arrays of microscopic wells. An inkjet printer (NP 2.1 GeSim, Germany) is used to fill micro-wells with poly (vinyl pyrrolidone) (PVP K10). The micro-wells are fabricated with cavity diameters of 300 μm down to 50 μm with SU-8 with two steps of negative photolithography. Inkjet printing is shown to be a suitable technique to dispense defined volumes of solution (down to 0.3 nL) in a highly reproducible way. The filling with polymer can be controlled varying the concentration of the solution and the number of dispensed droplets. Solutions of up to 20 wt.% PVP in water are successfully spotted.

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Authors: Marizza, P. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern)
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Loading of micro-containers for oral delivery with supercritical CO$_2$ aided impregnation

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Authors: Marizza, P. (Intern), Keller, S. S. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern), Kikic, I. (Ekstern), Moneghini, M. (Ekstern), Boisen, A. (Intern)
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Micro fabrication of biodegradable polymer drug delivery devices
The pharmaceutical industry is presently facing several obstacles in developing oral drug delivery systems. This is primarily due to the nature of the discovered drug candidates. The discovered drugs often have poor solubility and low permeability across the gastrointestinal epithelium. Furthermore, they are often degraded before they can be absorbed. The result is low bioavailability of the drugs. To overcome these challenges, better drug delivery systems need to be developed. Recently, micro systems have emerged as promising candidates to solve the challenges of poor solubility, low permeability and degradation. These systems are for the majority based on traditional materials used in micro technology, such as SU-8, silicon, poly(methyl methacrylate). The next step in developing these new drug delivery systems is to replace classical micro fabrication materials with biodegradable polymers. In order to successfully do this, methods for fabricating micro structures in biodegradable polymers need to be developed.

The goal of this project has been to develop methods for micro fabrication in biodegradable polymers and to use these methods to produce micro systems for oral drug delivery. This has successfully been achieved by fabrication of micro container systems made of poly(L-lactic acid) and polycaprolactone.

To achieve this, polymer solutions have been developed using the theory of Hansen's solubility parameters. The solutions are used to fabricate polymer films by spin coating, which are used in the fabrication of micro devices for oral drug delivery. Films consisting of both polymer and pharmaceuticals have also been developed by spin coating. A deep reactive ion etch producing sloped sidewalls for stamp production has been developed. The sloped sidewalls ensure a successful separation of stamp and film after patterning. Large scale methods for filling of micro reservoirs based on embossing, screen printing and solvent casting have been developed.

In vitro drug release experiments on both type of micro devices have been performed. The experiments show that most of the drug is released from the developed devices. Additionally, it has been shown that it is possible to control the release of drug by adding polymeric coatings.

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Authors: Nagstrup, J. (Intern), Boisen, A. (Intern), Keller, S. S. (Intern)
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Micromechanical PDGF recognition via lab-on-a-disc aptasensor arrays
A plug-and-play CD-like platform is used to perform a statistical detection of platelet derived growth factor (PDGF) proteins through aptamer-based surface functionalization of multiple microcantilever arrays. When PDGF proteins bind to aptamer coatings, the cantilevers deflect. The deflection response is monitored by optical read-out units from a commercial DVD-
ROM device. We report on the use of an improved sensing platform which facilitates measurements under continuous liquid flow and with temperature control. Also, the mechanical wobbling of the DVD-ROM platform has been minimized and the scanning system has been optimized in order to detect cantilever deflections in liquid with nanometer scale resolution. The capability of the sensing platform is demonstrated by detection of clinically relevant concentrations of PDGF proteins. We present statistical measurements on 100 microcantilevers at different concentrations of PDGF, ranging from 10nM to 400nM. Hereby it is possible to reliably characterize the averaged mechanical response of cantilevers as a function of protein concentration.
Micro string resonators as temperature sensors

The resonance frequency of strings is highly sensitive to temperature. In this work we have investigated the applicability of micro string resonators as temperature sensors. The resonance frequency of strings is a function of the tensile stress which is coupled to temperature by the thermal expansion of the string and the frame clamping it. The sensitivity improves when the length and pre-stress are reduced and the difference in thermal expansion, Young's modulus and resonant mode are increased. At low tensile stress, the sensitivity becomes highly dependent on temperature. The investigation was done with silicon rich silicon nitride (SiNx), nickel (Ni) and aluminum (Al) micro strings. Aluminum strings show a relative sensitivity of up to 15±1 %/°C, which is more than 100 times higher than values reported by other groups for similar devices. Sub-millisecond time constants can be achieved due to the low thermal mass of the strings. A temperature resolution of 2.5×10^-4 °C has been achieved with silicon nitride strings. The theoretical limit for the temperature resolution of 8×10^-8 °C has not been reached yet and requires further improvement of the sensor.

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Authors: Larsen, T. (Ekstern), Schmid, S. (Intern), Boisen, A. (Intern)
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Scopus rating (2014): SJR 0.171 SNIP 0.202 CiteScore 0.17
In this work the use of a high-throughput nanomechanical detection system based on a DVD-ROM optical drive and cantilever sensors is presented for the detection of urokinase plasminogen activator receptor inflammatory biomarker (uPAR). Several large scale studies have linked elevated levels of soluble uPAR (suPAR) to infectious diseases, such as HIV, and certain types of cancer. Using hundreds of cantilevers and a DVD-based platform, cantilever deflection response from antibody–antigen recognition is investigated as a function of suPAR concentration. The goal is to provide a cheap and portable detection platform which can carry valuable prognostic information. In order to optimize the cantilever response the antibody immobilization and unspecific binding are initially characterized using quartz crystal microbalance technology. Also, the choice of antibody is explored in order to generate the largest surface stress on the cantilevers, thus increasing the signal. Using optimized experimental conditions the lowest detectable suPAR concentration is currently around 5 nM. The results reveal promising research strategies for the implementation of specific biochemical assays in a portable and high-throughput microsensor-based detection platform.
Non-covalent conjugates of single-walled carbon nanotubes and folic acid for interaction with cells overexpressing folate receptors

We here present a method to form a noncovalent conjugate of single-walled carbon nanotubes and folic acid aimed to interact with cells over-expressing folate receptors. The bonding was obtained without covalent chemical functionalization using a simple, rapid "one pot" synthesis method. The zeta potential for the single-walled carbon nanotube–folic acid solution was _32.4 mV at pH 7.0 and the result indicates that the folic acid coating inhibited aggregation of the carbon nanotubes. Properties of the single-walled carbon nanotube–folic acid conjugate were analyzed using ultraviolet-visible, fluorescence and Raman spectroscopies. While the folic acid fluorescence signature was significantly quenched by the presence of single-walled carbon nanotubes, the Raman spectra of the conjugate displayed a decreased distribution of sp3 sites. Both results were attributed to the noncovalent functionalization of the single-walled carbon nanotubes with folic acid. A more detailed investigation of the single-walled carbon nanotube–folic acid conjugates utilizing scanning electron microscopy, atomic force microscopy and energy-dispersive X-ray spectroscopy confirmed the presence of the well-defined folic acid coating on the individual single-walled carbon nanotubes. The single-walled carbon nanotube–folic acid conjugates were incubated with THP-1 cells and the internalization was evaluated by Giemsa staining with light microscopy, and cytotoxicity was evaluated using the MTT reduction assay. The cytotoxicity studies presented a low toxicity of the conjugates in the THP-1 cells. The low toxicity and the cellular uptake of single-walled carbon nanotube–folic acid by cancer cells suggest their potential use in carbon nanotube-based drug delivery systems and in the diagnosis of cancer or tropical diseases such as leishmaniasis.

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Organisations: Department of Micro- and Nanotechnology, Nano Bio Integrated Systems, Polymer Microsystems for Medical Diagnostics, Nanoprobes, Universidad Industrial de Santander
Authors: Castillo, J. J. (Ekstern), Rindzevicius, T. (Intern), Novoa, L. V. (Ekstern), Svendsen, W. E. (Intern), Rozlosnik, N. (Intern), Boisen, A. (Intern), Escobar, P. (Ekstern), Martínez, F. (Ekstern), Castillo-Léon, J. (Intern)
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Electronic versions:
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Online measurement of mass density and viscosity of pL fluid samples with suspended microchannel resonator

Physical characterization of viscous samples is crucial in chemical, pharma and petroleum industry. For example, in the refining industry of petroleum, water percentage is verified by measuring the density of a sample. In this article we present a suspended microchannel resonator (SMR) which uses 5 pL of a fluid sample and measures its density with a resolution of 0.01 kg/m 3 and a sensitivity of 16 Hz/kg/m3. The resonator can also simultaneously measure viscosity of the solutions with an accuracy of 0.025 mPa s. The SMR is part of a system which contains packaging and tubing to deliver samples to the resonator. The system can easily handle multiple viscous fluids to measure their densities and viscosities. The SMR is transparent, facilitating visual inspection of the microchannel content. © 2013 Elsevier B.V.
Photothermal analysis of individual nanoparticulate samples using micromechanical resonators

The ability to detect and analyze single sample entities such as single nanoparticles, viruses, spores, or molecules is of fundamental interest. This can provide insight into the individual specific properties which may differ from the statistical sample average. Here we introduce resonant photothermal spectroscopy, a novel method that enables the analysis of individual nanoparticulate samples. Absorption of light by an individual sample placed on a microstring resonator results in local heating of the string, which is reflected in its resonance frequency. The working principle of the spectrometer is demonstrated by analyzing the optical absorption of different micro- and nanoparticles on a microstring. We present the measurement of a simple absorption spectrum of multiple polystyrene microparticles illuminated with an unfocused LED light source. Using a diode laser, single 170 nm polystyrene nanoparticles are detected. With the current setup, nanoparticulate samples with a mass of ∼40 ag are detectable. By using nanostrings, visible and infrared photothermal spectroscopy in the subattogram mass regime is possible and single molecule detection is within reach. © 2013 American Chemical Society.
Micromechanical photothermal infrared spectroscopy is a promising technique, where absorption-related heating is detected by frequency detuning of microstring resonators. We present photothermal infrared spectroscopy with mechanical string resonators providing rapid identification of femtogram-scale airborne samples. Airborne sample material is directly collected on the microstring with an efficient nondiffusion limited sampling method based on inertial impaction. Resonance frequency shifts, proportional to the absorbed heat in the microstring, are recorded as monochromatic IR light is scanned over the mid-infrared range. As a proof-of-concept, we sample and analyze polyvinylpyrrolidone (PVP) and the IR spectrum measured by photothermal spectroscopy matches the reference IR spectrum measured by an FTIR spectrometer. We further identify the organic surface coating of airborne TiO₂ nanoparticles with a total mass of 4 pg. With an estimated detection limit of 44 fg, the presented sensor demonstrates a new paradigm in ultrasensitive vibrational spectroscopy for identification of airborne species.

General information
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Authors: Yamada, S. (Intern), Schmid, S. (Intern), Larsen, T. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 10531-10535
Plasma etching on large-area mono-, multi- and quasi-mono crystalline silicon

We use plasma etched Black Si (BS)[1][2] nanostructures to achieve low reflectance due to the resulting graded refractive index at the Si-air interface. The goal of this investigation is to develop a suitable texturing method for Si solar cells. Branz
et al. [3] report below 3% average reflectance for their 16.8% efficient black Si cell using a metal-assisted, chemical etching method on FZ mono-crystalline Si substrates. Yoo et al. [4] use RIE similar to this work on large-area, multi-crystalline Si cells and achieve a 16.1% efficiency despite a relatively high reflectance of 13.3%. Despite several advantages such as; (i) excellent light trapping, (ii) dry, single-sided and scalable process method and (iii) etch independence on crystallinity of Si, RIE-texturing has so far not been proven superior to standard wet texturing, primarily as a result of lower power conversion efficiency due to increased surface recombination. This work shows promising potential of future improvements in power conversion efficiency, since excellent light absorption has been shown for large-area, industry grade CZ Si wafers with several identified areas of improvement. We show that the RIE nanostructures lead to superior light absorption independent of crystalline grade and incident angle. A texturing method which is applicable to all industry-relevant grades of Si and which yields improved performance at non-ideal incident angles has a major scientific and commercial relevance. The nanostructures were fabricated using maskless RIE in a O2 and SF6 plasma, and the surface topology was optimized for solar cell applications by varying gas flows, pressure, power and process time. The starting substrates were 156x156 mm p-type, CZ mono-, multi- and quasi-mono crystalline Si wafers, respectively, with a thickness of 200 μm. Reflectance measurements of the RIE-textured mono-, multi and quasi-mono Si surfaces were performed using a broadband lightsource (Mikropack DH-2000), an integrating sphere (Mikropack ISP-30-6-R), and a spectrometer (Ocean Optics QE65000, 280-1000 nm). The reference solar spectral irradiance for AM 1.5 was used to calculate the weighted average reflectance in the wavelength range from 280-1000 nm. Our mask-less, scalable RIE nanostructuring of the Si surface is shown to reduce the AM1.5-weighted average reflectance to a level below 1 % in a fully optimized RIE texturing, and thus holds a significant potential for improvement of solar cell performance compared to current industrial standards. The reflectance is shown to remain below that of conventional textured cells also at high angle of incidence. The process is shown to be equally applicable to mono-, multi- and quasi-mono-crystalline Si.

1

Plasma texturing on large-area industrial grade CZ silicon solar cells

We report on an experimental study of nanostructuring of silicon solar cells using reactive ion etching (RIE). A simple mask-less, scalable RIE nanostructuring of the solar cell surface is shown to reduce the AM1.5-weighted average reflectance to a level below 1 % in a fully optimized RIE texturing, and thus holds a significant potential for improvement of the cell performance compared to current industrial standards. The reflectance is shown to remain below that of conventional textured cells also at high angle of incidence. The process is shown to be equally applicable to mono-, multi- and quasi-mono-crystalline Si. The process was successfully integrated in fabrication of solar cells using only industry standard processes on a Czochralski (CZ) silicon starting material. The resulting cell performance was compared to cells with conventional texturing. For cells, where the nanostructuring was not fully optimized (reflectance larger than 2 %), an efficiency of 16.5 % at 1 sun was demonstrated.
Plasma texturing on large-area industrial grade CZ silicon solar cells

In this work we have performed a detailed study of the influence of various parameters on spray coating of polymer films. Our aim is to produce polymer films of uniform thickness (500 nm to 1 μm) and low roughness compared to the film thickness. The coatings are characterized with respect to thickness, roughness (profilometer), and morphology (optical microscopy). Polyvinylpyrrolidone (PVP) is used to do a full factorial design of experiments with selected process parameters such as temperature, distance between spray nozzle and substrate, and speed of the spray nozzle. A mathematical model is developed for statistical analysis which identifies the distance between nozzle and substrate as the most significant parameter. Depending on the drying of the sprayed droplets on the substrate, we define two broad regimes, "dry" and "wet". The optimum condition of spraying lies in a narrow window between these two regimes, where we obtain a film of desired quality. Both with increasing nozzle-substrate distance and temperature, the deposition moves from a wet state to a dry regime. Similar results are also achieved for solvents with low boiling points. Finally, we study film formation during spray coating with poly (d,l-lactide) (PDLLA). The results confirm the processing knowledge obtained with PVP and indicate that the observed trends are identical for spraying of other polymer films.

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Process optimization of ultrasonic spray coating of polymer films

In this work we have performed a detailed study of the influence of various parameters on spray coating of polymer films. Our aim is to produce polymer films of uniform thickness (500 nm to 1 μm) and low roughness compared to the film thickness. The coatings are characterized with respect to thickness, roughness (profilometer), and morphology (optical microscopy). Polyvinylpyrrolidone (PVP) is used to do a full factorial design of experiments with selected process parameters such as temperature, distance between spray nozzle and substrate, and speed of the spray nozzle. A mathematical model is developed for statistical analysis which identifies the distance between nozzle and substrate as the most significant parameter. Depending on the drying of the sprayed droplets on the substrate, we define two broad regimes, "dry" and "wet". The optimum condition of spraying lies in a narrow window between these two regimes, where we obtain a film of desired quality. Both with increasing nozzle-substrate distance and temperature, the deposition moves from a wet state to a dry regime. Similar results are also achieved for solvents with low boiling points. Finally, we study film formation during spray coating with poly (d,l-lactide) (PDLLA). The results confirm the processing knowledge obtained with PVP and indicate that the observed trends are identical for spraying of other polymer films.

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Pyrolysed carbon resonators: Fabrication and characterization

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Authors: Amato, L. (Intern), Armato, B. (Ekstern), Villanueva Torrijo, L. G. (Intern), Emnéus, J. (Intern), Heiskanen, A. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern), Schmid, S. (Intern)
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Real-time single airborne nanoparticle detection with nanomechanical resonant filter-fiber
Nanomechanical resonators have an unprecedented mass sensitivity sufficient to detect single molecules, viruses or nanoparticles. The challenge with nanomechanical mass sensors is the direction of nano-sized samples onto the resonator. In this work we present an efficient inertial sampling technique and gravimetric detection of airborne nanoparticles with a nanomechanical resonant filter-fiber. By increasing the nanoparticle momentum the dominant collection mechanism changes from diffusion to more efficient inertial impaction. In doing so we reach a single filter-fiber collection efficiency of 65 ± 31% for 28 nm silica nanoparticles. Finally, we show the detection of single 100 nm silver nanoparticles. The presented method is suitable for environmental or security applications where low-cost and portable monitors are demanded. It also constitutes a unique technique for the fundamental study of single filter-fiber behavior. We present the direct measurement of diffusive nanoparticle collection on a single filter-fiber qualitatively confirming Langmuir's model from 1942.

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Scopus rating (2016): CiteScore 4.63 SJR 1.692 SNIP 1.354
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.034 SNIP 1.597 CiteScore 5.3
Resonant fiber based aerosol particle sensor and method
The present invention relates to methods and devices for determining the weight of small particles, typically being nano-sized particles by use of resonating fibers in the form of elongate members being driven into resonance by an actuator or e.g. thermal noise/fluctuation. The frequency shift in resonance frequency due to depositing of nano-sized particles is correlated with the mass deposited on the elongate member and the vibration frequency of the elongate member is determined by a detector. The read-out from the detector is transformed into a mass deposited on the elongate member. Particles are deposited by letting a fluid with the particles flow past the elongate member.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Boisen, A. (Intern), Schmid, S. (Intern)
Publication date: 2013

Publication information
IPC: G01N 9/00
Patent number: WO2013/064157
Date: 10/05/2013
Original language: English

Bibliographical note
DTU reference no: 92600
Main Research Area: Technical/natural sciences
Publication: Research › Patent – Annual report year: 2013

Resonant photothermal IR spectroscopy of picogram samples with microstring resonator
Here, we report a demonstration of resonant photothermal IR spectroscopy using microstrings in mid-infrared region providing rapid identification of picogram samples. In our microelectromechanical resonant photothermal IR spectroscopy system, samples are deposited directly on microstrings using an in-situ sampling method and the resonance frequency of the string is measured optically. Resonance frequency shifts, proportional to the absorbed heat, are recorded in real time as monochromatic infrared light is being scanned over the mid-infrared range. These resonant photothermal IR spectroscopy spectra, obtained from picogram samples, suggest promising future applications of this approach.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Yamada, S. (Intern), Schmid, S. (Intern), Boisen, A. (Intern)
Publication date: 2013

Host publication information
Title of host publication: Proceedings of the The 17th International Conference on Solid-State Sensors, Actuators and Microsystems
Sensitive determination of the Young's modulus of thin films by polymeric microcantilevers

A method for the highly sensitive determination of the Young's modulus of TiO₂ thin films exploiting the resonant frequency shift of a SU-8 polymer microcantilever (MC) is presented. Amorphous TiO₂ films with different thickness ranging from 10 to 125 nm were grown at low temperature (90 °C) with subnanometer thickness resolution on SU-8 MC arrays by means of atomic layer deposition. The resonant frequencies of the MCs were measured before and after coating and the elastic moduli of the films were determined by a theoretical model developed for this purpose. The Young's modulus of thicker TiO₂ films (>75 nm) was estimated to be about 110 GPa, this value being consistent with the value of amorphous TiO₂. On the other hand we observed a marked decrease of the Young's modulus for TiO₂ films with a thickness below 50 nm. This behavior was found not to be related to a decrease of the film mass density, but to surface effects according to theoretical predictions on size-dependent mechanical properties of nano- and microstructures.
Spray coating of microcontainers with eudragit using ferromagnetic shadow masks for controlled oral release of poorly water soluble drugs.

PURPOSE: To form a lid of Eudragit S-100 or L-100 on the cavity of drug-filled microcontainers (micro scale oral drug delivery devices) by utilizing ferromagnetic masks. Furthermore, investigations of drug release in biorelevant gastric and intestinal media were evaluated for testing the ability of controlling the drug release of poorly soluble drugs from the microcontainers.

METHODS: Cylindrical microcontainers (inner diameter of 240 μm) were fabricated in SU-8, using photolithography on silicon substrate. The microcontainers were filled with either cinnarizine (weak base) or amorphous furosemide salt (weak acid). The cavity of the drug-filled microcontainers were spray coated with a 2 wt% solution of either Eudragit S-100 (soluble below pH 5) or Eudragit L-100 (soluble above pH 6) in isopropanol. The spray coating process was performed using ferromagnetic shadow masks (380 μm) allowing for magnetic clamping to the substrate and therefore precise deposition of the polymer on the microcontainers to form a lid. The release of cinnarizine and amorphous furosemide salt from the coated microcontainers was performed in fasted biorelevant gastric (pH 1.6) and intestinal media (pH 6.5), respectively.

RESULTS: By use of the ferromagnetic shadow masks it was possible to deposit the Eudragit precisely and therefore possible to form a lid of the cavity of the microcontainers. The thickness of the Eudragit layer on the cavity of the microcontainers was approximately 8-10 μm for both types of Eudragit. It was possible to control the drug release of cinnarizine by using Eudragit L-100 in the gastric medium and also possible to control the release of amorphous furosemide salt by the Eudragit E-100 coating in the intestinal medium.

CONCLUSIONS: The ferromagnetic shadow masks made it possible to deposit a lid of Eudragit on the cavity of the microcontainers and this is important in terms of utilizing the microcontainers as an oral drug delivery system as the drug release can be controlled.
Surface-Enhanced Raman Spectroscopy Based Quantitative Bioassay on Aptamer-Functionalized Nanopillars Using Large-Area Raman Mapping

Surface-enhanced Raman spectroscopy (SERS) has been used in a variety of biological applications due to its high sensitivity and specificity. Here, we report a SERS-based biosensing approach for quantitative detection of biomolecules. A SERS substrate bearing gold-decorated silicon nanopillars is functionalized with aptamers for sensitive and specific detection of target molecules. In this study, TAMRA-labeled vasopressin molecules in the picomolar regime (1 pM to 1 nM) are specifically captured by aptamers on the nanostructured SERS substrate and monitored by using an automated SERS signal mapping technique. From the experimental results, we show concentration-dependent SERS responses in the picomolar range by integrating SERS signal intensities over a scanning area. It is also noted that our signal mapping approach significantly improves statistical reproducibility and accounts for spot-to-spot variation in conventional SERS quantification. Furthermore, we have developed an analytical model capable of predicting experimental intensity distributions on the substrates for reliable quantification of biomolecules. Lastly, we have calculated the minimum needed area of Raman mapping for efficient and reliable analysis of each measurement. Combining our SERS mapping analysis with an aptamer-functionalized nanopillar substrate is found to be extremely efficient for detection of low-abundance biomolecules.
Towards airborne nanoparticle mass spectrometry with nanomechanical string resonators

Airborne nanoparticles can cause severe harm when inhaled. Therefore, small and cheap portable airborne nanoparticle monitors are highly demanded by authorities and the nanoparticle producing industry. We propose to use nanomechanical resonators to build the next generation cheap and portable airborne nanoparticle sensors. Recently, nanomechanical mass spectrometry was established. One of the biggest challenges of nanomechanical sensors is the low efficiency of diffusion-based sampling. We developed an inertial-based sampling method that enables the efficient sampling of airborne nanoparticles on a nanomechanical sensor operating directly in air. We measured a sampling rate of over 1000 particles per second, for 28 nm silica nanoparticles with a concentration of 380000 #/cm3, collected on a 500 nm wide nanomechanical string resonator. We show that it is possible to reach a saturated sampling regime in which 100% of all nanoparticles are captured that are owing in the projection of the nanostring. We further show that it is possible to detect single airborne nanoparticles by detecting 50 nm Au particles with a 250 nm wide string resonator. Our resonators are currently operating in the first bending mode. Mass spectrometry of airborne nanoparticles requires the simultaneous operation in the first and second mode, which can be implemented in the transduction scheme of the resonator. The presented results lay the cornerstone for the realization of a portable airborne nanoparticle mass spectrometer.
Towards Picomolar Detection with DVD-ROM Optical Technology

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Surface Engineering, Academia Sinica Taiwan, Copenhagen University Hospital
Number of pages: 2
Publication date: 2013

Using Experience From Explosives Detection in Development of Biosensors Based On Nanomechanical Responses

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Boisen, A. (Intern)
Publication date: 2013
Main Research Area: Technical/natural sciences
Publication information
Journal: Electrochemical Society. Meeting Abstracts (Online)
Volume: MA2013-02
ISSN (Print): 2151-2043
Original language: English
Electronic versions:
Meet_Abstr._2013_Boisen_2791.pdf

Bibliographical note
© 2013 The Electrochemical Society
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Publication: Research - peer-review › Conference abstract in journal – Annual report year: 2013

A DVD-ROM based high-throughput cantilever sensing platform
This thesis has been written as a partial fulfillment of the requirements for obtaining the PhD degree at DTU Nanotech. The project has been carried out at the Technical University of Denmark (DTU) at the department of Micro- and
Nanotechnology, in the three-years period between November 2008 and October 2011. The project was part of the Xsense research network, funded by the Strategic Danish Research Council, and supervised by Prof. Anja Boisen. The goal of the Xsense project is to design and fabricate a compact and cheap device for explosive sensing in air and liquid. Four different technologies (Cantilevers, Calorimetric, Colorimetric and Raman) were to be integrated into a single portable platform. My PhD project has been focusing on the cantilever technology part. Furthermore, I have been addressing the issue of designing and fabricating the overall sensing platform, which is going to integrate the four different sensors. The platform was developed specifically for cantilever sensor applications. Preliminary tests on Raman-based device integration has been carried out. The inclusion of the other two sensing techniques is currently under development. This thesis reports on the demonstration of a high-throughput label-free sensor platform utilizing cantilever-based sensors. These sensors have often been acclaimed to facilitate highly parallelized operation. Unfortunately, so far no concept has been presented which offers large datasets as well as easy liquid sample handling. We use optics and mechanics from a DVD player to handle liquid samples and to read-out cantilever deflection and resonant frequency. In a few minutes, several liquid samples can be analyzed in parallel, measuring over several hundreds of individual cantilevers.

Three generations of systems have been developed and tested during the three years. These devices have been used for sensing of proteins, antibodies and explosives. Different rotating platforms, specifically designed for gas and liquid measurements, have also been designed, fabricated and tested. The resulting platform represents a completely novel and powerful tool for analyzing biochemical reactions through cantilever sensors, where the reliability of the measurements is ensured by statistical analysis and by parallel characterization of cantilevers.

**General information**

State: Published  
Organisations: Department of Micro- and Nanotechnology  
Authors: Bosco, F. (Intern), Boisen, A. (Intern)  
Number of pages: 180  
Publication date: 2012

**Publication information**

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Publisher: Technical University of Denmark (DTU)  
Original language: English  
Main Research Area: Technical/natural sciences  
Electronic versions:  
Thesis_Bosco_28_10_2011.pdf  
Publication: Research › Ph.D. thesis – Annual report year: 2012

**An Astigmatic Detection System for Polymeric Cantilever-based Sensors**

We demonstrate the use of an astigmatic detection system (ADS) for resonance frequency identification of polymer microcantilever sensors. The ADS technology is based on a DVD optical head combined with an optical microscope (OM). The optical head has a signal bandwidth of 80 MHz, allowing thermal fluctuation measurements on cantilever beams with a subnanometer resolution. Furthermore, an external excitation can intensify the resonance amplitude, enhancing the signal-to-noise ratio. The full width at half maximum (FWHM) of the laser spot is 568 nm, which facilitates read-out on potentially submicrometer-sized cantilevers. The resonant frequency of SU-8 microcantilevers is measured by both thermal fluctuation and excited vibration measurement modes of the ADS.

**General information**

State: Published  
Organisations: Department of Micro- and Nanotechnology, Academia Sinica Taiwan, National Taiwan University  
Authors: Hwu, E. (Ekstern), Liao, H. (Ekstern), Bosco, F. (Intern), Chen, C. (Ekstern), Keller, S. S. (Intern), Boisen, A. (Intern), Huang, K. (Ekstern)  
Pages: 580939  
Publication date: 2012  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Sensors  
ISSN (Print): 1687-725X  
Ratings:  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Scopus rating (2017): SNIP 0.673 SJR 0.288 CiteScore 1.39  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): SJR 0.273 SNIP 0.863 CiteScore 1.4
Centrifugally driven microfluidic disc for detection of chromosomal translocations

Chromosome translocations are a common cause of congenital disorders and cancer. Current detection methods require use of expensive and highly specialized techniques to identify the chromosome regions involved in a translocation. There is a need for rapid yet specific detection for diagnosis and prognosis of patients. In this work we demonstrate a novel, centrifugally-driven microfluidic system for controlled manipulation of oligonucleotides and subsequent detection of chromosomal translocations. The device is fabricated in the form of a disc with capillary burst microvalves employed to control the fluid flow. The microvalves in series are designed to enable fluid movement from the center towards the periphery of the disc to handle DNA sequences representing translocation between chromosome 3 and 9. The translocation detection is performed in two hybridization steps in separate sorting and detection chambers. The burst frequencies of the two capillary burst microvalves are separated by 180 rpm enabling precise control of hybridization in each of the chambers. The DNA probes targeting a translocation are immobilized directly on PMMA by a UV-activated procedure, which is compatible with the disc fabrication method. The device performance was validated by successful specific hybridization of the translocation derivatives in the sorting and detection chambers.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems, Kennedy Center, University of Copenhagen
Authors: Brøgger, A. L. (Intern), Kwasny, D. (Intern), Bosco, F. G. (Intern), Silahtaroglu, A. (Forskerdatabase), Tümer, Z. (Forskerdatabase), Boisen, A. (Intern), Svendsen, W. E. (Intern)
Pages: 4628-4634
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Lab on a Chip
Volume: 12
Issue number: 22
ISSN (Print): 1473-0197
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 6.05 SJR 2.158 SNIP 1.586
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.98 SJR 2.162 SNIP 1.569
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.239 SNIP 1.721 CiteScore 5.74
Dense high aspect ratio pillar arrays for carbon MEMS electrodes

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Bioanalytics, Technical University of Denmark, Capres A/S, Ecole Polytechnique, University of California at Irvine, University of Canterbury, Lund University
Authors: Amato, L. (Intern), Hansen, R. J. (Ekstern), Heiskanen, A. (Intern), Gammelgard, L. (Ekstern), Rindzevicius, T. (Intern), Martinez-Duarte, R. (Ekstern), Singh Bisht, G. (Ekstern), Downard, A. (Ekstern), Baronian, K. (Ekstern), Tenje, M. (Ekstern), Madou, M. (Ekstern), Boisen, A. (Intern), Emnéus, J. (Intern), Keller, S. S. (Intern)
Number of pages: 1
Publication date: 2012
Fabrication of high-aspect ratio SU-8 micropillar arrays

SU-8 is the preferred photoresist for development and fabrication of high aspect ratio (HAR) three dimensional patterns. However, processing of SU-8 is a challenging task, especially when the film thickness as well as the aspect ratio is increasing and the size of the features is close to the resolution limit of photolithography. This paper describes process optimization for the fabrication of dense SU-8 micropillar arrays (2.5μm spacing) with nominal height 20μm and nominal diameter 2.5μm (AR 8). Two approaches, differing in temperature, ramping rate and duration of the baking steps were compared as part of the photolithographic processing, in order to evaluate the effect of baking on the pattern resolution. Additionally, during the post-processing, supercritical point drying and hard baking were introduced yielding pillars with diameter 1.8μm, AR=11 and an improved temporal stability.
High frequency bulk resonators for bio/chemical diagnostics and monitoring applications

In the environmental monitoring field there is a vast variety of possible applications for microfabricated MEMS sensors. As an example, a network of miniaturized sensors could detect toxic gases, harmful airborne, explosives in air or, in liquid, monitor the quality of drinking water. The integration of miniaturized MEMS mass sensors into lab on chip systems will lead to point of care systems designed to be inexpensive, portable, and field-ready with high sensitivity and specificity.

One of the most common techniques to transduce the interaction between the sensor and the target chemical species is by monitoring the target mass, that is continuously deposited or removed from the sensor's surface, while the sensor's structure vibrates in resonance.

This thesis presents the development of MEMS mass sensors based on mechanical microresonators in the very high frequency range 12-132 MHz. This devices can be operated in gaseous environments thanks to the high Q-factors and show very high mass sensitivities and very small mass resolutions. The resonators have been microfabricated at the DTU-Danchip facility exploiting the microfabrication knowledge already present in the DyNEMS group.

The devices have been characterized in terms of electrical properties and mass sensing performance. Chemical and biological mass sensing experiments have been performed in order to investigate the behavior of these devices in different environments. The microresonators have been used to detect copper ions in drinking water and as temperature sensors in humid environment. Moreover, they have been used as tool to investigate the interaction between water molecules and DNA. Finally, nanograss have been etched into the body of the microresonators in order to improve the mass sensitivity of the devices.

On the whole, the experimental results demonstrate that new and highly sensitive mass sensing systems, based on the MEMS microresonators presented in this thesis, could be developed.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Cagliani, A. (Intern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Number of pages: 159
Publication date: 2012

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
AlbertoCaglianiPHDthesis..PDF
Publication: Research › Ph.D. thesis – Annual report year: 2012

Inkjet printing as a novel drug loading technique of micro-containers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Technical University of Denmark
Authors: Marizza, P. (Intern), Keller, S. S. (Intern), Rades, T. (Ekstern), Boisen, A. (Intern)
Publication date: 2012

Host publication information
Title of host publication: Proceedings of the 6th Annual PSSRC Symposium 2012
Main Research Area: Technical/natural sciences
Investigation of cleaning and regeneration methods for reliable construction of DNA cantilever biosensors

Biosensing systems based on detecting changes in cantilever surface stress have attracted great interest. To achieve high reliability of measurements, high quality and high reproducibility in functionalization of the sensor surface are key points. In this paper, we investigate different methods to clean and regenerate the sensing surface of cantilever biosensors. Perchloric acid potential sweep, potassium hydroxide-hydrogen peroxide, and piranha cleaning are investigated here. Peak-current potential differences from cyclic voltammetry, X-ray photo-electron spectroscopy and fluorescence detection are applied to characterize surface cleanliness. The experimental results show that piranha cleaning is the most reliable and efficient cleaning procedure.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, BioLabChip, Bioanalytics, McGill University
Authors: Quan, X. (Intern), Yi, S. (Intern), Heiskanen, A. (Intern), Wolff, A. (Intern), Grutter, P. (Ekstern), Boisen, A. (Intern)
Number of pages: 2
Publication date: 2012
Main Research Area: Technical/natural sciences
Electronic versions:
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Relations
Activities:
9th International Nanomechanical Sensing Workshop
Publication: Research - peer-review › Paper – Annual report year: 2012

Investigations by Raman Microscopy if Spatial Confinement of Amorphous Indomethacin Can Lead to Increased Stability

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen, University of Otago
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Gordon, K. C. (Ekstern), Boisen, A. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern)
Number of pages: 2
Publication date: 2012
Main Research Area: Technical/natural sciences

Bibliographical note
Poster presentation.
Source: PublicationPreSubmission
Source-ID: 97539248
Publication: Research - peer-review › Paper – Annual report year: 2012

Microfluidic System With Capillary Burst Valves For Detection Of Chromosomal Translocations

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Nano Bio Integrated Systems
Authors: Brøgger, A. L. (Intern), Kwasny, D. (Intern), Bosco, F. (Intern), Boisen, A. (Intern), Svendsen, W. E. (Intern)
Publication date: 2012
Event: Poster session presented at III International Workshop on Analytical Miniaturization and NANOtechnologies, Barcelona, Spain.
Main Research Area: Technical/natural sciences
Source: dtu
Source-ID: u::6276
Micromechanical aptasensor-based protein detection using a compact-disc format microfluidics system
A plug-and-play CD-like platform is used to perform a statistical detection of Platelet Derived Growth Factor (PDGF) proteins through aptamer-based surface functionalization of microcantilevers. When PDGF proteins bind to the aptamers, the cantilevers deflect. This deflection is monitored by optical readout heads from a DVD-ROM. The improved sensing platform facilitates measurements in continuous liquid flow with temperature control. Also, the wobbling of the CD platform has been reduced to a minimum and the scanning system has been optimized in order to detect cantilever deflections in liquid in the nanometer range. The capability of the sensing platform is demonstrated by detection of clinically relevant concentrations of PDGF proteins. We have performed statistical measurements on 100 microcantilevers at different concentrations of PDGF, ranging from 10 nM to 400 nM. Hereby it is possible to reliably characterize the averaged mechanical response of cantilevers as a function of protein concentration.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Columbia University, Academia Sinica Taiwan
Authors: Bosco, F. (Intern), Yang, J. (Ekstern), Chen, C. H. (Ekstern), Hwu, E. (Ekstern), Keller, S. S. (Intern), Bache, M. (Intern), Lin, Q. (Ekstern), Boisen, A. (Intern)
Pages: 858 - 861
Publication date: 2012

Micro-Mechanical Temperature Sensors
Temperature is the most frequently measured physical quantity in the world. The field of thermometry is therefore constantly evolving towards better temperature sensors and better temperature measurements. The aim of this Ph.D. project was to improve an existing type of micro-mechanical temperature sensor or to develop a new one. Two types of micro-mechanical temperature sensors have been studied: Bilayer cantilevers and string-like beam resonators. Both sensor types utilize thermally generated stress. Bilayer cantilevers are frequently used as temperature sensors at the micro-scale, and the goal was therefore to improve their sensitivity. Bilayer cantilevers are usually made by coating a ceramic cantilever with a metal. They were in this case coated with the polymer SU-8 to increase the sensitivity. The measured sensitivity of the fabricated cantilevers turned out to be one half of the expected value. The reduced sensitivity was due to initial bending of the cantilevers and poor adhesion between the two cantilever materials. No further attempts were made to improve the sensitivity of bilayer cantilevers.

The concept of using string-like resonators as temperature sensors has, for the first time, been studied in details both theoretically and experimentally. The measured sensitivity of silicon nitride, nickel and aluminum strings scales in accordance with the theory. A relative change of -15 +/- 1%/°C was demonstrated using low stressed aluminum strings. This value is more than 100 times higher than values reported by other groups for similar devices. A temperature resolution of 2.5x10^-4 °C was achieved using high Q silicon nitride strings. This temperature resolution is better than for other types of micro-scale resonating temperature sensors.

The anelastic behavior observed for the strings was least pronounced for the silicon nitride strings. This combined with their better temperature resolution makes them the best temperature sensor candidate.

The concept of using a string-based photothermal spectrometer for microand nano-particle detection has been investigated. Detection and identifi-cation of single micro-particles have been demonstrated successfully using a single color irradiation source. The current setup has the potential of detecting single sub-micrometer particles. The detection of wavelength dependent light absorption by micro-particles has also been demonstrated with success.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Larsen, T. (Intern), Boisen, A. (Intern), Schmid, S. (Intern)
Number of pages: 124
Publication date: 2012
Multi-colorimetric sensor array for detection of illegal materials
The detection of low pressure illegal compounds is an important analytical problem which requires reliable, selective and sensitive detection methods which provide the highest level of confidence in the result. Therefore, to contribute in the successful development of the recognition technology and signal processing enhancements to sensing methods, recognition ability, data acquisition time and data processing algorithms are necessary. In this research we work towards the development of a rapid, easy in use, highly sensitive, specific (minimal false positives) sensor based on a colorimetric sensing technology.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Nanoprobes, Surface Engineering, Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Kostesha, N. (Intern), Boisen, A. (Intern), Jakobsen, M. H. (Intern), Alstrøm, T. S. (Intern), Larsen, J. (Intern)
Number of pages: 4
Publication date: 2012

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Title of host publication: 2012 IEEE Sensors
Publisher: IEEE
ISBN (Print): 978-1-4577-1766-6
ISSN: 1930-0395
Main Research Area: Technical/natural sciences
Conference: 2012 IEEE Sensors, Taipei, Taiwan, Province of China, 28/10/2012 - 28/10/2012
DOIs: 10.1109/ICSENS.2012.6411474
Source: dtu
Source-ID: n:oai:DTIC-ART:iel/377909958::25510
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

M. S. Schmidt et al. describe on page OP11 a simple, two-step fabrication process to assemble flexible, freestanding nanopillars into large-area substrates. These substrates can be made using readily available silicon-processing equipment and are suitable for SERS, having a large, uniform Raman enhancement.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, DTU Danchip
Authors: Schmidt, M. S. (Intern), Hübner, J. (Intern), Boisen, A. (Intern)
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Advanced Materials
Volume: 24
Issue number: 10
ISSN (Print): 0935-9648
Ratings:
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Physical stability and dissolution of spatially confined amorphous indomethacin: The effect of different heating and cooling rates

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern), Rades, T. (Ekstern), Müllertz, A. (Ekstern)
Number of pages: 1
Publication date: 2012
Event: Abstract from Annual Meeting and Exposition of the American Association of Pharmaceutical Scientists (AAPS), Chicago, United States.
Main Research Area: Technical/natural sciences

Bibliographical note
Process Optimization for Spray Coating of Poly (vinyl pyrrolidone)

Poly(vinyl pyrrolidone) (PVP) is an important synthetic polymer which has a wide variety of applications in the biomedical field because of its film forming properties including adhesion, excellent physiological compatibility, low toxicity, and reasonable solubility in water and most organic solvents [1]. Recently some studies have been published [2, 3] using micromechanical sensors to characterize thin polymer coatings under various conditions. With the final aim to deposit thin PVP film on cantilevers we studied the process optimization of PVP by spray coating on microscope glass slides. Here, we present a study of the parameters determining the quality of the deposited film. Spray Coating was done in an Exacta Coat Ultrasonic Spraying System (Sonotek, USA). The main components are illustrated in fig. 1. The tip of the ultrasonic atomizer nozzle was actuated at a frequency of 120 kHz. Nitrogen gas was connected to the inlet of the air focusing shroud. The nitrogen pressure was monitored by a pressure sensor and regulated by a valve. The gas flow and the position of the air focusing shroud allowed the control of the diameter and shape of the spray-coating beam. The movement of the nozzle was controlled by an x-y-z stage. A shadow mask was put on a glass slide before deposition to cover some area from spraying. The masked areas acted as a baseline for characterizing the final coating by a surface profilometer (Veeco Dektak8) from where the thickness and roughness value were calculated as shown schematically in fig. 2. The surface texture was observed with an Optical Microscope (Zeiss). A 0.5 wt. % solution of PVP in water was prepared and introduced in the central column of the nozzle using a syringe pump. Each slide was coated 10 times with a flow rate of 0.1 ml/min and nitrogen pressure of 0.03 Bar which was kept constant for all the experiments. The parameters varied are speed of the moving nozzle while spraying (nozzle path shown schematically in fig. 2), temperature of the substrate and distance between nozzle and substrate. Surface morphology of the films is governed mainly by the rate of drying of the spray on the substrate. The depositions can be broadly classified into a dry state, a wet state and an optimized condition in between. The profilometer scan in fig. 3 and the microscope images in fig. 4 show the surface for a distance between the nozzle and the substrate of (a) 100 mm, (b) 70 mm and (c) 90 mm respectively. The further the nozzle is away from the substrate the faster the deposited polymer film dries. Spraying with a distance of 100 mm gives rise to the dry state (fig. 3a) with avg. roughness (Ra) 158 nm. When the distance between nozzle and substrate decreases to 70 mm i.e., at the wet state, Ra reduces to 22 nm. The disadvantage of the wet condition is that as the polymer remains wet for a longer time it accumulates at the edge of the deposition to form peaks of few microns in height (fig. 3b). The optimized condition (fig. 3c) lies in between at a distance of 90 mm where we get a compromise between the dry and the wet state where Ra is 76 nm but there are no edge peaks as shown before. With an increase in temperature (fig. 5a, b and c) the deposition moves from the wet to dry state are roughness increases due to rapid drying of the sprayed drops. Same dry state is observed for coating with an aqueous solution at 60°C (fig. 5c) and when a low boiling solvent like dichloromethane (fig. 5d) is used for deposition at room temperature. The speed of the spraying nozzle influences both the final thickness and roughness of the film. The roughness becomes significant when the nozzle is very fast and the amount of polymer sprayed is not enough to coalesce and form a continuous film. This study shows the inter-correlation of different parameters for uniform film formation by spray coating. The findings will be used for coating of cantilevers and for studies of material characteristics of thin polymer films used for example drug delivery.

General Information
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Organisations: Department of Micro- and Nanotechnology, Amphiphilic Polymers in Biological Sensing, Nanoprobes
Authors: Bose, S. (Intern), Keller, S. S. (Intern), Boisen, A. (Intern), Almdal, K. (Intern)
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Spatial confinement can lead to increased stability of amorphous indomethacin

The aim of this study was to investigate whether the physical stability of amorphous indomethacin can be improved by separating the drug material into small units by the use of microcontainers. Crystallisation from the spatially confined amorphous indomethacin in the microcontainers was determined and compared with the crystallisation kinetics of amorphous bulk indomethacin. Amorphous indomethacin in both a bulk form and contained within microcontainers was prepared by melting of bulk or container-incorporated γ-indomethacin, respectively, followed by quench-cooling. Microcontainers of three different sizes (diameters of 73 μm, 174 μm and 223 μm) were used for the confinement of amorphous indomethacin, in order to elucidate whether the size of the microcontainer had an influence on the stability of the amorphous form. Following preparation, all samples were stored at 30°C and 23% RH. A sample of 100
microcontainers of each size was selected and measured on a Raman microscope over a period of 30 days to ascertain whether the indomethacin in each container was amorphous or crystalline. Over time, a crystallisation number was obtained for the amorphous indomethacin in the microcontainers. The crystallisation numbers from the microcontainers were compared with the crystallisation kinetics of the amorphous bulk indomethacin, as determined by FT-Raman spectroscopy. Comparison of the numeric crystallisation in the microcontainers with the crystallisation kinetics of the amorphous bulk indomethacin showed that spatial confinement of indomethacin led to a significantly lower extent of crystallisation of the amorphous form. In the 174 μm microcontainers, 29.0 ± 2.6% of the amorphous indomethacin crystallised to the stable γ-form over a period of 30 days, whilst 38.3 ± 1.5% of the amorphous indomethacin crystallised in the 223 μm microcontainers. Both these values were significantly different from that observed in the amorphous bulk indomethacin, where 51.0% crystallised to the γ-form after 30 days. Comparing the 174 and 223 μm microcontainers also revealed a significantly greater stabilising effect of the 174 μm microcontainers (p-value of 0.0061). Surprisingly, for microcontainers with an inner diameter of 73 μm, no stability improvement was found when compared to amorphous bulk indomethacin. It was observed that the amorphous indomethacin within these containers converted to the α-form of indomethacin (a metastable polymorph) which was unexpected at the storage conditions at 30°C and 23% RH.
Stability of amorphous drug formulations in microcontainers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen, University of Otago
Authors: Nielsen, L. H. (Intern), Keller, S. S. (Intern), Gordon, K. C. (Ekstern), Boisen, A. (Intern), Rades, T. (Ekstern)
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Main Research Area: Technical/natural sciences

Stabilisation of amorphous drug formulations in microcontainers

Statistical analysis of DNT detection using chemically functionalized microcantilever arrays

The need for miniaturized and sensitive sensors for explosives detection is increasing in areas such as security and demining. Micrometer sized cantilevers are often used for label-free detection, and have previously been reported to be able to detect explosives. However, only a few measurements from 1 to 2 cantilevers have been reported, without any information on repeatability and reliability of the presented data. In explosive detection high reliability is needed and thus a statistical measurement approach needs to be developed and implemented. We have developed a DVD-based read-out system capable of generating large sets of cantilever data for vapor and liquid phase detection of 2,4-dinitrotoluene (DNT).

Gold coated cantilevers are initially functionalized with tetraTTF-calix[4]pyrrole molecules, specifically designed to bind nitro-aromatic compounds. The selective binding of DNT molecules on the chemically treated surfaces results in significant bending of the cantilevers and in a decrease of their resonant frequencies. We present averaged measurements obtained from up to 72 cantilevers being simultaneously exposed to the same sample. Compared to integrated reference cantilevers with non-selective coatings the tetraTTF-calix[4]pyrrole functionalized cantilevers reveal a uniform and reproducible behavior.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, Academia Sinica Taiwan, University of Southern Denmark
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Main Research Area: Technical/natural sciences
Surface chemical functionalisation of epoxy photoresist-based microcantilevers with organic-coated TiO2 nanocrystals

In this Letter, a solution-based approach has been used for chemically immobilising oleic acid (OLEA)-capped TiO2 nanocrystals (NCs) on the surface of microcantilevers formed of SU-8, a negative tone epoxy photoresist. The immobilisation has been carried out at room temperature, under visible light, in ambient atmosphere and without applying any external driving force or chemical activation of the epoxy photoresist surface. Atomic force microscopy, scanning electron microscopy and X-ray photoelectron spectroscopy investigation demonstrate the spontaneous chemical anchoring of the organic-coated TiO2 NCs on the microcantilevers, which resulted in a highly interconnected nanoporous multilayer structure. The chemical and morphological characterisation shows that the immobilised NCs do not change either their pristine morphology or the chemical structure after binding. Spectroscopic investigation infers that the TiO2 NCs chemically bind through the free and highly reactive epoxy groups located on the epoxy photoresist surface by means of the OLEA capping molecules. Finally, the results show that the fabrication procedure of the microcantilevers has not been affected by the immobilisation protocol. The capability of the immobilised TiO2 NCs to generate surface-reactive hydroxyl radicals under UV-light irradiation has a good potential for detecting families of organic compounds when integrating the modified microcantilevers in electronic noses.
Test system and method
The present invention relates to an apparatus for detecting compounds, the apparatus having a device defining a disk-shaped geometry, the device having a centre, a plurality of fluid channels each comprising a fluid inlet positioned at a first distance from the centre and a fluid channel end at a second distance from the centre, the second distance being larger than the first distance, one or more sensors arranged at each fluid channel, wherein the sensors each comprise at least one optical detectable member, the test apparatus further comprising one or more optical sensing devices arranged for sensing the at least one optical detectable member of the one or more sensors, and a rotation device adapted for rotating the device so that the sensors pass over the one or more optical sensing devices. Further the present invention relates to a method for determining compounds comprising providing an apparatus for detecting compounds having a device defining a disk-shaped geometry, the device having a centre, a plurality of fluid channels each comprising a fluid inlet positioned at a first distance from the centre and a fluid channel end at a second distance from the centre, the second distance being larger than the first distance, one or more sensors arranged at each fluid channel, wherein the sensors each comprise at least one optical detectable member, the test apparatus further comprising one or more optical sensing devices arranged for sensing the at least one optical detectable member of the one or more sensors, and a rotation device adapted for rotating the device so that the sensors pass over the one or more optical sensing devices, the method comprising: providing a fluid at an inlet near the centre of the device, rotating the device, and obtaining properties of the sensors using the optical sensing devices.
3D microstructuring of biodegradable polymers

Biopolymer films with a thickness of 100μm are prepared using spin coating technique with solutions consisting of 25wt.% polycaprolactone or poly-l-lactide in dichloromethane. SU-8 stamps are fabricated using three photolithography steps. The stamps are used to emboss 3D microstructures in the biopolymer films. It is found that the best pattern transfer for the polycaprolactone films is achieved just below the melting point at 60°C. For the poly-l-lactide films the best pattern transfer is achieved at 120°C.

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Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Nagstrup, J. (Intern), Keller, S. S. (Intern), Almdal, K. (Intern), Boisen, A. (Intern)
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An electrochemical-cantilever platform for hybrid sensing applications

This work presents a fully-functional, microfabricated electrochemical-cantilever hybrid platform with flow control. A new cantilever chip format is designed, fabricated, and mounted in a custom polymer flow cell. Issues such as leakage and optical/electrical access are addressed, and combined mechanical and electrochemical performance is investigated. Lastly, a cantilever is "defunctionalized" in situ to create a reference cantilever for differential measurements in detection of Cu2+ ions at concentrations of 10 μM and 100 nM.
Biodegradable micromechanical sensors

The development of biopolymers for food packaging, medical engineering or drug delivery is a growing field of research [1]. At the same time, the interest in methods for detailed analysis of biopolymers is increasing. Micromechanical sensors are versatile tools for the characterization of mechanical and thermal properties of polymers. For example, measurements of the resonance frequency of cantilevers were used to characterize thin polymer coatings in various environmental conditions [2]. Also, the influence of humidity on the Young’s modulus of SU-8 was evaluated [3]. However, introduction of biopolymers to microfabrication is challenging, as these polymers are affected by common processes such as photolithography or wet etching. Here, we present two methods for fabrication of biodegradable micromechanical sensors. First, we fabricated bulk biopolymer microcantilevers using nanoimprint lithography (NIL). Second, we used spray-coating to deposit thin biodegradable films on microcantilevers. Both approaches allowed the determination of the Young’s modulus of the biopolymer. Furthermore, biodegradation by enzymes was investigated.

Cantilever-based micro-particle filter with simultaneous single particle detection

Currently, separation of whole blood samples on lab-on-a-chip systems is achieved via filters followed by analysis of the filtered matter such as counting of blood cells. Here, a micro-chip based on cantilever technology is developed, which enables simultaneous filtration and counting of micro-particles from a liquid. A hole-array is integrated into a micro-cantilever, which is inserted into a microfluidic channel perpendicular to the flow. A metal pad at the apex of the cantilever enables an optical read-out of the deflection of the cantilever. When a micro-particle is too large to pass a hole in the cantilever, clogging of the holes increases the flow resistance of the cantilever. This causes a bending of the device, which can be detected by the optical read-out system. By arranging an array of such cantilevers with different hole sizes, separation by size can be achieved. In this paper a proof of concept of the device is demonstrated by filtering and counting 20 µm polystyrene beads dispersed in an aqueous solution.
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.264 SNIP 2.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.165 SNIP 2.073
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.057 SNIP 1.881
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.416 SNIP 1.579
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.103 SNIP 1.507
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.763 SNIP 1.651
Web of Science (2001): Indexed yes
Cantilever-Based Microwave Biosensors: Analysis, Designs and Optimizations

This paper presents a novel microwave readout scheme for measuring deflection of cantilevers in nanometer range. The cantilever deflection can be sensed by the variation of transmission levels or resonant frequencies of microwave signals. The sensitivity of the cantilever biosensor based on LC resonators is at first theoretically analyzed. A LC resonator based biosensor with beams is designed and optimized by using 3D electromagnetic (EM) simulations, where the beam is a typical variation of cantilevers. The sensitivity of the lossless biosensor is predicted as 4.6MHz/nm. The 3-dB bandwidths of the resonances are narrowed for improving the resolution of distinguishing resonances by reducing conductive loss of electrodes. The lossy biosensor can achieve the highest sensitivity as 5.6 MHz/nm and narrowest 3-dB bandwidth as 5 GHz.

General information
State: Published
Organisations: Electromagnetic Systems, Department of Electrical Engineering, Department of Micro- and Nanotechnology
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Cantilever-like micromechanical sensors
The field of cantilever-based sensing emerged in the mid-1990s and is today a well-known technology for label-free sensing which holds promise as a technique for cheap, portable, sensitive and highly parallel analysis systems. The research in sensor realization as well as sensor applications has increased significantly over the past 10 years. In this review we will present the basic modes of operation in cantilever-like micromechanical sensors and discuss optical and electrical means for signal transduction. The fundamental processes for realizing miniaturized cantilevers are described with focus on silicon-and polymer-based technologies. Examples of recent sensor applications are given covering such diverse fields as drug discovery, food diagnostics, material characterizations and explosives detection.

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Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Dohn, S. (Intern), Keller, S. S. (Intern), Schmid, S. (Intern), Tenje, M. (Intern)
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Damping mechanisms in high-Q micro and nanomechanical string resonators

Resonant micro and nanostrings were found to have extraordinarily high quality factors (Qs). Since the discovery of the high Qs of silicon nitride nanostrings, the understanding of the underlying mechanisms allowing such high quality factors has been a topic of several investigations. So far it has been concluded that Q is enhanced due to the high energy stored in the string tension. In this paper, damping mechanisms in string resonators are systematically investigated by varying the geometry and the tensile stress of silicon nitride microstrings. The measured quality factors are compared to an analytical model for Q based on bending-related damping mechanisms. It is shown that internal material damping is limiting the quality factor of narrow strings with a width of 3 μm. Q is strongly width dependent and clamping losses evidently seem to be the limiting damping mechanism for wider strings. It is further shown that Q is influenced by interference effects in the substrate and thus by the clamping of the macroscopic chip. A maximum quality factor of up to 7 million is presented for high-stress silicon nitride strings with a resonance frequency of 176 kHz.
Data representation and feature selection for colorimetric sensor arrays used as explosives detectors

Within the framework of the strategic research project Xsense at the Technical University of Denmark, we are developing a colorimetric sensor array which can be useful for detection of explosives like DNT, TNT, HMX, RDX and TATP and identification of volatile organic compounds in the presence of water vapor in air. In order to analyze colorimetric sensors with statistical methods, the sensory output must be put into numerical form suitable for analysis. We present new ways of extracting features from a colorimetric sensor and determine the quality and robustness of these features using machine learning classifiers. Sensors, and in particular explosive sensors, must not only be able to classify explosives, they must also be able to measure the certainty of the classifier regarding the decision it has made. This means there is a need for classifiers that not only give a decision, but also give a posterior probability about the decision. We will compare K-nearest neighbor, artificial neural networks and sparse logistic regression for colorimetric sensor data analysis. Using the sparse solutions we perform feature selection and feature ranking and compare to Gram-Schmidt orthogonalization.

Deposition of biopolymer films on micromechanical sensors

The influence of various parameters on the spray-coating of thin films of poly(l-lactide) (PLLA) was investigated. The optimized processing conditions were used for deposition of the biodegradable polymer on arrays of SU-8 microcantilevers. The resonance frequency of the cantilevers before and after spray-coating was measured which allowed the characterization of the mechanical properties of the coatings. Initial experiments on enzymatic degradation of the PLLA were performed.
Development and characterization of electrochemical cantilever sensor for bio/chemical sensing applications

We report the improvements made to our previously developed electrochemical cantilever (EC) sensor, where nanoporous gold material is employed as working electrodes in microcantilever arrays, while combined counter-reference electrodes are integrated on the chip. For a surface stress change of 1 mN/m induced on the microcantilever, the cantilever deflects 7.3 nm at the free end, indicating high sensitivity to surface stress changes. The results suggest that the performance of the electrochemical cell is stable. A much enhanced sensitivity in surface chemistry-driven actuation can be achieved by using nanoporous gold with a high-surface area to volume ratio.

Development of a microfabricated electrochemical-cantilever hybrid platform

The design and fabrication of a combined electrochemical-cantilever microfluidic system is described. A chip integrating cantilevers with electrodes into a microchannel is presented with the accompanying polymer flow cell. Issues such as electrical and fluid connections are addressed, electromechanical behavior in ionic solution is investigated, and two uses of the system are demonstrated. First, all cantilevers are functionalized with cysteine, to facilitate detection of Cu²⁺ ions, then one cantilever is electrochemically cleaned in situ to generate a reference cantilever for differential measurements. Two concentrations of Cu²⁺ ions are successfully measured in this way. Clean cantilevers are used to probe a solution with and without [Fe(CN)₆]³⁻/⁴⁻ redox couple present, demonstrating the combined voltammetric and deflection readout.
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.07 SJR 1.343 SNIP 1.464
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.225 SNIP 1.484 CiteScore 4.84
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.229 SNIP 1.658 CiteScore 4.37
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.261 SNIP 1.638 CiteScore 4.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.412 SNIP 1.674 CiteScore 3.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.485 SNIP 1.752 CiteScore 4.08
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.434 SNIP 1.437
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.317 SNIP 1.518
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.448 SNIP 1.566
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.446 SNIP 1.598
Scopus rating (2006): SJR 1.359 SNIP 1.535
Scopus rating (2005): SJR 1.28 SNIP 1.843
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.327 SNIP 1.506
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.185 SNIP 1.395
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.076 SNIP 1.078
Scopus rating (2001): SJR 0.841 SNIP 1.145
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.958 SNIP 1.309
Web of Science (2000): Indexed yes
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Development of nanoporous gold electrodes for electrochemical applications

In this work we have used simple microfabrication techniques and chemical de-alloying of co-sputtered AgAu alloys to create nanoporous gold (np-Au) electrodes. The physical properties of the np-Au electrodes were investigated using scanning electron microscopy with energy dispersive X-ray analysis, X-ray photo-electron spectroscopy and profilometer. The electrochemical performance of the np-Au electrodes was measured by cyclic voltammetry and electrochemical impedance spectroscopy. We have fabricated np-Au electrodes with pore sizes between 10 nm and 60 nm, directly related to the Ag:Au ratio. The electrochemical results reveal that np-Au electrodes have much lower impedance than the conventional Au electrodes, due to the significantly higher surface area to volume ratio of np-Au. The np-Au electrodes made from Ag66Au34 and Ag60Au40 show more than 10-fold magnitude reduction in impedance compared to conventional Au electrodes. These results show that np-Au electrodes have a great potential for electrochemical applications.
Nanoporous gold, Electrochemistry, Cyclic voltammetry, Electrochemical impedance spectroscopy

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Development of nanostructured protective “sight glasses” for IR gas sensors

In this work protective “sight glasses” for infrared gas sensors showing a sub-wavelength nanostructure with random patterns have been fabricated by reactive ion etching (RIE) in an easy and comparable cheap single step mask-less process. By an organic coating, the intrinsic water repellent property of the surface could be enhanced, shown by contact angle and roll-off angle measurements. The "self-cleaning" surface property and chemical robustness towards aggressive environments are demonstrated. FT-IR spectroscopy concerning the optical properties of these nanostructured silicon windows revealed a stable anti-reflective "moth-eye" effect in certain wavelength ranges owing to the nanostructures.

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Organisations: Department of Micro- and Nanotechnology, Plasma Physics and Technology Programme, Risø National Laboratory for Sustainable Energy, Nanoprobe Group, NanoSystemsEngineering Section, Danfoss A/S
Authors: Bergmann, R. (Intern), Davis, Z. J. (Intern), Schmidt, M. S. (Intern), Clausen, S. (Intern), Boisen, A. (Intern), Jensen, J. M. (Ekstern), Buchner, R. (Ekstern), Stolberg-Rohr, T. (Ekstern), Jakobsen, M. H. (Intern)
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Differential thermal analysis microsystem for explosive detection

A micro differential thermal analysis (DTA) system is used for detection of trace explosive particles. The DTA system consists of two silicon micro chips with integrated heaters and temperature sensors. One chip is used for reference and one for the measurement sample. The sensor is constructed as a small silicon nitride membrane incorporating heater elements and a temperature measurement resistor. In this manuscript the DTA system is described and tested by measuring calorimetric response of 3 different kinds of explosives (TNT, RDX and PETN). This project is carried out under the framework of the Xsense project at the Technical University of Denmark (DTU) which combines four independent sensing techniques, these micro DNT sensors will be included in handheld explosives detectors with applications in homeland security and landmine clearance.
Fabrication and characterization of SRN/SU-8 bimorph cantilevers for temperature sensing

Polymer coated ceramic cantilevers are highly sensitive to temperature changes, due to the large difference in coefficient of thermal expansion of the two materials. Silicon rich nitride (SRN) cantilevers coated with SU-8 for temperature sensing were fabricated and tested. The devices were coated with SU-8 through spin coating before they were released to obtain bimorph cantilevers. Deflection versus temperature measurements were carried out in ambient and nitrogen atmosphere. In ambient atmosphere, two different effects were observed as the temperature was cycled between 20 and 50°C; (i) shrinkage of SU-8 with increasing temperature, due to evaporation of absorbed moisture and (ii) thermal expansion of SRN and SU-8. Separately, these two effects generate bending in opposite direction. The observed overall bending was seen to be a combination of both. In nitrogen atmosphere, the cantilevers showed a unidirectional deflection versus temperature characteristic. Transverse bending of the cantilevers resulted in an increased rigidity of the cantilevers which could explain the ~50% lower temperature response compared to the theoretical values.
Fabrication of a cantilever-based microfluidic flow meter with nL min\(^{-1}\) resolution

A microfluidic flow meter based on cantilever deflection is developed, showing a resolution down to 3 nL min\(^{-1}\) for flows in the microliter range. The cantilevers are fabricated in SU-8 and have integrated holes with dimensions from 5 x 5 to 20 x 20 μm\(^2\). The holes make it possible to measure in a liquid environment. With a lithography optimization, holes as small as 3 x 3 μm\(^2\) can be opened. Further on, an isotropic Si etch step is inserted into the fabrication sequence to ensure a high release yield of the devices (percentage of usable/not broken chips compared to the amount of released chips). With this etch the cantilever structures are under-etched before they are released by tweezers and the release yield is enhanced from 41.5% to 84.0%. In a continuous flow mode, the deflection of the cantilevers is directly proportional to the flow rate. By tuning the design of the integrated grid (hole size, hole-to-hole distance, amount of holes, etc) the sensitivity of the sensor can be changed.
Fabrication of biopolymer cantilevers using nanoimprint lithography
The biodegradable polymer poly(l-lactide) (PLLA) was introduced for the fabrication of micromechanical devices. For this purpose, thin biopolymer films with thickness around 10 μm were spin-coated on silicon substrates. Patterning of microcantilevers is achieved by nanoimprint lithography. A major challenge was the high adhesion between PLLA and silicon stamp. Optimized stamp fabrication and the deposition of a 125 nm thick fluorocarbon anti-stiction coating on the PLLA allowed the fabrication of biopolymer cantilevers. Resonance frequency measurements were used to estimate the Young's modulus of the device material.

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BFI (2016): BFI-level 2
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Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
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Fabrication of high aspect ratio SU-8 micropillar arrays

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Organisations: Department of Micro- and Nanotechnology
Authors: Amato, L. (Intern), Keller, S. S. (Intern), Heiskanen, A. (Intern), Dimaki, M. (Intern), Emnéus, J. (Intern), Boisen, A. (Intern), Tenje, M. (Intern)
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Main Research Area: Technical/natural sciences

Fabrication of resonant micro cantilevers with integrated transparent fluidic channel

Microfabricated cantilevers are proving their potential as excellent tools for analysis applications. In this paper, we describe the design, fabrication and testing of resonant micro cantilevers with integrated transparent fluidic channels. The
Cantilevers have been devised to measure the density of fluids or detect particles suspended in a fluid by sensing the change in total mass of the structure. The 4 × 4 μm² integrated microfluidic channel makes it possible to flow a fluid through the channel while the cantilevers are resonating. The movement of any particles (present in the fluid) can be visually observed through the transparent fluidic channel. The resonant frequency of the cantilever is changed by the fluid inside the channel, due to the change in mass. The shift in the resonant frequency can be translated into a density of the fluid or into the presence of macro/micro molecules. Such cantilevers can be used as density sensors, to monitor growth of biological cells, measure mass of particles, etc.
In this paper we present a completely new and fully automated system for parallel microcantilever-based biosensing. Our platform is able to monitor simultaneously the change of resonance frequency (dynamic mode), of deflection (static mode), and of surface roughness of hundreds of cantilevers in a very short time over multiple biochemical reactions. We have proven that our system is capable to measure 900 independent microsensors in less than a second. Here, we report statistical biosensing results performed over a haptens-antibody assay, where complete characterization of the biochemical binding on the cantilever surfaces is obtained with higher accuracy than standard optical lever-based setups.

**General information**

State: Published

Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section, Academia Sinica Taiwan


Pages: 877-880

Publication date: 2011

**Host publication information**

Title of host publication: IEEE 24. International Conference on Micro Electro Mechanical Systems

Publisher: IEEE

ISBN (Print): 978-1-4244-9632-7

Main Research Area: Technical/natural sciences


Surface roughness, Measurement by laser beam, Surface treatment, Resonant frequency, Optical sensors, Laser beams

DOI: 10.1109/MEMSYS.2011.5734565

Source: orbit

Source-ID: 279185

Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

**High throughput label-free platform for statistical bio-molecular sensing**

Sensors are crucial in many daily operations including security, environmental control, human diagnostics and patient monitoring. Screening and online monitoring require reliable and high-throughput sensing. We report on the demonstration of a high-throughput label-free sensor platform utilizing cantilever based sensors. These sensors have often been acclaimed to facilitate highly parallelized operation. Unfortunately, so far no concept has been presented which offers large datasets as well as easy liquid sample handling. We use optics and mechanics from a DVD player to handle liquid samples and to read-out cantilever deflection and resonant frequency. Also, surface roughness is measured. When combined with cantilever deflection the roughness is discovered to hold valuable additional information on specific and...
unspecific binding events. In a few minutes, 30 liquid samples can be analyzed in parallel, each by 24 cantilever-based sensors. The approach was used to detect the binding of streptavidin and antibodies.

**General information**

State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Surface Engineering Group, Polymer Micro and Nano Engineering Section, Academia Sinica Taiwan
Pages: 2411-2416
Publication date: 2011
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Lab on a Chip
Volume: 11
Issue number: 14
ISSN (Print): 1473-0197
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 6.05 SJR 2.158 SNIP 1.586
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 5.98 SJR 2.162 SNIP 1.569
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.239 SNIP 1.721 CiteScore 5.74
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.555 SNIP 1.797 CiteScore 5.6
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.397 SNIP 1.693 CiteScore 5.9
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.405 SNIP 1.731 CiteScore 5.35
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.54 SNIP 1.788 CiteScore 5.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.718 SNIP 1.876
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.673 SNIP 2.164
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.833 SNIP 1.849
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.441 SNIP 1.827
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.564 SNIP 1.61
Hollow cantilever-based density sensors with embedded microfluidic channel

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Khan, F. (Intern), Schmid, S. (Intern), Davis, Z. J. (Intern), Yan, W. (Ekstern), Stenby, E. (Ekstern), Boisen, A. (Intern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings of International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Microfluidics, Hollow cantilevers, Oil samples, Density sensing
Source: orbit
Source-ID: 278241
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2011

Investigation of Electrochemical and Mechanical Behaviour of Electrochemical Cantilever Sensor by Electrochemical methods

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Quan, X. (Intern), Fischer, L. M. (Intern), Boisen, A. (Intern), Tenje, M. (Intern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings
Volume: Paper No. 196
Main Research Area: Technical/natural sciences
Electronic versions:
Investigation of Electrochemical.pdf

Relations
Activities:
2nd International Conference on Nanotechnology
Source: orbit
Source-ID: 313916
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Large area fabrication of leaning silicon nanopillars for surface enhanced raman spectroscopy

General information
Micromechanical sensors for the measurement of biopolymer degradation

We present microcantilever-based sensors for the characterization of biopolymer degradation by enzymes. Thin films of Poly(L-lactide) (PLLA) were spray-coated onto SU-8 cantilevers with well-known material properties and dimensions. The micromechanical sensors were immersed in solutions of proteinase K to investigate enzymatic degradation of PLLA. A decrease of the resonance frequency after immersion indicated degradation of the biopolymer coating and allowed the estimation of the degradation rate at a specific enzyme concentration.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Dynamic NEMS Group, Nanocarbon, Technical University of Denmark
Authors: Keller, S. S. (Intern), Gammelgaard, L. (Intern), Jensen, M. P. (Ekstern), Schmid, S. (Intern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Publication date: 2011

Host publication information
Publisher: IEEE
ISBN (Print): 978-1-4244-9632-7
Main Research Area: Technical/natural sciences
SU-8 cantilevers, POLY(L-lactide) thin films, Micromechanical sensors, Spray coating, Microcantilever-based sensors, Immersion, Biopolymer degradation, Biopolymer coating, Proteinase K, Enzymes, Resonance frequency
DOIs:
10.1109/MEMSYS.2011.5734460
Source: orbit
Source-ID: 277721
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Microwave absorption properties of gold nanoparticle doped polymers

This paper presents a method for characterizing microwave absorption properties of gold nanoparticle doped polymers. The method is based on on-wafer measurements at the frequencies from 0.5GHz to 20GHz. The on-wafer measurement method makes it possible to characterize electromagnetic (EM) property of small volume samples. The epoxy based SU8 polymer and SU8 doped with gold nanoparticles are chosen as the samples under test. Two types of microwave test devices are designed for exciting the samples through electrical coupling and magnetic coupling, respectively. Measurement results demonstrate that the nanocomposites absorb a certain amount of microwave energy due to gold nanoparticles. Higher nanoparticle concentration results in more significant absorption effect.

General information
State: Published
Organisations: Electromagnetic Systems, Department of Electrical Engineering, Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section, Università degli Studi di Bari Aldo Moro, Goethe University Frankfurt
Pages: 19-22
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Solid State Electronics
Volume: 57
Issue number: 1
ISSN (Print): 0038-1101
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.923 SJR 0.492 CiteScore 1.7
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.544 SNIP 0.976 CiteScore 1.67
In the framework of the research project "Xsense" at the Technical University of Denmark (DTU) we are developing a simple colorimetric sensor array which can be useful in detection of explosives like DNT, TATP, HMX, RDX and identification of reagents needed for making homemade explosives. The technology is based on an array of chemoselective compounds immobilized on a solid support. Upon exposure to the analyte in suspicion the colorimetric array changes color. Each chosen compound reacts chemo-selectively with analytes of interest. A change in a color signature indicates the presence of unknown explosives and volatile organic compounds (VOCs). We are working towards the selection of compounds that undergo color changes in the presence of explosives and VOCs, as well as the development of an immobilization method for the molecules. Digital imaging of the colorimetric array before and after exposure to the analytes creates a color difference map which gives a unique fingerprint for each explosive and VOCs. Such sensing technology can be used for screening relevant explosives in a complex background as well as to distinguish mixtures of volatile organic compounds distributed in gas and liquid phases. This sensor array is inexpensive, and can potentially be produced as single use disposable.

Multi-colorimetric sensor array for detection of explosives in gas and liquid phase

On-wafer measurement, Microwave absorption, Polymer nanocomposites, Gold nanoparticles

DOIs:
10.1016/j.sse.2010.10.021

State: Published
Organisations: Department of Micro- and Nanotechnology, Cognitive Systems, Department of Informatics and Mathematical Modeling, Nanoprobes Group, NanoSystemsEngineering Section, Surface Engineering Group, Polymer
Multisensor array for detection of analytes or mixtures thereof in gas or liquid phase

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Jeppesen, J. O. (Ekstern), Kostesha, N. (Intern), Johnsen, C. (Ekstern), Nielsen, K. A. (Ekstern), Boisen, A. (Intern), Jakobsen, M. H. (Intern)
Publication date: 2011

Publication information
Patent number: WO 2011121077
Date: 06/10/2011
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 316992
Publication: Research › Patent – Annual report year: 2011

Quality factor improvement of silicon nitride micro string resonators
Resonant micro and nano strings are of interest for sensor applications due to their extraordinary high quality factors, low mass and tunable resonant frequency. It has been found that the quality factor of strings is usually limited by clamping loss. In this work, clamping loss has been addressed by varying the clamping design and string geometry. We present silicon nitride micro strings with quality factors (Q) of up to 4 million in high vacuum achieved by minimizing clamping loss. For applications such as for chemical sensing, strings need to vibrate at atmospheric pressure. Maximal quality factor values in air were measured for the shortest strings with the highest resonant frequency having an optimal width to height ratio.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration Group, NanoSystemsEngineering Section, Nanoprobes Group
Authors: Schmid, S. (Intern), Malm, B. (Intern), Boisen, A. (Intern)
Pages: 481 - 484
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: International Conference on Micro Electro Mechanical Systems
ISSN (Print): 1084-6999
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.422 SJR 0.281 CiteScore 0.91
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.312 SNIP 0.495 CiteScore 0.67
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.337 SNIP 0.54 CiteScore 0.73
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.422 SNIP 0.654 CiteScore 0.63
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.368 SNIP 0.63 CiteScore 0.72
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.38 SNIP 0.691 CiteScore 0.57
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Rotating microcantilever array platform for high-throughput statistical biosensing

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section, Academia Sinica Taiwan
Authors: Bosco, F. (Intern), Chen, C. H. (Ekstern), Hwu, E. T. (Ekstern), Keller, S. S. (Intern), Boisen, A. (Intern)
Publication date: 2011
Main Research Area: Technical/natural sciences
Links:
http://www.nmc2011.org/
Source: orbit
Source-ID: 277920
Publication: Research - peer-review › Conference article – Annual report year: 2011

SERS substrate and a method of providing a SERS substrate
Source: US2011116089A A substrate primarily for SERS determination, the substrate has a number of elongate elements with a density of at least 1x108 elongate elements per cm2 and having metal coated tips. When the elements may be made to lean toward each other, such as by providing a drop of a liquid thereon and allowing the liquid to dry, groups of tips of elongate elements are formed and the Raman enhancement is extremely high.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes
Authors: Schmidt, M. S. (Intern), Boisen, A. (Intern), Hübner, J. (Intern)
Publication date: 2011

Publication Information
Country: Denmark
IPC: B05D1/36
Patent number: WO2011047690
Date: 28/04/2011
Original language: English

Bibliographical note
DTU reference nummer: 92468-09
Main Research Area: Technical/natural sciences
Publication: Research › Patent – Annual report year: 2012

Spatial confinement of amorphous indomethacin increases stability

General information
Surface enhanced Raman scattering substrates consumables for Raman spectroscopy

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Schmidt, M. S. (Intern), Boisen, A. (Intern), Hübner, J. (Intern)
Publication date: 2011

Publication information
Patent number: WO 2011047690
Date: 28/04/2011
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317048
Publication: Research › Patent – Annual report year: 2011

The Xsense project: The application of an intelligent sensor array for high sensitivity handheld explosives detectors

Multiple independent sensors are used in security and military applications in order to increase sensitivity, selectivity and data reliability. The Xsense project has been initiated at the Technical University of Denmark in collaboration with a number of partners in an effort to produce a handheld sensor for trace detection of explosives. We are using micro- and nano technological approaches for integrating four sensing principles into a single device. At the end of the project, the consortium aims at having delivered a sensor platform consisting of four independent detector principles capable of identifying concentrations of TNT, DNT, HMX and RDX at sub parts-per-billion (ppb) levels and with a false positive rate less than 1 parts-per-thousand. The specificity, sensitivity, reliability and the speed of responses are ensured by the use of advanced data processing, surface functionalization and nanostructured sensors and sensor design.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Cognitive Systems, Department of Informatics and Mathematical Modeling, Surface Engineering Group, Polymer Micro and Nano Engineering Section, University of Southern Denmark, University of Alberta
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE Sensors Applications Symposium
Publisher: IEEE
ISBN (Print): 978-1-4244-8063-0
Main Research Area: Technical/natural sciences
Sensor arrays, Surface treatment, Temperature sensors, Explosives, Chemical sensors
Electronic versions: 05739782[1].pdf
DOI: 10.1109/SAS.2011.5739782
Transparent hollow micro cantilevers based mass sensor

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Khan, F. (Intern), Schmid, S. (Intern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings of International Workshop on Nanomechanical Sensing
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 316123
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2011

Ultrasensitive string-based temperature sensors
Resonant strings are a promising concept for ultra sensitive temperature detection. We present an analytical model for the sensitivity with which we optimize the temperature response of resonant strings by varying geometry and material. The temperature sensitivity of silicon nitride and aluminum microstrings was measured. The relative change in resonant frequency per temperature change of -1.74 +/- 0.04%/ degrees C of the aluminum strings is more than one order of magnitude higher than of the silicon nitride strings and of comparable state-of-the-art AuPd strings.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, VTT - Technical Research Centre of Finland, Nokia Research Center
Authors: Larsen, T. (Intern), Schmid, S. (Intern), Gronberg, L. (Ekstern), Niskanen, A. O. (Ekstern), Hassel, J. (Ekstern), Dohn, S. (Intern), Boisen, A. (Intern)
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Volume: 98
Issue number: 12
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.499 SNIP 1.226 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.861 SNIP 1.492 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.146 SNIP 1.633 CiteScore 3.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Xsense: a miniaturised multi-sensor platform for explosives detection

Realizing that no one sensing principle is perfect we set out to combine four fundamentally different sensing principles into one device. The reasoning is that each sensor will complement the others and provide redundancy under various environmental conditions. As each sensor can be fabricated using microfabrication the inherent advantages associated with MEMS technologies such as low fabrication costs and small device size allows us to integrate the four sensors into one portable device at a low cost.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Cognitive Systems, Department of Informatics and Mathematical Modeling, University of Southern Denmark, University of Alberta
Pages: 803123-7
Publication date: 2011
Microfluidic sensors based on perforated cantilevers
Development of the colorimetric sensor array for detection of explosives and volatile organic compounds in air

In the framework of the research project 'Xsense' at the Technical University of Denmark (DTU) we are developing a simple colorimetric sensor array which can be useful in detection of explosives like DNT and TNT, and identification of volatile organic compounds in the presence of water vapor in air. The technology is based on an array of chemoresponsive dyes immobilized on a solid support. Upon exposure to the analyte in suspicion the dye array changes color. Each chosen dye reacts chemo selectively with analytes of interest. A change in a color signature indicates the presence of unknown explosives and volatile organic compounds (VOCs). We are working towards the selection of dyes that undergo color changes in the presence of explosives and VOCs, as well as the development of an immobilization method for the molecules. Digital imaging of the dye array before and after exposure to the analytes creates a color difference map which gives a unique fingerprint for each explosive and volatile organic compound. Such sensing technology can be used to screen for relevant explosives in a complex background as well as to distinguish mixtures of volatile organic compounds distributed in gas phase. This sensor array is inexpensive, and can potentially be produced as single use disposable.
Diffusion of water into SU-8 microcantilevers

We present a method to monitor the diffusion of liquid molecules in polymers. A microdrop of water is deposited by a piezoelectric drop generator onto the upper surface of a cantilever made of SU-8 based photoresist. In response, the cantilever bends in the opposite direction. We find that this bending is mainly caused by the diffusion of water into the cantilever and the consequent swelling of SU-8. Using a one-dimensional diffusion model and assuming a simple swelling law, we qualitatively model the bending of the cantilever during in and out diffusion of water in SU-8. With a more sophisticated finite element model the diffusion coefficient of water in the SU-8 polymer can be determined quantitatively from the dynamics of cantilever bending.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Max Planck Institute
Authors: Liu, C. (Ekstern), Liu, Y. (Ekstern), Sokuler, M. (Ekstern), Fell, D. (Ekstern), Keller, S. (Ekstern), Boisen, A. (Intern), Butt, H. (Ekstern), Auernhammer, G. (Ekstern), Bonaccurso, E. (Ekstern)
Pages: 10577-10583
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Physical Chemistry Chemical Physics
Volume: 12
Issue number: 35
ISSN (Print): 1463-9076
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.04 SJR 1.686 SNIP 1.089
Web of Science (2017): Indexed yes
Double layer resist process scheme for metal lift-off with application in inductive heating of microstructures

We present a new method to define metal electrodes on top of high-aspect-ratio microstructures using standard photolithography equipment and a single chromium mask. A lift-off resist (LOR) layer is implemented in an SU-8 photolithography process to selectively remove metal at the end of the processing. In this way, we have successfully defined metal electrodes on top of 75 μm high SU-8 microstructures to be used as test structures for the measurement of temperature increase due to inductive heating.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Ouattara, L. (Intern), Knutzen, M. (Intern), Keller, S. U. (Intern), Hansen, M. F. (Ekstern), Boisen, A. (Intern)
Pages: 1226-1228
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 87
Issue number: 5-8
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.027 SNIP 1.06
Web of Science (2008): Indexed yes
Drift study of SU8 cantilevers in liquid and gaseous environments

We present a study of the drift, in terms of cantilever deflections without probe/target interactions, of polymeric SU8 cantilevers. The drift is measured in PBS buffer (pH 7.4) and under vacuum (1 mbar) conditions. We see that the cantilevers display a large drift in both environments. We believe this is because the polymer matrix absorbs liquid in one situation whereas it is being degassed in the other. An inhomogeneous expansion/contraction of the cantilever is seen because one surface of the cantilever may still have remains of the release layer from the fabrication. To further study the effect, we coat the cantilevers with a hydrophobic coating, perfluorodecyltrichlorosilane (FDTS). Fully encapsulating the SU8 cantilever greatly reduces the drift in liquid whereas a less significant change is seen in vacuum.

General information

State: Published
Organisations: Nanoprobes Group, NanoSystems Engineering Section, Department of Micro- and Nanotechnology, Dynamic NEMS Group
Authors: Tenje, M. (Intern), Keller, S. S. (Intern), Dohn, S. (Intern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Pages: 596-598
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information

Journal: Ultramicroscopy
Volume: 110
Issue number: 6
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.06 SJR 1.824 SNIP 1.317
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 1.896 SNIP 1.176
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.066 SNIP 1.326 CiteScore 2.78
Web of Science (2015): Indexed yes
**Fabrication of polymer microcantilevers by nanoimprint lithography**

**General information**

**State:** Published

**Organisations:** Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nano-Bio Integrated Systems Group, Biomedical Micro Systems Section

**Authors:** Greve, A. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)

**Publication date:** 2010

**Publication information**
Fabrication of thin SU-8 cantilevers: initial bending, release and time stability

SU-8 cantilevers with a thickness of 2 μm were fabricated using a dry release method and two steps of SU-8 photolithography. The processing of the thin SU-8 film defining the cantilevers was experimentally optimized to achieve low initial bending due to residual stress gradients. In parallel, the rotational deformation at the clamping point allowed a qualitative assessment of the device release from the fluorocarbon-coated substrate. The change of these parameters during several months of storage at ambient temperature was investigated in detail. The introduction of a long hard bake in an oven after development of the thin SU-8 film resulted in reduced cantilever bending due to removal of residual stress gradients. Further, improved time-stability of the devices was achieved due to the enhanced cross-linking of the polymer. A post-exposure bake at a temperature T-PEB = 50 degrees C followed by a hard bake at T-HB = 90 degrees C proved to be optimal to ensure low cantilever bending and low rotational deformation due to excellent device release and low change of these properties with time. With the optimized process, the reproducible fabrication of arrays with 2 μm thick cantilevers with a length of 500 μm and an initial bending of less than 20 μm was possible. The theoretical spring constant of these cantilevers is k = 4.8 +/- 2.5 mN m(-1), which is comparable to the value for Si cantilevers with identical dimensions and a thickness of 500 nm.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Keller, S. U. (Intern), Haefliger, D. (Ekstern), Boisen, A. (Intern)
Pages: 45024
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 20
Issue number: 4
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
A heater design, used in a micro-calorimetric sensor, has been optimized for temperature uniformity in order to increase the sensitivity and reliability of detection of trace amounts of explosives. In this abstract the design, fabrication and characterization is described. The performance of the novel heater design is characterized by measuring the temperature coefficient of resistivity (TCR) values and by mapping the temperature distribution using Raman spectroscopy. The new heater design is seen to have increased the temperature uniformity by a factor of 2.3.

**Micro-calorimetric sensor for vapor phase explosive detection with optimized heat profile**

A heater design, used in a micro-calorimetric sensor, has been optimized for temperature uniformity in order to increase the sensitivity and reliability of detection of trace amounts of explosives. In this abstract the design, fabrication and characterization is described. The performance of the novel heater design is characterized by measuring the temperature coefficient of resistivity (TCR) values and by mapping the temperature distribution using Raman spectroscopy. The new heater design is seen to have increased the temperature uniformity by a factor of 2.3.
Modeling the Kelvin polarization force actuation of Micro- and Nanomechanical systems

Polarization forces have become of high interest in micro- and nanomechanical systems. In this paper, an analytical model for a transduction scheme based on the Kelvin polarization force is presented. A dielectric beam is actuated by placing it over the gap of two coplanar electrodes. Finite element method simulations are used to characterize the scheme and to evaluate a field correction factor, which results from simplifying the form of the electric field. The model has been shown to be valid for dielectrics with different permittivities. The presented model facilitates the design of microresonators and nanoresonators with dielectric actuation, which offers a great freedom in the choice of structural material.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Schmid, S. (Intern), Hierold, C. (Ekstern), Boisen, A. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Physics
Volume: 107
Issue number: 5
ISSN (Print): 0021-8979
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.03 SJR 0.739 SNIP 0.953
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.72 SJR 0.906 SNIP 0.977
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.821 SNIP 0.996 CiteScore 1.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.039 SNIP 1.197 CiteScore 2.04
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.155 SNIP 1.286 CiteScore 2.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.312 SNIP 1.291 CiteScore 2.13
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.374 SNIP 1.3 CiteScore 2.24
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.484 SNIP 1.204
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.51 SNIP 1.237
Nanostructured surface enhanced Raman scattering substrates for explosives detection

Here we present a method for trace detection of explosives in the gas phase using novel surface enhanced Raman scattering (SERS) spectroscopy substrates. Novel substrates that produce an exceptionally large enhancement of the Raman effect were used to amplify the Raman signal of explosives molecules adsorbed onto the substrate. The substrates were fabricated in a cleanroom process which only requires two steps to produce well controlled nano-sized high aspect ratio metal pillars. These substrates had superior chemical sensing performance in addition to a more cost effective fabrication process compared to existing commercial substrates. Therefore it is believed that these novel substrates will be able to make SERS more applicable in mobile explosives detection systems to be deployed in for example landmine clearance actions.
Novel SU-8 based vacuum wafer-level packaging for MEMS devices

This work presents a simple and low-cost SU-8 based wafer-level vacuum packaging method which is CMOS and MEMS compatible. Different approaches have been investigated by taking advantage of the properties of SU-8, such as chemical resistance, optical transparency, mechanical reliability and versatility. A novel technique of wafer level adhesive bonding, which uses SU-8 as structural and adhesive material, has been developed and successfully demonstrated. Optical inspection and SEM images were used in order to measure the package lid bending and probe the encapsulation sealing. In addition, an indirect vacuum level measurement has been carried out by comparing the different quality factors of a test cantilever resonator when this element is packed or unpacked.
Polymer-coated vertical-cavity surface-emitting laser diode vapor sensor

We report a new method for monitoring vapor concentration of volatile organic compounds using a vertical-cavity surface-emitting laser (VCSEL). The VCSEL is coated with a polymer thin film on the top distributed Bragg reflector (DBR). The analyte absorption is transduced to the electrical domain through modulation of the VCSEL output power as the polymer swell. We have investigated the responsivity of this technique experimentally using a plasma polymerized polystyrene coating and explain the results theoretically as a reflectance modulation of the top DBR.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Department of Micro- and Nanotechnology, Polymer Microsystems for Cell Processing Group, Polymer Micro and Nano Engineering Section, Nanoprobes Group, NanoSystems Engineering Section, Nanophotonics Theory and Signal Processing
Pages: 76150A
Publication date: 2010
Conference: Vertical-Cavity Surface-Emitting Lasers, San Francisco, CA, USA, 01/01/2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Proceedings of SPIE, the International Society for Optical Engineering
Volume: 7615
ISSN (Print): 0277-786X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.43 SJR 0.243 SNIP 0.289
Resonant microcantilevers are highly sensitive to added masses and have the potential to be used as mass-spectrometers. However, making the detection of individual added masses quantitative requires the position determination for each added mass. We derive expressions relating the position and mass of several added particles to the resonant frequencies of a cantilever, and an identification procedure valid for particles with different masses is proposed. The
identification procedure is tested by calculating positions and mass of multiple microparticles with similar mass positioned on individual microcantilevers. Excellent agreement is observed between calculated and measured positions and calculated and theoretical masses.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Dohn, S. (Intern), Schmid, S. (Intern), Amiot, F. (Intern), Boisen, A. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Volume: 97
Issue number: 4
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.499 SNIP 1.226 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.861 SNIP 1.492 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.146 SNIP 1.633 CiteScore 3.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.57 SNIP 1.739 CiteScore 3.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.814 SNIP 1.917 CiteScore 4.04
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Real-Time Particle Mass Spectrometry Based on Resonant Micro Strings

Micro- and nanomechanical resonators are widely being used as mass sensors due to their unprecedented mass sensitivity. We present a simple closed-form expression which allows a fast and quantitative calculation of the position and mass of individual particles placed on a micro or nano string by measuring the resonant frequency shifts of the first two bending modes. The method has been tested by detecting the mass spectrum of micro particles placed on a micro string. This method enables real-time mass spectrometry necessary for applications such as personal monitoring devices for the assessment of the exposure dose of airborne nanoparticles.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Schmid, S. (Intern), Dohn, S. (Intern), Boisen, A. (Intern)
Pages: 8092-8100
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors
Volume: 10
Issue number: 9
ISSN (Print): 1424-8220
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.23 SJR 0.584 SNIP 1.55
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.78 SJR 0.623 SNIP 1.614
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.647 SNIP 1.643 CiteScore 2.21
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.707 SNIP 1.796 CiteScore 2.4
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
In this paper, we present a novel approach for measuring the resonant frequency of cantilevers fabricated in polymeric materials. We re-designed the use of a commercial DVD-ROM pickup head and combine it with a glass-polymer substrate in order to obtain a light and portable device to measure the resonant frequency of polymer cantilevers. The use of the Pyrex-SU-8 clamping substrate allows an easy replacement of the cantilever chips and a fast alignment process to the DVD-ROM laser beam. We show measurements of thermal noise for SU-8 and TOPAS cantilevers in air and liquid environment.

**Bibliographical note**
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**Source:** orbit
**Source-ID:** 270362
**Publication:** Research - peer-review › Journal article – Annual report year: 2010

**Self-aligned cantilever positioning for on-substrate measurements using DVD pickup head**

In this paper, we present a novel approach for measuring the resonant frequency of cantilevers fabricated in polymeric materials. We re-designed the use of a commercial DVD-ROM pickup head and combine it with a glass-polymer substrate in order to obtain a light and portable device to measure the resonant frequency of polymer cantilevers. The use of the Pyrex-SU-8 clamping substrate allows an easy replacement of the cantilever chips and a fast alignment process to the DVD-ROM laser beam. We show measurements of thermal noise for SU-8 and TOPAS cantilevers in air and liquid environment.

**General information**
**State:** Published
**Organisations:** Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
**Authors:** Bosco, F. (Intern), Hwu, E. T. (Ekstern), Keller, S. U. (Intern), Greve, A. (Intern), Boisen, A. (Intern)
**Pages:** 708-711
**Publication date:** 2010
**Main Research Area:** Technical/natural sciences

**Publication information**
**Journal:** Microelectronic Engineering
**Volume:** 87
Surface Functionalization of Epoxy-Resist-Based Microcantilevers with Iron Oxide Nanocrystals

A functionalization procedure is integrated in the fabrication of micromechanical SU-8 cantilevers in order to chemically bind organic-capped Fe2O3 NCs at the photoresist surface, under visible light, ambient atmosphere and room temperature. The achieved highly interconnected NC multilayer network is demonstrated an active layer for real-time detection of acetone vapor molecules.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Ingrosso, C. (Intern), Sardella, E. (Ekstern), Keller, S. S. (Intern), Dohn, S. (Intern), Striccoli, M. (Ekstern), Agostiano, A. (Ekstern), Boisen, A. (Intern), Curri, M. (Ekstern)
Pages: 3288-3292
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Advanced Materials
Volume: 22
Issue number: 30
ISSN (Print): 0935-9648
Ratings:
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 21.1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 17.79
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 18.5
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 16.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 15.78
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 14.41
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 12.28
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
The influence of refractive index change and initial bending of cantilevers on the optical lever readout method

It has been speculated that the initial bending of cantilevers has a major influence on the detector signal in a cantilever-based sensor using the optical lever readout method. We have investigated theoretically as well as experimentally the changes induced in the detector signal when the optical lever technique is used to monitor a cantilever with initial bending during changes in the refractive index of the surrounding media. We find that for changes in refractive index as small as $10^{-4}$ the detector signal is highly dependent on the initial bending of the cantilever. The findings are validated experimentally using an environmental chamber and varying the pressure. We sketch routes to circumvent the problem and formulas suitable for data treatment are given.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nano-Bio Integrated Systems Group, Biomedical Micro Systems Section
Authors: Dohn, S. (Intern), Greve, A. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 065104
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Review of Scientific Instruments
Volume: 81
Issue number: 6
ISSN (Print): 0034-6748
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.32 SJR 0.585 SNIP 0.858
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.2 SJR 0.703 SNIP 1.048
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.686 SNIP 0.908 CiteScore 1.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.972 SNIP 1.261 CiteScore 1.45
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.9 SNIP 1.099 CiteScore 1.28
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Thermoplastic microcantilevers fabricated by nanoimprint lithography

Nanoimprint lithography has been exploited to fabricate micrometre-sized cantilevers in thermoplastic. This technique allows for very well defined microcantilevers and gives the possibility of embedding structures into the cantilever surface. The microcantilevers are fabricated in TOPAS and are up to 500 μm long, 100 μm wide, and 4.5 μm thick. Some of the cantilevers have built-in ripple surface structures with heights of 800 nm and pitches of 4 μm. The yield for the cantilever fabrication is 95% and the initial out-of-plane bending is below 10 μm. The stiffness of the cantilevers is measured by deflecting the cantilever with a well-characterized AFM probe. An average stiffness of 61.3 mN m$^{-1}$ is found. Preliminary tests with water vapour indicate that the microcantilevers can be used directly for vapour sensing applications and illustrate the influence of surface structuring of the cantilevers.
Two-Step Fabrication of Metal-Coated Silicon Nanopillars with Large Raman Enhancement

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, DTU
Authors: Schmidt, M. S. (Intern), Hübner, J. (Intern), Boisen, A. (Intern)
Pages: 912-913
Publication date: 2010

Host publication information
Title of host publication: Xxii International Conference on Raman Spectroscopy
Place of publication: Melville
Publisher: American Institute of Physics

Wafer scale coating of polymer cantilever fabricated by nanoimprint lithography
Microcantilevers can be fabricated in TOPAS by nanoimprint lithography, with the dimensions of 500 Å, 4.5 μm length, 100 Å, 100 μm thickness and 100 Å, 100 μm width. By using a plasma polymerization technique it is possible to selectively functionalize individually cantilevers with a polymer coating, on wafer scale by using a shadow masking technique.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, NSE-Optofluidics Group, Polymer Microsystems for Cell Processing Group, Polymer Micro and Nano Engineering Section
Pages: 612-614
Publication date: 2010

Host publication information
Title of host publication: 2010 IEEE 23rd International Conference on Micro Electro Mechanical Systems (MEMS)
Xsense: using nanotechnology to combine detection methods for high sensitivity handheld explosives detectors

In an effort to produce a handheld explosives sensor the Xsense project has been initiated at the Technical University of Denmark in collaboration with a number of partners. Using micro- and nano technological approaches it will be attempted to integrate four detection principles into a single device. At the end of the project, the consortium aims at having delivered a sensor platform consisting of four independent detector principles capable of detecting concentrations of TNT at sub parts-per-billion (ppb) concentrations and with a false positive rate less than 1 parts-per-thousand. The specificity, sensitivity and reliability are ensured by the use of clever data processing, surface functionalisation and nanostructured sensors and sensor surfaces.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Cognitive Systems, Department of Informatics and Mathematical Modeling, Surface Engineering Group, Polymer Micro and Nano Engineering Section, University of Southern Denmark, Oak Ridge National Laboratory

Publication information
Journal: Proceedings of the SPIE - The International Society for Optical Engineering
Volume: 7664
ISSN (Print): 0277-786X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.43 SJR 0.243 SNIP 0.289
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SNIP 0.258 SJR 0.226
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.212 SNIP 0.239 CiteScore 0.3
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.217 SNIP 0.249 CiteScore 0.3
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.234 SNIP 0.273 CiteScore 0.26
ISI indexed (2013): ISI indexed no
Acetone vapor sensing using a vertical cavity surface emitting laser diode coated with polystyrene

We report theoretical and experimental on a new vapor sensor, using a single-mode vertical-cavity surface-emitting laser (VCSEL) coated with a polymer sensor coating, which can detect acetone vapor at a volume fraction of 2.5%. The sensor provides the advantage of standard packaging, small form-factor, mechanical stability and low cost when combined with a monolithically integrated photodiode detector.

General information
State: Published
Source-ID: 258428
Publication: Research › Ph.D. thesis – Annual report year: 2009

High frequency Resonators for liquid based Bio/Chemical diagnostics and monitoring applications

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Hales, J. H. (Intern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Number of pages: 114
Publication date: May 2009
Autonomous valve for detection of biopolymer degradation

We present a polymer microvalve that allows the detection of biopolymer degradation without the need of external energy. The valve is based on a polymer container filled with a colored marker solution and closed by a thin lid. This structure is covered by a film of poly(L-lactide) and degradation of the biopolymer triggers the release of the color which is detected visually. The autonomous valve has potential for the fast testing of biopolymer degradation under various environmental conditions or by specific enzymes.

Cantilever sensors: Nanomechanical tools for diagnostics

Cantilever sensors have attracted considerable attention over the last decade because of their potential as a highly sensitive sensor platform for high throughput and multiplexed detection of proteins and nucleic acids. A micromachined cantilever platform integrates nanoscale science and microfabrication technology for the label-free detection of biological molecules, allowing miniaturization. Molecular adsorption, when restricted to a single side of a deformable cantilever beam, results in measurable bending of the cantilever. This nanoscale deflection is caused by a variation in the cantilever surface stress due to biomolecular interactions and can be measured by optical or electrical means, thereby reporting on the presence of biomolecules. Biological specificity in detection is typically achieved by immobilizing selective receptors or probe molecules on one side of the cantilever using surface functionalization processes. When target molecules are injected into the fluid bathing the cantilever, the cantilever bends as a function of the number of molecules bound to the probe molecules on its surface. Mass-produced, miniature silicon and silicon nitride microcantilever arrays offer a clear path to the development of miniature sensors with unprecedented sensitivity for biodetection applications, such as toxin detection, DNA hybridization, and selective detection of pathogens through immunological techniques. This article discusses applications of cantilever sensors in cancer diagnosis.
**Compact Electrically tunable Waveplate Based on Liquid Crystal Photonic Bandgap Fibers**

A compact tunable waveplate based on negative dielectric liquid crystal photonic bandgap fibers is presented. The birefringence can be tuned electrically to work as a quarter-wave or a half-wave plate in the wavelength range 1520nm-1600nm.

**General information**

State: Published
Organisations: Fiber Optics, Devices and Non-linear Effects, Department of Photonics Engineering, Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Fiber Sensors and Supercontinuum Generation
Authors: Wei, L. (Intern), Alkeskjold, T. T. (Intern), Keller, S. U. (Intern), Lindhard, J. M. (Ekstern), Jensen, H. V. (Intern), Nielsen, K. (Intern), Boisen, A. (Intern), Bjarklev, A. O. (Intern)
Publication date: 2009

**Host publication information**

Title of host publication: Technical digest, CLEO/QELS
Publisher: IEEE
ISBN (Print): 978-1-55752-869-8
Main Research Area: Technical/natural sciences
Conference: Conference on Lasers and Electro-Optics (CLEO)/International Quantum Electronics Conference (IQEC), Baltimore, MA, United States, 01/06/2009 - 01/06/2009
Electronic versions: Wei2.pdf

**Bibliographical note**

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Source: orbit
Source-ID: 247101
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

**Design & fabrication of cantilever array biosensors**

Surface immobilization of functional receptors on microfabricated cantilever arrays offers a new paradigm for the development of biosensors based on nanomechanics. Microcantilever-based systems are capable of real-time, multiplexed detection of unlabeled disease markers in extremely small volumes of samples. Currently available fabrication technology will allow the integration of electronic readout and sample introduction into a single unit, decreasing the device size, detection time, and cost. Biosensing technologies based on microfabricated cantilever arrays involving multiple cantilevers, electronic processing, and even local telemetry on a single chip have the potential of satisfying the need for highly sensitive and selective multiple-target detection in very small samples. Here we will review the design and fabrication process of cantilever-based biosensors.

**General information**

State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Thundat, T. (Ekstern)
Pages: 32-38
Publication date: 2009
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Materials Today
Volume: 12
Issue number: 9
ISSN (Print): 1369-7021
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Gold Cleaning Methods for Electrochemical Detection Applications

This work investigates methods for obtaining reliably clean gold film surfaces. Nine gold cleaning methods are investigated here: UV ozone photoreactor; potassium hydroxide-hydrogen peroxide; potassium hydroxide potential sweep; sulfuric acid hydrogen peroxide; sulfuric acid potential cycling; hydrochloric acid potential cycling; dimethylamine borane reducing agent solutions at 25 and 65 degrees C; and a dilute form of Aqua Regia. Peak-current potential-differences obtained from cyclic voltammetry and charge transfer resistance obtained from electrochemical impedance spectroscopy, as well as X-ray photo-electron spectroscopy are used to characterize surface cleanliness. A low peak-current potential-difference and charge transfer resistance indicates a cleaner surface, as does a higher percentage of elemental gold on the electrode surface. The potassium hydroxide potential sweep method is found to leave the gold surface the cleanest overall.

General information
Longitudinal bulk acoustic mass sensor

Design, fabrication and characterization, in terms of mass sensitivity, is presented for a polycrystalline silicon longitudinal bulk acoustic cantilever. The device is operated in air at 51 MHz, resulting in a mass sensitivity of 100 Hz/fg (1 fg = 10^{-15} g). The initial characterization is conducted by depositing a minute mass by means of focused ion beam. The total noise in the currently applied measurement system allows for a mass resolution of 0.4 fg in air.

General information

State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Hales, J. H. (Intern), Teva, J. (Intern), Boisen, A. (Intern), Davis, Z. J. (Intern)
Pages: 311-314
Publication date: 2009

Host publication information

Publisher: IEEE
ISBN (Electronic): 978-1-4244-4193-8
Main Research Area: Technical/natural sciences
Electronic versions:
Hales.pdf
DOIs:
10.1109/SENSOR.2009.5285500

Bibliographical note

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Source: orbit
Source-ID: 251980
Publication: Research › Article in proceedings – Annual report year: 2009

Longitudinal bulk acoustic mass sensor

A polycrystalline silicon longitudinal bulk acoustic cantilever is fabricated and operated in air at 51 MHz. A mass sensitivity of 100 Hz/fg (1 fg = 10^{-15} g) is obtained from the preliminary experiments where a minute mass is deposited on the device by means of focused ion beam. The total noise in the currently applied measurement system allows for a minimum detectable mass of 0.5 fg in air.

General information
Mass spec goes nanomechanical

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern)
Pages: 404-405
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Nature Nanotechnology
Volume: 4
Issue number: 7
ISSN (Print): 1748-3387
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 25.47 SJR 20.612 SNIP 8.171
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 21.85 SJR 18.916 SNIP 7.649
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 18.842 SNIP 8.019 CiteScore 22.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 17.177 SNIP 8.047 CiteScore 21.76
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Micro-calorimetric sensor for vapour phase explosive detection with optimized heat profile

A heater design, used in a micro-calorimetric sensor, has been optimized for temperature uniformity and the sensor has been used for detection of trace amounts of explosives. In this abstract the design, characterization and functionality is described. The performance of the novel heater design is characterized by measuring the temperature coefficient of resistivity (TCR) values and by mapping the temperature distribution using Raman spectroscopy. The new heater design has increased the temperature uniformity and calorimetric measurements on DNT (2,4-Dinitrotoluene) show more reproducible and better defined signals.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Greve, A. (Intern), Olsen, J. K. (Intern), Boisen, A. (Intern), Privorotskaya, N. (Ekstern), King, W. P. (Ekstern), Senesac, L. (Ekstern), Thundat, T. (Ekstern)
Pages: 723-726
Publication date: 2009

Host publication information
Title of host publication: Sensors, 2009 IEEE
Publisher: IEEE
ISBN (Print): 978-1-4244-4548-6
Main Research Area: Technical/natural sciences
Electronic versions:
Greve.pdf
DOIs:
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Bibliographical note
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Source: orbit
Micro-differential thermal analysis detection of adsorbed explosive molecules using microfabricated bridges

Although micromechanical sensors enable chemical vapor sensing with unprecedented sensitivity using variations in mass and stress, obtaining chemical selectivity using the micromechanical response still remains as a crucial challenge. Chemoselectivity in vapor detection using immobilized selective layers that rely on weak chemical interactions provides only partial selectivity. Here we show that the very low thermal mass of micromechanical sensors can be used to produce unique responses that can be used for achieving chemical selectivity without losing sensitivity or reversibility. We demonstrate that this method is capable of differentiating explosive vapors from nonexplosives and is additionally capable of differentiating individual explosive vapors such as trinitrotoluene, pentaerythritol tetranitrate, and cyclotrimethylene trinitramine. This method, based on a microfabricated bridge with a programmable heating rate, produces unique and reproducible thermal response patterns within 50 ms that are characteristic to classes of adsorbed explosive molecules. We demonstrate that this micro-differential thermal analysis technique can selectively detect explosives, providing a method for fast direct detection with a limit of detection of 600x10(-12) g. ©2009 American Institute of Physics

General information
State: Published
Organisations: Nanoprobes Group, NanoSystems Engineering Section, Department of Micro- and Nanotechnology, Dynamic NEMS Group
Pages: 035102
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Review of Scientific Instruments
Volume: 80
Issue number: 3
ISSN (Print): 0034-6748
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.32 SJR 0.585 SNIP 0.858
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.2 SJR 0.703 SNIP 1.048
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.686 SNIP 0.908 CiteScore 1.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.972 SNIP 1.261 CiteScore 1.45
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.9 SNIP 1.099 CiteScore 1.28
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.017 SNIP 1.277 CiteScore 1.45
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.868 SNIP 1.108 CiteScore 1.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Micro-particle filter made in SU-8 for biomedical applications

We have integrated a micro-particle filter in a polymer cantilever to filter micro-particles from a fluid while simultaneously measuring the amount of filtered particles. In a 3.8 mum thick SU-8 cantilever a filter was integrated with pore sizes between 3 and 30 mum. The chip was inserted in a microfluidic system and water with differently sized polystyrene beads was pumped through the filter. Particles which are larger than the pore sizes, cannot pass the filter and will increase the flow resistance of the cantilever. With more and more captured particles the cantilever starts to deflect, which can be detected by an optical read-out system.
Self-mixing interferometry in VCSELs for nanomechanical cantilever sensing

We have investigated optical read-out of uncoated polymer micrometer-sized cantilever sensors by self-mixing interference in VCSELs for single-molecule gas sensing. A resolution ~0.2 nm is measured, which is much better than current methods.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanophotonics Theory and Signal Processing
Authors: Larsson, D. (Intern), Greve, A. (Intern), Hvam, J. M. (Intern), Boisen, A. (Intern), Yvind, K. (Intern)
Pages: 1-2
Publication date: 2009

Host publication information
Publisher: IEEE
ISBN (Print): 978-1-55752-869-8
Main Research Area: Technical/natural sciences
Conference: Conference on Lasers and Electro‐Optics (CLEO)/International Quantum Electronics Conference (IQEC), Baltimore, MA, United States, 01/06/2009 - 01/06/2009
Electronic versions:
Larsson.pdf

Bibliographical note
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Source: orbit
Source-ID: 251675
Publication: Research › Article in proceedings – Annual report year: 2009

Self-mixing interferometry in vertical-cavity surface-emitting lasers for nanomechanical cantilever sensing

We have experimentally investigated self-mixing interference produced by the feedback of light from a polymer micrometer-sized cantilever into a vertical-cavity surface-emitting laser for sensing applications. In particular we have investigated how the visibility of the optical output power and the junction voltage depends on the laser injection current and the distance to the cantilever. The highest power visibility obtained from cantilevers without reflective coatings was 60%, resulting in a very high sensitivity of 45 mV/nm with a noise floor below 1.2 mV. Different detection schemes are discussed.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanophotonics Theory and Signal Processing

Bibliographical note
Copyright: 2009 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE
Source: orbit
Source-ID: 251979
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009
Towards easily reproducible nano-structured SERS substrates

In this paper we present a quick and easy method for producing relatively large areas of substrate that enhance the Raman effect, using standard semiconductor processing techniques such as reactive ion etching of silicon and electron beam metal deposition. As standard cleanroom processes are used, it is possible to narrowly control the parameters of the fabrication process to create silicon nano-pillars with controlled heights and spacing. The silicon nano-pillars are coated by thin films of silver and/or gold to create surfaces that greatly enhance the Raman effect. Surface enhanced Raman scattering (SERS) has numerous applications in chemical sensing, with high sensitivity and fast analysis speed seen as the main advantages, and these novel substrates are believed to be able to make SERS more applicable.
Piezoresistive polymer composites for cantilever readout

Microcantilever based biochemical sensors can be used for detection of surface stress changes, due to the adsorption of specific molecules on one side of the cantilever. The method is fast and label-free and due to the small dimensions, it opens the possibility of fabricating point-of-care measurement devices. Surface stress changes of a cantilever sensor can be detected by an integrated piezoresistive readout. The goal of this PhD thesis is to increase the sensitivity of polymer based cantilever sensors, by investigating new strain sensitive (piezoresistive) polymer materials, that can improve the piezoresistive readout. A two- and four-probe electrode chip, for measuring the strain sensitivity of the materials, have been designed and fabricated with standard cleanroom technology. A thin film layer of polymer material is structured on the chips and by insertion in a four-point bending fixture, the deposited thin film can be strained, while measuring how the resistance changes. This allows the determination of the strain sensitivity of the materials. Three qualitatively different material types have been investigated: conductive polymer composites, an intrinsically conductive polymer and thin gold films. Conducting polymer composites consisting of SU-8 (an epoxy based photoresist) and different concentrations of carbon- and silver nanoparticles have been investigated. For the carbon nanoparticle doped SU-8 composites, a positive piezoresistive effect was measured, with the largest effect towards the lower concentrations. No significant piezoresistive effect was observed for the silver nanoparticle doped composites. Thin film structures of the intrinsically conductive polymer, polyaniline, have been fabricated and a negative piezoresistive effect was observed. Thin gold films were investigated, with the aim of measuring the piezoresistive effect in discontinuous gold films. Various thin film thicknesses were investigated and the piezoresistive effect was found to be close to the value of bulk gold.
A novel fabrication technique for free-hanging homogeneous polymeric cantilever waveguides

We present a novel bonding technique developed for the fabrication of a cantilever-based biosensing system with integrated optical read-out. The read-out mechanism is based on single-mode waveguides fabricated monolithically in SU-8. For optimal operation of the read-out mode, the cantilever waveguides should be homogenous and this bonding technique ensures free-hanging cantilevers that are surrounded by the same material for bottom and top claddings. The bonding step is necessary because SU-8 is a negative resist where free-hanging structures cannot be fabricated directly. This paper gives details on the processing aspects and the parameters of the fabrication steps.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Nordström, M. (Ekstern), Calleja, M. (Ekstern), Hübner, J. (Intern), Boisen, A. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 18
Issue number: 1
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Characterization of NTA-Thiol Monolayers on Au Electrodes for Application in a Cantilever-based heavy Metal Ion Sensor

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Bioanalytics Group, Biomedical Micro Systems Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section
Publication date: 2008

Host publication information
Title of host publication: Proceeding of the 3rd International Workshop on Nanomechanical Sensors
Place of publication: Mainz, Germany
Main Research Area: Technical/natural sciences
Conference: The 5th International Workshop on Nano Mechanical Sensing, Mainz, Germany, 19/05/2008 - 19/05/2008
Source: orbit
Source-ID: 229492
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Characterization of NTA-Thiol Monolayers on Au Electrodes for Application in a Cantilever-based Hybrid Sensor for Heavy Metal Ion Detection

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Bioanalytics Group, Biomedical Micro Systems Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section
Publication date: 2008

Event: Poster session presented at International Workshop of Nanomechanical Sensors, Mainz, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 231870
Characterization of NTA-Thiol Monolayers on Au Electrodes for Application in a Hybrid Sensor for Heavy Metal Ion Detection

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Bioanalytics Group, Biomedical Micro Systems Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Proceeding of MNE
Original language: English
Source: orbit
Source-ID: 231154
Publication: Research - peer-review › Conference article – Annual report year: 2008

Covalent surface functionalization og a micro mechanical cantilever by organic capped TiO2 and gamma.Fe2O3 Nanocrystals

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Ingrosso, C. (Intern), Striccoli, M. (Ekstern), Agostiano, A. (Ekstern), Sardella, E. (Ekstern), Voigt, A. (Ekstern), Gruetzner, G. (Ekstern), Keller, S. U. (Intern), Blagoi, G. (Intern), Boisen, A. (Intern), Curri, M. (Ekstern)
Publication date: 2008
Event: Poster session presented at 34th International Conference on Micro and Nano Engineering, Athens, Greece.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 234000
Publication: Research - peer-review › Poster – Annual report year: 2008

Detection of adsorbed explosive molecules using thermal response of suspended microfabricated bridges
Here we present a thermophysical technique that is capable of differentiating vapor phase adsorbed explosives from nonexplosives and is additionally capable of differentiating individual species of common explosive vapors. This technique utilizes pairs of suspended microfabricated silicon bridges that can be heated in a controlled fashion. The differential thermal response of the bridges with and without adsorbed explosive vapor shows unique and reproducible characteristics depending on the nature of the adsorbed explosives. The tunable heating rate method described here is capable of providing unique signals for subnanogram quantities of adsorbed explosives within 50 ms. (C) 2008 American Institute of Physics.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Dynamic NEMS Group, Oak Ridge National Laboratory
Pages: 154102
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Volume: 93
Issue number: 15
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Epoxy based photoresist/carbon nanoparticle composites
We have fabricated composites of SU-8 polymer and three different types of carbon nanoparticles (NPs) using ultrasonic mixing. Structures of composite thin films have been patterned on a characterization chip with standard UV photolithography. Using a four-point bending probe, a well defined stress is applied to the composite thin film and we have demonstrated that the composites are piezoresistive. Stable gauge factors of 5-9 have been measured, but we have also observed piezoresistive responses with gauge factors as high as 50. As SU-8 is much softer than silicon and the gauge factor of the composite material is relatively high, carbon nanoparticle doped SU-8 is a valid candidate for the piezoresistive readout in polymer based cantilever sensors, with potentially higher sensitivity than silicon based cantilevers.
Fabrication of Cantilevers by NIL

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanophotonic Devices, Department of Photonics Engineering, NSE-Optofluidics Group, Nanophotonics Theory and Signal Processing
Authors: Greve, A. (Intern), Keller, S. U. (Intern), Larsson, D. (Intern), Kristensen, A. (Intern), Yvind, K. (Intern), Hvam, J. M. (Intern), Boisen, A. (Intern)
Publication date: 2008

Host publication information
Title of host publication: In proceeding of "International Workshop on Nanomechanical Cantilever Sensors"
Publisher: Max Planck Institute for Polymer Research
Main Research Area: Technical/natural sciences
Workshop: International Workshop on Nanomechanical Cantilever Sensors, Mainze, Germany, 19/05/2008 - 19/05/2008
Source: orbit
Source-ID: 233656
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Functionalization of SU-8 Photoresist Surfaces with IgG Proteins

The negative epoxy-based photoresist SU-8 has a variety of applications within microelectromechanical systems (MEMS) and lab-on-a-chip systems. Here, several methods to functionalize SU-8 surfaces with IgG proteins were investigated. Fluorescent labeled proteins and fluorescent sandwich immunoassays were employed to characterize the binding efficiency of model proteins to bare SU-8 surface, SU-8 treated with cerium ammonium nitrate (CAN) etchant and CAN treated surfaces modified by aminosilanization. The highest binding capacity of antibodies was observed on bare SU-8. This explains why bare SU-8 in a functional fluorescent sandwich immunoassay detecting C-reactive protein (CRP) gave twice as high signal as compared with the other two surfaces. Immunoassays performed on bare SU-8 and CAN treated SU-8 resulted in detection limits of CRP of 30 and 80 ng/ml respectively which is sufficient for detecting CRP in clinical...
samples, where concentrations of 3–10 μg/ml are normal for healthy individuals. In conclusion, bare SU-8 and etched SU-8 can be modified with antibodies by a simple adsorption procedure which simplifies building lab-on-a-chip systems in SU-8. Additionally, we report the fabrication process and use of microwells created in a SU-8 layer with the same dimensions as a standard microscope glass slide that could fit into fluorescent scanners. The SU-8 microwells minimize the reagent consumption and are straightforward to handle compared to SU-8 coated microscope slides.

**General information**

State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Fluidic Array Systems and Technology Group, Biomedical Micro Systems Section
Authors: Blagoi, G. (Intern), Keller, S. U. (Intern), Johansson, A. (Intern), Boisen, A. (Intern), Dufva, H. M. (Intern)
Pages: 2896-2902
Publication date: 2008
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Applied Surface Science
Volume: 255
Issue number: 5
ISSN (Print): 0169-4332
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.22 SJR 1.093 SNIP 1.328
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.37 SJR 0.956 SNIP 1.221
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.89 SNIP 1.268 CiteScore 3.13
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.948 SNIP 1.453 CiteScore 2.96
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.96 SNIP 1.475 CiteScore 2.78
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.913 SNIP 1.362 CiteScore 2.26
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.908 SNIP 1.386 CiteScore 2.27
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.922 SNIP 1.126
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.84 SNIP 1.024
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.89 SNIP 1.084
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.791 SNIP 0.935
Gold Cleaning Methods for Electrochemical Detection Applications

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Bioanalytics Group, Biomedical Micro Systems Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section
Publication date: 2008
Event: Poster session presented at 34th International Conference on Micro and Nano Engineering, Athens, Greece.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 231873
Publication: Research - peer-review › Poster – Annual report year: 2008

Gold Cleaning Methods for Electrochemical Detection Applications

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Bioanalytics Group, Biomedical Micro Systems Section, Surface Engineering Group, Polymer Micro and Nano Engineering Section
Publication date: 2008
Event: Poster session presented at 34th International Conference on Micro and Nano Engineering, Athens, Greece.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 231873
Publication: Research - peer-review › Poster – Annual report year: 2008

Improvement of the Release Yield of SU-8 Micro-Particle Filters by an additional ASE etch Step

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Noeth, N. (Intern), Keller, S. U. (Intern), Boisen, A. (Intern)
Intrinsically conductive polymer thin film piezoresistors
We report on the piezoresistive effect in the intrinsically conductive polymer, polyaniline. A process recipe for indirect patterning of thin film polyaniline has been developed. Using a specially designed chip, the polyaniline thin films have been characterised with respect to resistivity and strain sensitivity using two- and four-point measurement method. We have found that polyaniline has a negative gauge factor of $K = -4.9$, which makes it a candidate for piezoresistive read-out in polymer based MEMS-devices. (C) 2007 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section Authors: Lillemose, M. (Intern), Spieser, M. (Intern), Christiansen, N. (Ekstern), Christensen, A. (Ekstern), Boisen, A. (Intern)
Pages: 969-971
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 85
Issue number: 5-6
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
Laser self-mixing interferometry in VCSELs - an ultra-compact and massproduceable deflection detection system for nanomechanical polymer cantilever sensors

We have realised an ultra-compact deflection detection system based on laser self-mixing interferometry in a Vertical-Cavity Surface-Emitting Laser (VCSEL). The system can be used together with polymer nanomechanical cantilevers to form chemical sensors capable of detecting less than 1nm deflection.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Optimized plasma-deposited fluorocarbon coating for dry release and passivation of thin SU-8 cantilevers

Plasma-deposited fluorocarbon coatings are introduced as a convenient method for the dry release of polymer structures. In this method, the passivation process in a deep reactive ion etch reactor was used to deposit hydrophobic fluorocarbon films. Standard photolithography with the negative epoxy-based photoresist SU-8 was used to fabricate polymer structures such as cantilevers and membranes on top of the nonadhesive release layer. The authors identify the plasma density as the main parameter determining the surface properties of the deposited fluorocarbon films. They show that by modifying the pressure during fluorocarbon deposition, the surface free energy of the coating can be tuned to allow for uniform wetting during spin coating of arbitrary thin SU-8 films. Further, they define an optimal pressure regime for the release of thin polymer structures at high yield. They demonstrate the successful release of SU-8 cantilevers and membranes with thicknesses down to 2.3 and 1.7 μm respectively, which is a considerable improvement to what has been achieved by dry release of all-polymer structures to date. Furthermore, chemical reaction of the SU-8 with the fluorocarbon coating during processing leads to a considerable increase of the surface free energy on one side of the released cantilevers. This process-integrated back side passivation is interesting for the use of the devices in biosensing applications. (c) 2007 American Vacuum Society.
Photochemical modification and patterning of SU-8 using Anthraquinone photolinkers

Bioactive protein patterns and microarrays achieved by selective localization of biomolecules find various applications in biosensors, bio-microelectromechanical systems (bio-MEMS), and in basic protein studies. In this paper we describe simple photochemical methods to fabricate two-dimensional patterns on a Novolac A derivative polymer (SU-8) and, subsequently, their functionalization with biomolecules. Anthraquinone (AQ) derivatives are used to chemically modify and pattern SU-8 surfaces. Features as small as 20 μm are obtained when using uncollimated light. The X–Y spatial resolution of micropatterned AQ molecules is improved to 1.5 μm when a collimated light source is used. This micropatterning
process will be important for the functionalization of MEMS-based biosensors. The method saves several processing steps and can be integrated in cleanroom fabrication thus avoiding contamination of the sensor surfaces.
Processing of thin SU-8 films

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Keller, S. U. (Intern), Blagoi, G. (Intern), Lillemose, M. (Intern), Häfliger, D. (Intern), Boisen, A. (Intern)
Pages: 125020
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 18
Issue number: 12
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Here, we present the activities within our research group over the last five years with cantilevers fabricated in the polymer SU-8. We believe that SU-8 is an interesting polymer for fabrication of cantilevers for bio/chemical sensing due to its simple processing and low Young’s modulus. We show examples of different integrated read-out methods and their characterisation. We also show that SU-8 cantilevers have a reduced sensitivity to changes in the environmental temperature and pH of the buffer solution. Moreover, we show that the SU-8 cantilever surface can be functionalised directly with receptor molecules for analyte detection, thereby avoiding gold-thiol chemistry.
The Influence of an ASE Etch Process on SU-8 Layer and on the Release Yield of SU-8 Microarticle Filters

General information
State: Published
The Influence of an ASE Etch Process on SU-8 Layer and on the Release Yield of SU-8 Micro-cantilevers

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Noeth, N. (Intern), Keller, S. U. (Intern), Boisen, A. (Intern)
Publication date: 2008
Event: Poster session presented at International Workshop on Nanomechanical Cantilever Sensors, Mainze, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 232278
Publication: Research - peer-review › Poster – Annual report year: 2008

Ultra Soft cantilever based Sensors using Silicon based materials

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Davis, Z. J. (Intern), Dohn, S. (Intern), Boisen, A. (Intern)
Publication date: 2008
Event: Poster session presented at International Workshop on Nanomechanical Cantilever Sensors, Mainze, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 229448
Publication: Research - peer-review › Poster – Annual report year: 2008

Ultra Soft cantilever based Sensors using Silicon based materials

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Davis, Z. J. (Intern), Dohn, S. (Intern), Boisen, A. (Intern)
Publication date: 2008
Event: Poster session presented at 34th International Conference on Micro and Nano Engineering, Athens, Greece.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 229453
Publication: Research - peer-review › Poster – Annual report year: 2008

Ultra Soft cantilever based Sensors using Silicon based materials

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Davis, Z. J. (Intern), Dohn, S. (Intern), Boisen, A. (Intern)
Number of pages: 364
Publication date: 2008
Nanoscale Four-Point Probes

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration Group, NanoSystemsEngineering Section, Nanoprobes Group, Department of Physics
Authors: Gammelgaard, L. (Intern), Bøggild, P. (Intern), Boisen, A. (Intern), Petersen, P. R. E. (Intern)
Publication date: Sep 2007

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Lauge Gammelgaard_thesis.pdf
Source: orbit
Source-ID: 207637
Publication: Research › Ph.D. thesis – Annual report year: 2007

Integrated optical read-out for polymeric cantilever-based sensors
This thesis presents a novel read-out method developed for cantilever-based sensors. Cantilevers are thin beams clamped at one end and during the last 10 years they have emerged as an interesting new type of bio/chemical sensor. The specific recognition of a chemical manifests itself as a bending of the cantilever from the generated surface stress. Conventionally the read-out used for this type of sensors is external and thereby very bulky. It is beneficial to fabricate a miniaturised system. Moreover, improved sensitivity is obtained by fabricating the cantilever in a polymeric material that has a low Young's modulus instead of the conventional materials Si and Si3N4. Here, a novel read-out method is presented where optical waveguides are used to integrate the light into the cantilever. It is an all-polymer device where both the cantilever and the waveguides are fabricated in the negative resist SU-8. Waveguides are structured on either side of the cantilever that is free-hanging in a microfluidic channel. Light is guided into the system and is either transmitted through the cantilever or reflected off the cantilever front-end, depending on the mode of operation. This work shows that waveguides, only supporting the fundamental mode at 1 310 nm and with a propagation loss of only 1.2 dB/cm can be fabricated and integrated with free-hanging cantilevers. A theoretical model is developed to analyse the read-out sensitivity of the two different read-out modes. From calibration experiments the minimum detectable cantilever deflection in the transmission mode is measured as 45 nm, which compares well with the calculated value of 30 nm. Proof-of-principle is shown for the reflection mode as well but no conclusive value can be determined for the read-out sensitivity. It is believed both these novel principles present interesting alternatives for integrated read-out for cantilever based sensors to enable to fabrication of point-of-care analysis systems.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Tenje, M. (Intern), Boisen, A. (Intern), Hübner, J. (Intern), Gomez, M. (Intern)
Number of pages: 157
Publication date: Jun 2007

Publication information
ISBN (Print): 87-89935-97-7
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Maria_Tenje.pdf
Source: orbit
Source-ID: 234050
Publication: Research › Ph.D. thesis – Annual report year: 2007
Cantilever Based Mass Sensing: Alternative Readout and Operation Schemes

Cantilever based mass sensors utilize that a change in vibrating mass will cause a change in the resonant frequency. This can be used for very accurate sensing of adsorption and desorption processes on the cantilever surface. The change in resonant frequency caused by a single molecule depends on various parameters including the vibrating mass of the cantilever and the frequency at which it vibrates. The minimum amount of molecules detectable is highly dependent on the noise of the system as well as the method of readout. The aim of this Ph.D. thesis has been twofold: To develop a readout method suitable for a portable device and to investigate the possibility of enhancing the functionality and sensitivity of cantilever based mass sensors. A readout method based on the hard contact between the cantilever and a biased electrode placed in close proximity to the cantilever is proposed. The viability of the method is shown theoretically, and the output signal is shown to scale very well with the dimensions of the cantilever, and hence should be applicable to nano-scale cantilevers. The hard contact method is proven to work on cantilevers on the micro- and nanoscale with measured resonant frequencies up to 11MHz. Values of the reciprocal frequency resolution as high as 80000 are obtained together with a signal to noise ratio of 108. The result is an almost digital readout, which in turn simplifies the detection of the resonant frequency considerably. An analytical expression is derived relating the mass and position of a particle attached to a cantilever to the resonant frequency. It is shown theoretical possible to find the mass and position of a particle by measurements of the resonant frequency of several bending modes. In the measurements the sensitivity of the cantilever based mass sensor is improved when operated at higher bending modes. By measuring the resonant frequency of several bending modes both the mass and position of an attached gold bead are determined.
based on suspended double clamped CNTs depending only on photolithography and standard Cleanroom processes.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Bioprobes
Authors: Mateiu, R. V. (Intern), Stöckli, T. (Ekstern), Knapp, H. F. (Ekstern), Keles, Y. (Ekstern), Bøggild, P. (Intern), Boisen, A. (Intern)
Pages: 1431-1435
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 84
Issue number: 5-8
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.027 SNIP 1.06
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.045 SNIP 1.138
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.966 SNIP 1.093
Cantilever-based sensor with integrated optical read-out using single mode waveguides

This work presents the design, fabrication and mechanical characterisation of an integrated optical read-out scheme for cantilever-based biosensors. A cantilever can be used as a biosensor by monitoring its bending caused by the surface stress generated due to chemical reactions occurring on its surface. Here, we present a novel integrated optical read-out scheme based on single-mode waveguides that enables the fabrication of a compact system. The complete system is fabricated in the polymer SU-8. This manuscript shows the principle of operation and the design well as the fabrication of the system and characterisation of the read-out method.

Comparison of several methods for chemical modification and micropatterning of the SU-8 photoresist

Comparison of several methods for chemical modification and micropatterning of the SU-8 photoresist

Comparison of several methods for chemical modification and micropatterning of the SU-8 photoresist

Comparison of several methods for chemical modification and micropatterning of the SU-8 photoresist

Comparison of several methods for chemical modification and micropatterning of the SU-8 photoresist
Design, fabrication and testing of a novel MEMS resonator for mass sensing applications

Micro- and nanoelectromechanical systems (MEMS/NEMS) have a high potential for mass sensing application. By miniaturization of the dimensions, higher and higher sensitivities can be achieved. Here we are presenting finite element modelling and optimization of a free–free beam type mechanical resonator. The hope is to optimize the mass sensitivity by increasing the Q-factor, which in turn, decreases the frequency noise in the system. Furthermore, a novel process sequence will be presented in order to fabricate micro and nanomechanical resonators with integrated electrostatic actuation and piezoresistive readout. Finally, some preliminary characterization results have been performed, demonstrating Q-factors up to 38,000 in high vacuum and 13,000 at moderate vacuum, on an array of cantilever devices, giving us some insight on how to optimize the mechanical design for gas based measurements. 2007 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 1601-1605
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: MICROELECTRONIC ENGINEERING
Volume: 84
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Fabrication of bulk acoustic silicon disk resonator for liquid operation

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Hales, J. H. (Intern), Davis, Z. J. (Intern), Tang, M. (Intern), Boisen, A. (Intern)
Pages: 367-368
Publication date: 2007

Host publication information
Title of host publication: Abstracts of MNE - 33rd International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 205911
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2007

Fabrication of magnetic cantilevers using a polymer composite

General information
State: Published
Organisations: Magnetic Systems, Department of Micro- and Nanotechnology, Bioprobes
Authors: Van Pelt, S. (Intern), Keller, S. U. (Intern), Blagoi, G. (Intern), Boisen, A. (Intern), Hansen, M. F. (Intern)
Pages: 433-434
Publication date: 2007

Host publication information
Fabrication of MEMS bridge for explosive detection

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Greve, A. (Intern), Hales, J. H. (Intern), Senesac, L. (Ekstern), Yi, D. (Ekstern), Thundat, T. (Ekstern), Boisen, A. (Intern)
Pages: 393-394
Publication date: 2007

Host publication information
Title of host publication: MNE - 33rd International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 205914
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2007

Inherently conductive polymer thin film piezoresistors

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Lillemose, M. (Intern), Spieser, M. (Intern), Christiansen, N. O. (Ekstern), Christensen, A. (Ekstern), Boisen, A. (Intern)
Pages: 749-750
Publication date: 2007

Host publication information
Title of host publication: MNE - 33rd International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 205909
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2007

Integrated optical readout for miniaturization of cantilever-based sensor system
The authors present the fabrication and characterization of an integrated optical readout scheme based on single-mode waveguides for cantilever-based sensors. The cantilever bending is read out by monitoring changes in the optical intensity of light transmitted through the cantilever that also acts as a waveguide. The complete system is fabricated in the photosensitive polymer SU-8. They show theoretical calculations on the expected sensitivity both when operated in air and liquid and compare these with experimental characterization of the system in air where the cantilever is deflected mechanically. The experimental results compare well with the results obtained from the theoretical calculations.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Nordström, M. (Intern), Zauner, D. (Intern), Calleja, M. (Ekstern), Hübner, J. (Intern), Boisen, A. (Intern)
Pages: 103512
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Mass and position determination of attached particles on cantilever based mass sensors

An analytical expression relating mass and position of a particle attached on a cantilever to the resulting change in cantilever resonant frequency is derived. Theoretically, the position and mass of the attached particle can be deduced by combining measured resonant frequencies of several bending modes. This finding is verified experimentally using a microscale cantilever with and without an attached gold bead. The resonant frequencies of several bending modes are measured as a function of the bead position. The bead mass and position calculated from the measured resonant frequencies are in good agreement with the expected mass and the position measured.
Measurement of the resonant frequency of nano-scale cantilevers by hard contact readout

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Microreactors
Authors: Dohn, S. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 463-464
Publication date: 2007
Miniature sensor suitable for electronic nose applications

A major research effort has been devoted over the years for the development of chemical sensors for the detection of chemical and explosive vapors. However, the deployment of such chemical sensors will require the use of multiple sensors probably tens of sensors in a sensor package to achieve selective detection. In order to keep the overall detector unit small, miniature sensors with sufficient sensitivity of detection will be needed. We report sensitive detection of dimethyl methylphosphonate DMMP, a stimulant for the nerve agents, using a miniature sensor unit based on piezoresistive microcantilevers. The sensor can detect parts-per-trillion concentrations of DMMP within 10 s exposure times. The small size of the sensor makes it ideally suited for electronic nose applications. © 2007 American Institute of Physics.
In this paper we describe a new photochemical method to tailor and pattern the surface of SU-8 negative photoresist. Antraquinone (AQ) derivatives were used to chemically modify and pattern SU-8 surfaces. Using AQ derivatives with electrophilic moieties (AQ-E), we could chemo-selectively change the wetting behaviour of SU-8. The resolution limit of the AQ photopatterning method was 20 μm when using an uncollimated light source. AQ modification followed by a reaction with amino groups of Alexa-647 cadaverine and a Biotin-amino derivative proved possible modification and patterning of polymeric cantilevers and other MEMS based sensors with biomolecules.
Optimized SU-8 processing for the fabrication of thin polymer cantilevers

We report on the experimentally observed reliability of the piezoresistive effect in strained poly 3,4-ethylenedioxythiophene (PEDT). PEDT is an intrinsic conductive polymer which can be patterned by conventional Cleanroom processing, and thus presents a promising material for all-polymer Microsystems. The measurements are made on microfabricated test chips with PEDT resistors patterned by conventional UV-lithography and reactive ion etching (RIE). We determine a gauge factor of 3.41 ± 0.42 for the strained PEDT and we see an increase in resistivity from 1.98 · 10^4 Ω m to 2.22 · 10^4 Ω m when the polymer is immersed in water for 30 min. The resistivity continues to increase to 2.66 · 10^4 Ω m when the resistor is thermally dried due to interactions with oxygen from the ambient. We measure the PEDT sheet resistance over a period of four weeks and see small fluctuations caused by humidity variations. 2007 Elsevier B.V. All rights reserved.
Silicon nitride micro/nano mechanical devices with integrated strain gauge readout

**General information**
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Tang, M. (Intern), Hales, J. H. (Intern), Boisen, A. (Intern)
Pages: 427-428
Publication date: 2007

**Host publication information**
Title of host publication: MNE - 33rd International Conference on Micro and Nano Engineering
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 205910
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2007

Single-mode waveguides with SU-8 polymer core and cladding for MOEMS applications

Fabrication and optical characterization of singlemode polymeric embedded waveguides are performed. A specific material combination (SU-8 2005 as core and the modified SU-8 mr-L 6050XP as cladding) is chosen in order to obtain a small refractive index difference for single-mode propagation combined with the conventional fabrication method UV lithography to facilitate the integration of different types of optical detection methods on lab-on-a-chip systems. We analyze the behavior of the refractive index and carefully observe how the value of the refractive index can be tailored during processing. We show that we can fabricate waveguides with an index difference in the order of 10−3, where both the core material and the cladding material are based on SU-8. The refractive index measurements are performed on thin polymeric films, while further optical characterizations are performed on waveguides with a height of 4.5 μm. We study the mode profiles of these waveguides and confirm that only the fundamental mode is excited. We also study the absorption spectra of the material in the wavelength range 800–1600 nm combined with cut-back measurements. We find that the waveguides have a propagation loss of 0.2–3 dB/cm in this wavelength range.

**General information**
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Nordström, M. (Ekstern), Zauner, D. (Intern), Boisen, A. (Intern), Hübner, J. (Intern)
Pages: 1284-1289
Publication date: 2007
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Lightwave Technology
Volume: 25
Issue number: 5
ISSN (Print): 0733-8724
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.42 SJR 1.166 SNIP 1.791
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Alternative Actuation and Detection Principles for Resonating Cantilevers

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Grigorov, A. (Intern), Boisen, A. (Intern)
Number of pages: 135
Publication date: Aug 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
avg_MyPhDsmall.pdf
Source: orbit
Source-ID: 193182
Publication: Research › Ph.D. thesis – Annual report year: 2006

Controlled Positioning of Carbon Nanotubes for Mass Sensing

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Mateiu, R. V. (Intern), Boisen, A. (Intern)
Number of pages: 115
Publication date: Mar 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 188887
Publication: Research › Ph.D. thesis – Annual report year: 2006

Nano-cantilevers fully integrated with CMOS for Ultrasensitive mass detection

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Forsén, E. S. (Intern), Boisen, A. (Intern)
Number of pages: 128
Publication date: Jan 2006

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Forsén.pdf
Source: orbit
Source-ID: 186321
Publication: Research › Ph. D. thesis – Annual report year: 2006

Batch fabrication of nanotubes suspended between microelectrodes

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Bioprobes
Cantilever based mass sensor with hard contact readout
We present a method for microcantilever resonant frequency detection. We measure the direct current from an intermittent contact once every vibration cycle between the conducting cantilever and a counterelectrode at a low bias voltage with respect to the cantilever, while the excitation frequency and amplitude are varied. The result is an almost "digital" detection of the resonant frequency. A relative frequency resolution $\Delta f/f$ of 1/80 000 with high signal to noise ratio in ambient conditions is demonstrated. The detection method can be applied to portable sensor systems with very high frequency nanoelectromechanical cantilevers using simple off-chip electronics.
Cantilever readout by hard contact

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Microreactors, Center for Individual Nanoparticle Functionality
Authors: Dohn, S. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 399-400
Publication date: 2006

Host publication information
Title of host publication: Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Characterisation Of Mechanical Sensors Using A Custom Built Characterisation System

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Publication date: 2006

Host publication information
Title of host publication: Proceedings of NanSens 2006
Main Research Area: Technical/natural sciences
Conference: NanSens 2006, 01/01/2006
Source: orbit
Source-ID: 191965
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Immobilisation of DNA to polymerised SU-8 photoresist

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes, Micro Array Technology
Pages: 1327-32
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Biosensors and Bioelectronics
Volume: 21
Issue number: 7
ISSN (Print): 0956-5663
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 7.83 SJR 2.373 SNIP 1.65
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.22 SJR 2.095 SNIP 1.619
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.044 SNIP 1.671 CiteScore 7.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.057 SNIP 1.716 CiteScore 6.57
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.029 SNIP 1.726 CiteScore 6.34
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.397 SNIP 1.592 CiteScore 5.7
Integrated tunneling sensor for nanoelectromechanical systems

Transducers based on quantum mechanical tunneling provide an extremely sensitive sensor principle, especially for nanoelectromechanical systems. For proper operation a gap between the electrodes of below 1 nm is essential, requiring the use of structures with a mobile electrode. At such small distances, attractive van der Waals and capillary forces become sizable, possibly resulting in snap-in of the electrodes. The authors present a comprehensive analysis and evaluation of the interplay between the involved forces and identify requirements for the design of tunneling sensors. Based on this analysis, a tunneling sensor is fabricated by Si micromachining technology and its proper operation is demonstrated. (c) 2006 American Institute of Physics.

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Sadewasser, S. (Ekstern), Abadal, G. (Ekstern), Barniol, N. (Ekstern), Dohn, S. (Intern), Boisen, A. (Intern)
Pages: 173101
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Volume: 89
Issue number: 17
ISSN (Print): 0003-6951
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.499 SNIP 1.226 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.861 SNIP 1.492 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.146 SNIP 1.633 CiteScore 3.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.57 SNIP 1.739 CiteScore 3.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.814 SNIP 1.917 CiteScore 4.04
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.018 SNIP 2.414
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 4.281 SNIP 2.22
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 4.178 SNIP 2.017
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 4.173 SNIP 2.066
Original language: English
ATOMIC-FORCE MICROSCOPY, FABRICATION, MASS DETECTION
Electronic versions:
Sadewasser.pdf
DOIs:
10.1063/1.2362593
Low-noise polymeric nanomechanical biosensors

A sensor device based on a single polymer cantilever and optical readout has been developed for detection of molecular recognition reactions without the need of a reference cantilever for subtraction of unspecific signals. Microcantilevers have been fabricated in the photoresist SU-8 with one surface passivated with a thin fluorocarbon layer. The SU-8 surface is sensitized with biological receptors by applying silanization methods, whereas the fluorocarbon surface remains inert to these processes. The thermal and mechanical properties of the chosen materials allow overcoming the main limitations of gold-coated silicon cantilevers: the temperature, pH, and ionic strength cross sensitivities. This is demonstrated by comparing the response of SU-8 cantilevers and that of gold-coated silicon nitride cantilevers to variations in temperature and pH. The sensitivity of the developed polymeric nanomechanical sensor is demonstrated by real-time detection of the human growth hormone with sensitivity in differential surface stress of about 1 mN/m. (c) 2006 American Institute of Physics.
We present an SU-8 micrometer sized cantilever strain sensor with an integrated piezoresistor made of a conductive composite of SU-8 polymer and carbon black particles. The composite has been developed using ultrasonic mixing. Cleanroom processing of the polymer composite has been investigated and it has been shown that it is possible to pattern the composite by standard UV photolithography. The composite material has been integrated into an SU-8 microcantilever and the polymer composite has been demonstrated to be piezoresistive with gauge factors around 15-20. Since SU-8 is much softer than silicon and the gauge factor of the composite material is relatively high, this polymer based strain sensor is more sensitive than a similar silicon based cantilever sensor. (c) 2006 American Institute of Physics.
Monolithic single mode SU-8 waveguides for integrated optics

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, InSERS
Authors: Nordström, M. (Intern), Zauner, D. (Intern), Boisen, A. (Intern), Hübner, J. (Intern)
Pages: 43-53
Publication date: 2006

Host publication information
Title of host publication: Proceedings of SPIE Photonics West
Volume: 6112
Main Research Area: Technical/natural sciences
Conference: Photonics West 2006, San Jose, CA, United States, 21/01/2006 - 21/01/2006
Source: orbit
Source-ID: 190833
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Nano and micro-cantilever sensors – new materials and new read-out principles

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Nanointegration, Microreactors, Center for Individual Nanoparticle Functionality
Pages: 5-6
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193942
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Nano-mechanical resonators for mass sensing applications

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 475-476
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193960
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Novel fabrication technique for free-hanging polymeric structures

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, InSERS
Authors: Nordström, M. (Intern), Hübner, J. (Intern), Boisen, A. (Intern)
Pages: 373-374
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193954
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Optimized dry-release and passivation of thin SU-8 cantilevers

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Keller, S. U. (Intern), Häfliger, D. (Intern), Boisen, A. (Intern)
Pages: 367-368
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193952
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Piezoresistive SU-8 cantilever floor for investigation of cell-substrate interactions and biomechanics

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Larsen, M. E. (Intern), Johansson, A. (Intern), Rasmussen, P. A. (Intern), Boisen, A. (Intern)
Pages: 271-272
Publication date: 2006

Host publication information
Polymeric cantilever-based biosensors with integrated readout

The authors present an SU-8 cantilever chip with integrated piezoresistors for detection of surface stress changes due to adsorption of biomolecules on the cantilever surface. Mercaptohexanol is used as a model biomolecule to study molecular interactions with Au-coated SU-8 cantilevers and surface stress changes of about 0.1 N/m are observed. The measurements indicate that the SU-8 surface is inert to mercaptohexanol molecules, which enables the use of a bare SU-8 cantilever as a reference. Moreover, the sensitivity of the cantilevers to pH changes is presented. The results demonstrate that SU-8 cantilevers are a promising alternative to Si-based cantilevers. (c) 2006 American Institute of Physics.
Reliability of Poly (3,4-Ethylenedioxythiophene) strain gauge

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes, Microfluidics Theory and Simulation, POEM
Authors: Mateiu, R. V. (Intern), Lillemose, M. (Intern), Hansen, T. E. (Intern), Boisen, A. (Intern), Geschke, O. (Intern)
Pages: 403-404
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193964
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Reliability of Poly (3,4-Ethylenedioxi-thiophene) Strain Gauge

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes, POEM
Authors: Mateiu, R. V. (Intern), Lillemose, M. (Intern), Hansen, T. (Ekstern), Boisen, A. (Intern), Geschke, O. (Intern)
Pages: 17-20
Publication date: 2006

Host publication information
Title of host publication: Proceedings of Eurosensors XX
Place of publication: Göteborg, Sweden
Edition: September
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 192645
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Self-positioning of polymer membranes driven by thermomechanically induced plastic deformation
Stress in polymeric resins is tailored by a thermomechanical process. It allows for controlled self-positioning of membranes in microdevices (see Figure). The process makes specific use of plastic deformation that results from the low viscosity of the polymer. This demonstrates that polymers offer new approaches to microfabrication that cannot be realized for common semiconductor materials without severe difficulties.

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Microreactors, Center for Individual Nanoparticle Functionality
Authors: Häfliger, D. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 238-241
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Advanced Materials
Volume: 18
Issue number: 2
ISSN (Print): 0935-9648
Ratings:
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 21.1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 17.79
Web of Science (2016): Indexed yes
Slanted side walls in SU-8 structures with ‘Step-and-Flash’ processing

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, InSERS
Authors: Nordström, M. (Intern), Hübner, J. (Intern), Boisen, A. (Intern)
Pages: 1269-1272
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 83
Issue number: 4-9
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
The polymer SU-8 is becoming widely used for all kinds of micromechanical and microfluidic devices, not only as a photoresist but also as the constitutional material of the devices. Many of these polymeric devices need to include a microfluidic system as well as electrical connection from the electrodes on the SU-8 chip to a printed circuit board. Here, we present two different methods of electrically connecting an SU-8 chip, which contains a microfluidic network and free-hanging mechanical parts. The tested electrical interconnection techniques are flip chip bonding using underfill or flip chip bonding using an anisotropic conductive film (ACF). These are both widely used in the Si industry and might also be used...
for the large scale interconnection of SU-8 chips. The SU-8 chip, to which the interconnections are made, has a microfluidic channel with integrated micrometer-sized cantilevers that can be used for label-free biochemical detection. All the bonding tests are compared with results obtained using similar Si chips. It is found that it is significantly more complicated to interconnect SU-8 than Si cantilever chips primarily due to the softness of SU-8.

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes, DELTA Microelectronics
Authors: Johansson, A. C. (Intern), Janting, J. (Intern), Schultz, P. (Intern), Hoppe, K. (Ekstern), Hansen, I. (Ekstern), Boisen, A. (Intern)
Pages: 314-319
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Micromechanics and Microengineering
Volume: 16
Issue number: 2
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Surface stress measurements in liquid using SU-8 cantilevers with integrated readout

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Johansson, A. (Intern), Blagoi, G. (Intern), Boisen, A. (Intern)
Pages: 49-50
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193943
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

System on chip mass sensor based on polysilicon cantilevers arrays for multiple detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Villarroya, M. (Ekstern), Verd, J. (Ekstern), Teva, J. (Ekstern), Abadal, G. (Ekstern), Forsén, E. S. (Intern), Perez-Murano, F. (Ekstern), Uranga, A. (Ekstern), Figueras, E. (Ekstern), Montserrat, J. (Ekstern), Esteve, J. (Ekstern), Boisen, A. (Intern), Barniol, N. (Ekstern)
Pages: 154-164
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors and Actuators A: Physical
Volume: 132
Issue number: 1
ISSN (Print): 0924-4247
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Temperature effects in Au piezoresistors integrated in SU-8 cantilever chips

We present a cantilever-based biosensor chip made for the detection of biochemical molecules. The device is fabricated entirely in the photosensitive polymer SU-8 except for integrated piezoresistors made of Au. The integrated piezoresistors...
are used to monitor the surface stress changes due to binding of biomolecules on the surface of the cantilever. Here we present the characterization of the chip with respect to temperature changes in the surrounding environment. Furthermore, self-heating of the piezoresistors due to the applied voltage over the resistors is investigated including the temperature increase of the cantilever surfaces. The obtained results indicate that although low voltages of about 0.5–1 V are required to avoid self-heating of the cantilevers, surface stress changes below 1 mN m⁻¹ can still be detected. The results are compared to previously presented results for Si-based cantilevers.

**General information**

State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, Microreactors, Center for Individual Nanoparticle Functionality
Authors: Johansson, A. (Intern), Hansen, O. (Intern), Hales, J. H. (Intern), Boisen, A. (Intern)
Pages: 2564–2569
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Micromechanics and Microengineering
Volume: 16
Issue number: 12
ISSN (Print): 0960-1317
Ratings:
- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.013 SNIP 1.637
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.144 SNIP 1.5
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 1.243 SNIP 1.616
- Web of Science (2008): Indexed yes
Three-dimensional microfabrication in negative resist using printed masks

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Häfliger, D. (Intern), Boisen, A. (Intern)
Pages: 951-957
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 16
Issue number: 5
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Towards on-chip explosive detection using silicon cantilevers

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Greve, A. (Intern), Hales, J. H. (Intern), Senesac, L. (Ekstern), Yi, D. (Ekstern), Thundat, T. (Ekstern), Boisen, A. (Intern)
Pages: 201-202
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193950
Publication: Research - peer-review » Article in proceedings – Annual report year: 2006
Wafer-scale fabrication of suspended TiW Nanowires

General information
State: Published
Organisations: Nanointegration, Department of Micro- and Nanotechnology, Bioprobes
Authors: Gammelgaard, L. (Intern), Dohn, S. (Intern), Wojtecki, R. (Ekstern), Boisen, A. (Intern)
Pages: 81-82
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Micro and Nano Engineering 2006 International Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 193945
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Characterization of the Resonant Properties of Multi-layer Cantilever Sensors

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nano-Bio Integrated Systems Group, Biomedical Micro Systems Section, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Publication date: Aug 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Sandberg.pdf
Source: orbit
Source-ID: 186039
Publication: Research › Ph.D. thesis – Annual report year: 2005

Aluminum nano-cantilevers for high sensitivity mass sensors
We have fabricated Al nano-cantilevers using a very simple one mask contact UV lithography technique with lateral dimensions under 500 nm and vertical dimensions of approximately 100 nm. These devices are demonstrated as highly sensitive mass sensors by measuring their dynamic properties. Furthermore, it is shown that Al has a potential higher sensitivity than Si based dynamic sensors. Initial testing of these devices has been conducted using a novel scanning electron microscope setup were the devices were tested under high vacuum conditions. The Q-factor was measured to approximately 200 and the mass sensitivity was measured to 2 attograms/Hz by depositing electron beam induced carbon at the end of the nano-cantilever.

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Davis, Z. J. (Intern), Boisen, A. (Intern)
Publication date: 2005

Host publication information
Title of host publication: 5th IEEE Conference on Nanotechnology, 2005.
Publisher: IEEE
ISBN (Print): 0-7803-9199-3
Main Research Area: Technical/natural sciences
Conference: 5th IEEE Conference on Nanotechnology, 2005., 01/01/2005
Electronic versions:
Boisen.pdf
DOI: 10.1109/NANO.2005.1500709
Aluminum nanocantilevers for high sensitivity mass sensors

We have fabricated Al nanocantilevers using a simple, one mask contact UV lithography technique with lateral and vertical dimensions under 500 and 100 nm, respectively. These devices are demonstrated as highly sensitive mass sensors by measuring their dynamic properties. Furthermore, it is shown that Al has a potential higher sensitivity than Si based dynamic sensors. Initial testing of these devices has been conducted using a scanning electron microscope setup were the devices were tested under high vacuum conditions. The Q factor was measured to be approximately 200 and the mass sensitivity was measured to 2 ag/Hz by depositing electron-beam-induced carbon at the end of the nanocantilever. (c) 2005 American Institute of Physics.
Aluminum nanocantilevers for high sensitivity mass sensors

We have fabricated Al nanocantilevers using a simple, one mask contact UV lithography technique with lateral and vertical dimensions under 500 and 100 nm, respectively. These devices are demonstrated as highly sensitive mass sensors by measuring their dynamic properties. Furthermore, it is shown that Al has a potential higher sensitivity than Si based dynamic sensors. Initial testing of these devices has been conducted using a scanning electron microscope setup were the devices were tested under high vacuum conditions. The Q factor was measured to be approximately 200 and the mass sensitivity was measured to 2 ag/Hz by depositing electron-beam-induced carbon at the end of the nanocantilever.
Building a multi-walled carbon nanotube-based mass sensor with the atomic force microscope

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Mateiu, R. V. (Intern), Kuhle, A. (Ekstern), Marie, R. C. W. (Intern), Boisen, A. (Intern)
Pages: 233-237
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Ultramicroscopy
Volume: 105
Issue number: 1-4
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.06 SJR 1.824 SNIP 1.317
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 1.896 SNIP 1.176
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.066 SNIP 1.326 CiteScore 2.78
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.628 SNIP 1.598 CiteScore 2.59
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.761 SNIP 1.323 CiteScore 2.66
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.866 SNIP 1.562 CiteScore 2.31
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.659 SNIP 1.328 CiteScore 2.35
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.722 SNIP 1.239
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.755 SNIP 1.544
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.583 SNIP 1.716
Web of Science (2008): Indexed yes
Cantilever Based Sensing Devices for Diagnostics

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Boisen, A. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 196571
Publication: Research - peer-review › Journal article – Annual report year: 2005

Cantilever Based Sensing Devices with integrated Read-out and Electronics

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Boisen, A. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 186084
Publication: Research › Paper – Annual report year: 2005

Cantilever surface stress sensors with single-crystalline silicon piezoresistors
We present a cantilever with piezoresistive readout optimized for measuring the static deflection due to isotropic surface stress on the surface of the cantilever [Sens. Actuators B 79(2-3), 115 (2001)]. To our knowledge nobody has addressed the difference in physical regimes, and its influence on cantilever sensors with integrated piezoresistive readout, that one finds between typical atomic force microscopy measurements and the surface stress sensors used in, e.g., biochemical measurements. We have simulated the response from piezoresistive cantilevers as a function of resistor type and placement for the two different regimes, i.e., surface stress measurements and force measurements. The model thus provides the means to specifically design piezoresistive cantilevers for surface stress measurements. (c) 2005 American Institute of Physics.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology Group, MicroElectroMechanical Systems Section, Nanoprobes Group, NanoSystemsEngineering Section, Center for Individual Nanoparticle Functionality
Cell Total Analysis System

Characterization system for resonant micro- and nanocantilevers
We present a system for characterization of the resonant properties of micro- and nanocantilever sensors. The system has been constructed as a vacuum chamber with capabilities for controlling environmental conditions such as pressure, temperature, and chemical constituents. Characterization can be achieved either electrically or using a specialized laser-optical detection system. The system has been used to characterize the resonant properties of SiO2 cantilevers as well as other resonant structures. We present experimental results of a SiO2 resonant cantilever, showing an exceptional accuracy in resonant frequency determination, and demonstrating the importance of resonance characterization in a controlled environment. ©2005 American Institute of Physics

Publication information
Journal: Review of Scientific Instruments
Volume: 76
Issue number: 12
ISSN (Print): 0034-6748
Ratings:
BFI (2018): BFI-level 1
Contact printed masks for 3D microfabrication in negative resist

We present a process based on contact printed shadow masks for three dimensional microfabrication of soft and sensitive overhanging membranes in SU-8. A metal mask is transferred onto unexposed SU-8 from an elastomer stamp made of polydimethylsiloxane. This mask is subsequently embedded into the negative resist to protect buried material from UV-exposure. Unlike direct evaporation-deposition of a mask onto the SU-8, printing avoids high stress and radiation, thus preventing resist wrinkling and prepolymerization. We demonstrate effective monolithic fabrication of soft, 4-μm thick and 100-μm long cantilevers integrated in a microfluidic system. The process yields very flat and well defined membrane surfaces.
Controlled out-of-plane Positioning of Microfluidic Components in SU-8 driven by Plastic Strain

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Häfliger, D. (Intern), Boisen, A. (Intern)
Pages: 178-180
Publication date: 2005

Host publication information
Title of host publication: Digest techn. Papers MicroTAS 2005 Conference
Main Research Area: Technical/natural sciences
Conference: 9th International Conference on Miniaturized Systems for Chemistry and Life Sciences, Boston, MA, United States, 09/10/2005 - 09/10/2005
Source: orbit
Source-ID: 186040
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Design, Fabrication and Characterization of a Submicroelectromechanical Resonator with Monolithically Integrated CMOS Readout Circuit

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Verd, J. (Ekstern), Abadal, G. (Ekstern), Teva, J. (Ekstern), Villaroya Gaudó, M. (Ekstern), Uranga, A. (Ekstern), Borrisé, X. (Ekstern), Campabadal, F. (Ekstern), Esteve, J. (Ekstern), Figueras Costa, E. (Ekstern), Perez-Murano, F. (Ekstern), Davis, Z. J. (Intern), Forsén, E. S. (Intern), Boisen, A. (Intern)
Pages: 508-519
Publication date: 2005

Publication information
Journal: IEEE Journal of Microelectromechanical Systems
Volume: 14
Issue number: 3
ISSN (Print): 1057-7157
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SNIP 1.376 SJR 0.734 CiteScore 2.76
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.667 SNIP 1.209 CiteScore 2.09
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.764 SNIP 1.527 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.836 SNIP 1.539 CiteScore 2.22
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.929 SNIP 1.786 CiteScore 2.81
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.143 SNIP 1.928 CiteScore 2.7
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Direct Real-time Immunodetection of the Human Growth Hormone with Polymeric Nanomechanical Sensors

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioproses
Authors: Gomez, M. (Intern), Nordström, M. (Intern), Häfliger, D. (Intern), Boisen, A. (Intern), Lechuga, L. (Eksterne), Tamayo, J. (Eksterne)
Publication date: 2005

Host publication information
Title of host publication: Eurosensors XIX 2005
Main Research Area: Technical/natural sciences
Conference: Eurosensors XIX : September 11-14, Barcelona, Spain, 01/01/2005
Source: orbit
Source-ID: 186042
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Double sided surface stress cantilever sensor

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Rasmussen, P. (Eksterne), Grigorov, A. (Intern), Boisen, A. (Intern)
Pages: 1088–1091
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication Information
Journal: Journal of Micromechanics and Microengineering
Volume: 15
Issue number: 5
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.264 SNIP 2.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.165 SNIP 2.073
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.057 SNIP 1.881
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.416 SNIP 1.579
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.103 SNIP 1.507
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.763 SNIP 1.651
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.741 SNIP 1.011
Scopus rating (1999): SJR 0.742 SNIP 1.052
Original language: English
Source: orbit
Dry release of all-polymeric structures

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Häfliger, D. (Intern), Nordström, M. (Intern), Rasmussen, P. (Ekstern), Boisen, A. (Intern)
Pages: 88-92
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 78-79
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.027 SNIP 1.06
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.045 SNIP 1.138
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.966 SNIP 1.093
Dry release of all-polymer structures

We present a simple dry release technique which uses a thin fluorocarbon film for efficient removal of plastic microdevices from a mould or a handling substrate by reducing the adhesion between the two. This fluorocarbon film is deposited on the substrate in an advanced Si dry etch device utilising the C4F8 passivation plasma. Micromachined polymer chips made of SU-8 are removed from the handling substrate by lifting them off using mechanical tweezers. Effective release of chips of several mm² size within a few seconds and the lift-off of fragile, 5.5-μm-thin cantilevers at a yield of almost 100% were demonstrated on wafer-scale. The fluorocarbon film showed excellent compatibility with metal etch processes and polymer baking and curing steps. It further facilitates demoulding of polydimethylsiloxane stamps suitable for soft-lithography.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Haefliger, D. (Ekstern), Nordstrøm, M. (Ekstern), Rasmussen, P. A. (Intern), Boisen, A. (Intern)
Pages: 88-92
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 78-79
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Effect of gold coating on the Q-factor of resonant cantilevers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Sandberg, R. K. (Intern), Mølhave, K. (Intern), Boisen, A. (Intern), Svendsen, W. E. (Intern)
Pages: 2249-2253
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 15
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Enhanced functionality of cantilever based mass sensors using higher modes

By positioning a single gold particle at different locations along the length axis on a cantilever based mass sensor, we have investigated the effect of mass position on the mass responsivity and compared the results to simulations. A significant improvement in quality factor and responsivity was achieved by operating the cantilever in the fourth bending mode thereby increasing the intrinsic sensitivity. It is shown that the use of higher bending modes grants a spatial resolution and thereby enhances the functionality of the cantilever based mass sensor. (c) 2005 American Institute of Physics.

General information
State: Published
Organisations: Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nano-Bio Integrated Systems Group, Biomedical Micro Systems Section
Authors: Dohn, S. (Intern), Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 233501
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Volume: 86
Issue number: 23
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.499 SNIP 1.226 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.861 SNIP 1.492 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.146 SNIP 1.633 CiteScore 3.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.57 SNIP 1.739 CiteScore 3.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.814 SNIP 1.917 CiteScore 4.04
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Enhanced functionality of cantilever based mass sensors using higher modes and functionalized particles
By positioning a single gold-particle at different locations along the length axis on a cantilever based mass sensor, we have investigated the effect of mass position on the mass responsivity and compared the results to simulations. A significant improvement in quality factor and responsivity was achieved by operating the cantilever in the 4th bending mode, thereby increasing the intrinsic sensitivity. It is shown that the use of higher bending modes grants a spatial resolution and thereby enhances the functionality of the cantilever based mass sensor.

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Dohn, S. (Intern), Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Pages: 636-639
Publication date: 2005

Host publication information
Volume: 1
Publisher: IEEE
ISBN (Print): 0-7803-8994-8
Main Research Area: Technical/natural sciences
Conference: 13th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers '05), Seoul, Korea, Republic of, 01/01/2005
Electronic versions:
Sandberg.pdf
DOIs:
10.1109/SENSOR.2005.1496497
Enhanced sensitivity of gold coated resonant microcantilever at atmospheric pressure

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Sandberg, R. K. (Intern), Mølhave, K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Proceedings of MNE 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 182358
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Fast packaging of polymer cantilever chip by micromilling

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology, POEM
Authors: Johansson, A. (Intern), Perozzello, G. (Intern), Geschke, O. (Intern), Boisen, A. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 186055
Publication: Research › Poster – Annual report year: 2005

Fully integrated nanoresonator system with attogram/Hz mass resolution

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Pages: 556-559
Publication date: 2005

Host publication information
Title of host publication: Proceedings of MEMS 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 182381
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Highly Sensitive Polymer-based Cantilever-sensors for DNA Detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Gomez, M. (Intern), Nordström, M. (Intern), Alvarez, M. (Ekstern), Lechuga, L. (Ekstern), Boisen, A. (Intern), Tamayo, J. (Ekstern)
Number of pages: 680
Highly Sensitive Polymer-based Cantilever-sensors for DNA Detection

We present a technology for the fabrication of cantilever arrays aimed to develop an integrated biosensor microsystem. The fabrication process is based on spin coating of the photosensitive polymer and near-ultraviolet exposure. Arrays of up to 33 microcantilevers are fabricated in the novel polymer material SU-8. The low Young's modulus of the polymer, 40 times lower than that of silicon, enables to improve the sensitivity of the sensor device for target detection. The mechanical properties of SU-8 cantilevers, such as spring constant, resonant frequency and quality factor are characterized as a function of the dimensions and the medium. The devices have been tested for measurement of the adsorption of single stranded DNA and subsequent interstitial adsorption of lateral spacer molecules. We demonstrate that sensitivity is enhanced by a factor of six compared to that of commercial silicon nitride cantilevers. (c) 2005 Elsevier B.V. All rights reserved.
Investigation of the bond strength between the photo-sensitive polymer SU-8 and gold

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Department of Management Engineering
Authors: Nordström, M. (Intern), Johansson, A. (Intern), Sánchez Noguerón, E. (Eksterm), Clausen, B. H. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 152-157
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 78-79
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Mass Sensitivity of Cantilever Based Mass Sensors as a Function of Mass-Position

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Dohn, S. (Intern), Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Publication date: 2005
Nanocantilever Sensitivity Degradation From Bimorph Effects

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Publication date: 2005

Host publication information
Title of host publication: Proceedings of NanotechInsight 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 182360
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Nano Environment Monitoring Unit for Space Applications

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Hales, J. H. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Proceedings of the 5th Round Table on MNTs for Space
Main Research Area: Technical/natural sciences
Conference: 5th ESA Round Table on Micro/Nano Technologies for Space, AG Noordwijk, Netherlands, 03/10/2005 - 03/10/2005
Source: orbit
Source-ID: 194262
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Nanomechanical Cantilever based Explosive Vapour Detection System

General information
State: Published
Organisations: Bioprobes, Department of Micro- and Nanotechnology
Authors: Hales, J. H. (Intern), Thundat, T. (Ekstern), Boisen, A. (Intern)
Publication date: 2005
Event: Poster session presented at NanoSECURITY, Halle, Germany.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 186048
Publication: Research › Poster – Annual report year: 2005

Nanoscience Research at Technological University of Denmark and Industrial Perspectives

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Authors: Boisen, A. (Intern)
Publication date: 2005
Event: Paper presented at Seminar on Nanotechnology and Health, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Novel resonant cantilever mass change detection and resonant frequency tuning.
This paper reports a novel way to detect the resonant frequency of an electro-thermally actuated cantilever sensor that we have previously reported, in order to perform mass detection by resonant frequency shift detection. The device is based on monitoring the rupture of a clamped cantilever structure due to mass changes. Thus the device can only be used once and is best suited for qualitative mass detection. At the same time, the resonant frequency of the device can be tuned by the input signal power. This allows scanning power instead of frequency, and simplifies device operation and accompanying electronics.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Grigorov, A. (Intern), Boisen, A. (Intern)
Pages: 190-194
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 78-79
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Polymeric Micro-channel-based Functionalisation System for Micro-Cantilevers

A micro-channel system intended for functionalising micro-cantilevers used for biochemical detection has been designed, realised and characterised. The chip is fabricated in the resist SU-8, which is a photosensitive polymer offering a fast, cost-efficient and easy processing. Cantilevers present a new platform for biochemical detection with a high sensitivity. This micro-channel system is used for treating such a cantilever array with probe molecules prior to detection and it can also be used as the analysis set-up. The design of the micro-channel system provides a simple way of coating separate sections of a cantilever array with different probe molecules. The use of this channel system eliminates the time-consuming step of addressing each cantilever individually to obtain an array functionalised with different probe molecules. Using this micro-channel system in combination with a cantilever array establishes a method of detecting multiple target molecules simultaneously. Fluorescence experiments have been performed to show the working principle of the micro-channel system in combination with a cantilever array. (c) 2005 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Nordström, M. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 281-286
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Ultramicroscopy
Volume: 105
Issue number: 1-4
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.06 SJR 1.824 SNIP 1.317
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 1.896 SNIP 1.176
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Resonators with integrated CMOS circuitry for mass sensing applications, fabricated by electron beam lithography

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Ghatnekar-Nilsson, S. (Ekstern), Forsén, E. S. (Intern), Abadal, G. (Ekstern), Verdi, J. (Ekstern), Campabadal, F. (Ekstern), Perez-Murano, F. (Ekstern), Esteve, J. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern), Montelius, L. (Ekstern)
Self-actuated Polymeric Valve for Autonomous Sensing and Mixing
We present an autonomously operated microvalve array for chemical sensing and mixing, which gains the actuation energy from a chemical reaction on the valve structure. An 8-μm-thick flapper valve made in SU-8 is coated with stress-loaded Al on one side and Ti on the other side. The metal films keep the flapper in a flat, stress-balanced closed position. Upon contact with an analyte composed of a NaOH solution the Al film is etched from the valve surface unbalancing the surface stress and bending the flapper. A deflection of up to 45 μm is observed allowing for effective release of a green marker from a reservoir. Calculations reveal that valve operation with stress originating from biochemical processes will require considerable enhancement of the actuation efficiency.

Sloped Side Walls in SU-8 Structures with 'Step and Flash'
We present an autonomously operated microvalve array for chemical sensing and mixing, which gains the actuation energy from a chemical reaction on the valve structure. An 8-μm-thick flapper valve made in SU-8 is coated with stress-loaded Al on one side and Ti on the other side. The metal films keep the flapper in a flat, stress-balanced closed position. Upon contact with an analyte composed of a NaOH solution the Al film is etched from the valve surface unbalancing the surface stress and bending the flapper. A deflection of up to 45 μm is observed allowing for effective release of a green marker from a reservoir. Calculations reveal that valve operation with stress originating from biochemical processes will require considerable enhancement of the actuation efficiency.
SU-8 Cantilever Sensor System with Integrated Readout

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Microreactors, Bioprobes
Authors: Johansson, A. (Intern), Gomez, M. (Intern), Rasmussen, P. (Intern), Boisen, A. (Intern)
Pages: 111-115
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors and Actuators A. Physical
Issue number: 123-124
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.79 SJR 0.699 SNIP 1.363
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.79 SJR 0.787 SNIP 1.627
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.826 SNIP 1.553 CiteScore 2.73
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.866 SNIP 1.771 CiteScore 2.41
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.819 SNIP 1.762 CiteScore 2.53
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.91 SNIP 2.113 CiteScore 2.34
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.909 SNIP 2.103 CiteScore 2.5
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.11 SNIP 1.85
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.019 SNIP 1.666
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.977 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.957 SNIP 1.457
Scopus rating (2006): SJR 0.896 SNIP 1.676
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.909 SNIP 1.737
Temperature and pressure dependence of resonance in multi-layer microcantilevers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Mølhave, K. (Intern), Boisen, A. (Intern)
Pages: 1454–1458
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 15
Issue number: 8
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.264 SNIP 2.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.165 SNIP 2.073
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.057 SNIP 1.881
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.416 SNIP 1.579
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.103 SNIP 1.507
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.763 SNIP 1.651
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.741 SNIP 1.011
Scopus rating (1999): SJR 0.742 SNIP 1.052
Original language: English
Source: orbit
Source-ID: 182290
Publication: Research - peer-review › Journal article – Annual report year: 2005

Ultrasensitive mass sensor fully integrated with complementary metal-oxide-semiconductor circuitry
Nanomechanical resonators have been monolithically integrated on preprocessed complementary metal-oxide-semiconductor (CMOS) chips. Fabricated resonator systems have been designed to have resonance frequencies up to 1.5 MHz. The systems have been characterized in ambient air and vacuum conditions and display ultrasensitive mass detection in air. A mass sensitivity of 4 ag/Hz has been determined in air by placing a single glycerine drop, having a measured weight of 57 fg, at the apex of a cantilever and subsequently measuring a frequency shift of 14.8 kHz. CMOS integration enables electrostatic excitation, capacitive detection, and amplification of the resonance signal directly on the chip. (c) 2005 American Institute of Physics.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nano-Bio Integrated Systems Group, Biomedical Microsystems Systems Section, Nanoprobes Group, NanoSystemsEngineering Section
Pages: 043507
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Volume: 87
Issue number: 4
ISSN (Print): 0003-6951
Ratings:
A longitudinal thermal actuation principle for mass detection using a resonant micro-cantilever in a fluid medium

We propose a new thermal actuation mechanical principle, which allows dynamic actuation in most media: air, water, etc. It is used to excite a cantilever, aiming to perform mass detection using resonance shifts, in place of the electrostatic or magnetic actuation that are normally used. It differs from existing thermal actuation configurations as the actuation acts on the base of the cantilever device, as opposed to the whole length of the device, separating cantilever and actuator. This allows much bigger freedom in optimizing separately the dimensions of cantilever and actuator. Optimizing the mass sensitivity of the device depends on the relative and absolute dimensions of the cantilever, by limiting fluid damping, displaced mass and cantilever mass. The ability to detect resonance shifts depends on the resonant amplitude, which can be optimized by varying the actuator dimensions and shape configuration, subject of investigation in the following paper. (C) 2004 Elsevier B.V. All rights reserved.
An approach to a multi-walled carbon nanotube based mass sensor

We propose an approach to a nanoscale mass sensor based on a gold electrode structure, on which a multi-walled carbon nanotube (MWCNT) bridge can be placed and soldered. The structure is comprised of three electrodes with a width of 2 or 4 mum. Two outer electrodes with a length of 10 or 15 mum serve as source and drain electrodes for the MWCNT bridge, whereas an inner electrode with a length of 8 or 13 mum is for electrostatic excitation of the CNT. Some structures have an extra pair of outer electrodes, which may deflect the inner electrodes and thereby be used for stretching or compressing the bridging nanotube. The free standing MWCNTs were fabricated by chemical vapour deposition of Fe(H) phthalocyanine. A nanomanipulator with an x-y-z translation stage was used for placing the MWCNTs across the source-drain electrodes. The nanotubes were soldered onto the substrate by electron beam induced deposition of an organometallic compound. (C) 2004 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Mateiu, R. V. (Intern), Davis, Z. J. (Intern), Madsen, D. N. (Intern), Mølhave, K. (Intern), Bøggild, P. (Intern), Rasmussen, A. (Ekstern), Brorson, M. (Ekstern), Jacobsen, C. J. (Ekstern), Boisen, A. (Intern)
Pages: 670–674
Publication date: Jun 2004

Original language: English
dynamic thermal actuation, cantilever, resonance, fluid medium, mass detection

DOIs:
10.1016/j.mee.2004.03.069

Source: orbit
Source-ID: 61502
Publication: Research - peer-review › Conference article – Annual report year: 2004
Publication information
Journal: Microelectronic Engineering
Volume: 73–74
Issue number: SI
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.027 SNIP 1.06
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.045 SNIP 1.138
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.966 SNIP 1.093
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.952 SNIP 0.989
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1 SNIP 1.1
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.812 SNIP 0.956
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.712 SNIP 0.711
Scopus rating (2001): SJR 0.558 SNIP 0.645
Dry release of suspended nanostructures

A dry release method for fabrication of suspended nanostructures is presented. The technique has been combined with an anti-stiction treatment for fabrication of nanocantilever based nanoelectromechanical systems (NEMS). The process combines a dry release method, using a supporting layer of photoresist which is removed using oxygen ashing in a reactive ion etcher (RIE), with CHF3 plasma induced deposition of an fluorocarbon (FC) film acting as an antistiction coating. All in a single RIE sequence. The dry release process is contamination free and batch process compatible. Furthermore, the technique enables long time storage and transportation of produced devices without the risk of stiction. By combining the dry release method with a plasma deposited anti-stiction coating both fabrication induced stiction, which is mainly caused by capillary forces originating from the dehydration of meniscuses formed between suspended structures and the substrate during processing, as well as in-use stiction, occurring during mechanical operation of the system, are avoided. (C) 2004 Elsevier B.V. All rights reserved.
Nucleic acid reactions investigated by cantilever-based sensors

General information
State: Published
Organisations: NSE-Optofluidics Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Nanoprobes Group
Authors: Marie, R. (Intern), Boisen, A. (Intern), Christensen, C. B. V. (Intern)
Publication date: May 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Marie.pdf
Source: orbit
Source-ID: 61508
Publication: Research - peer-review › Journal article – Annual report year: 2004

Organic and Biological Molecular Layers on Functionalised Sensor Surfaces Studies with Atomic Force Microscopy
General information
State: Published
Organisations: Amphiphilic polymers in biological sensing Group, Self-organizing materials for nanotechnology Section, Department of Micro- and Nanotechnology, Department of Physics, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Holmberg, M. (Intern), Kyhle, A. (Intern), Boisen, A. (Intern)
Publication date: Apr 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Holmberg.pdf
Source: orbit
Source-ID: 61511
Publication: Research › Ph.D. thesis – Annual report year: 2004

Cantilever based sensors for surface stress measurements

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Rasmussen, P. A. (Intern), Boisen, A. (Intern)
Number of pages: 151
Publication date: Feb 2004

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Peter.pdf
Source: orbit
Source-ID: 36054
Publication: Research › Ph.D. thesis – Annual report year: 2004

AFM lithography for the definition of nanometre scale gaps: application to the fabrication of a cantilever-based sensor with electrochemical current detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Villarroya, M. (Ekstern), Pérez-Murano, F. (Ekstern), Martín, C. (Ekstern), Davis, Z. J. (Intern), Boisen, A. (Intern), Esteve, J. (Ekstern), Figueras, E. (Ekstern), Montserrat, J. (Ekstern), Barniol, N. (Ekstern)
Pages: 771–776
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Nanotechnology
Volume: 15
Issue number: 7
ISSN (Print): 0957-4484
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.01 SJR 1.079 SNIP 0.788
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.87 SJR 1.339 SNIP 0.945
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
A wet chemical treatment for specific change of the contact angle of SU-8

**General information**

State: Published  
Organisations: Department of Micro- and Nanotechnology  
Authors: Nordstrom, M. (Intern), Marie, R. C. W. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)  
Pages: 91-93  
Publication date: 2004
DNA hybridization detected by cantilever-based sensor with integrated piezoresistive read-out

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Marie, R. C. W. (Intern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Pages: 485-487
Publication date: 2004

Dry release of all polymer structures

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Häfliger, D. (Intern), Nordstrom, M. (Intern), Boisen, A. (Intern)
Pages: 88-89
Publication date: 2004

Electron beam lithography based fabrication of nanocantilever mass sensor systems on pre-processed CMOS

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Forsén, E. S. (Intern), Nilsson, S. G. (Ekstern), Abadal, G. (Ekstern), Murano, F. P. (Ekstern), Esteve, J. (Ekstern), Montserrat, J. (Ekstern), Figueras, E. (Ekstern), Campabadal, F. (Ekstern), Martorell, J. V. (Ekstern), Montelius, L. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern)
Pages: 108-109
Publication date: 2004

Fabrication of cantilever based mass sensors integrated with CMOS using direct write laser lithography on resist

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Forsén, E. S. (Intern), Nilsson, S. (Ekstern), Carlberg, P. (Ekstern), Abadal, G. (Ekstern), Perez-Murano, F. (Ekstern), Esteve, J. (Ekstern), Montserrat, J. (Ekstern), Figueras, E. (Ekstern), Campabadal, F. (Ekstern), Verd, J.
Highly Ordered Oligonucleotide Domain formation on Au(111), Book of Abstracts, 4.1.4 - Talk.

Investigation of the bond strength between the photo-sensitive polymer SU-8 and Au
We present the results from a thorough investigation of the bond strength between the photo-polymer SU-8 and Au. The data were obtained by pull-test experiments, below the glass transition temperature of the polymer. The different aspects that were investigated were: (i) different adhesion promotors between the SU-8 and Au (ii) the effect of the processing sequence, either keeping SU-8 as bottom layer or Au (iii) varying the UV exposure dosage of the SU-8. For comparison, also the bond strength between SU-8 and other materials was measured. We report on bond strength of 4.8 +/- 1.2 MPa between a 7.5 micr.- layer of SU-8 and Au without any adhesion promoter. This value increases to 11.7 +/- 2.1 MPa for a 30 micr.- layer of SU-8. The value of the bond strength can be increased by up to 75% using an adhesion promoter and fully optimising the processing conditions of the SU-8.

Laser lithography on resist bi-layer for nanoelectromechanical systems prototyping

General information
State: Published
Organisations: Department of Chemistry, Department of Micro- and Nanotechnology
Authors: Wackerbarth, H. (Intern), Grubb, M. (Intern), Marie, R. C. W. (Intern), Boisen, A. (Intern), Ulstrup, J. (Intern)
Publication date: 2004
Event: Abstract from The Eighth World Congress on Biosensors., Granada, Spain, 24-26. May, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61500
Publication: Research - peer-review › Journal article – Annual report year: 2004

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Nordström, M. (Intern), Johansson, A. (Intern), Sanches-Noguerón, E. (Ekstern), Clausen, B. (Ekstern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 214-215
Publication date: 2004

Host publication information
Title of host publication: International conference on Micro and Nano Engineering : Conference Proceedings
Publisher: Udefineret
Editors: Nordström, M., Clausen, B., al., E.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 159073
Publication: Research › Conference abstract for conference – Annual report year: 2004

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Forsén, E. S. (Intern), Carlberg, P. (Ekstern), Montelius, L. (Ekstern), Boisen, A. (Intern)
Pages: 491–495
Publication date: 2004
Main Research Area: Technical/natural sciences
Nanocantilever based mass sensors integrated with CMOS

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Forsén, E. S. (Intern), Nilsson, S. G. (Ekstern), Abadal, G. (Ekstern), Murano, F. P. (Ekstern), Esteve, J. (Ekstern), Montserrat, J. (Ekstern), Figueras, E. (Ekstern), Campabadal, F. (Ekstern), Martorell, J. V. (Ekstern), Montelius, L. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern)
Pages: 702-703
Publication date: 2004

Host publication information
Title of host publication: Proceedings of EuroSensors
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61813
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Novel Resonant cantilever mass change detection and resonant frequency tuning

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Grigorov, A. (Intern), Boisen, A. (Intern)
Pages: 228-229
Publication date: 2004

Host publication information
Title of host publication: Proceedings of MNE 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61820
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

On the electromechanical modelling of a resonating nano-cantilever-based transducer

An electromechanical model for a transducer based on a lateral resonating cantilever is described. The on-plane vibrations of the cantilever are excited electrostatically by applying DC and AC voltages from a driver electrode placed closely parallel to the cantilever. The model predicts the static deflection and the frequency response of the oscillation amplitude for different voltage polarization conditions. For the electrostatic force calculation the model takes into account the real deflection shape of the cantilever and the contribution to the cantilever-driver capacitance of the fringing field. Both the static and dynamic predictions have been validated experimentally by measuring the deflection of the cantilever by means of an optical microscope. (C) 2004 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Teva, J. (Ekstern), Abadal, G. (Ekstern), Davis, Z. J. (Intern), Verd, J. (Ekstern), Boisen, A. (Intern), Pérez.Murano, F. (Ekstern), Barniol, N. (Ekstern)
Pages: 225-232
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Ultramicroscopy
Volume: 100
Issue number: 3-4
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.06 SJR 1.824 SNIP 1.317
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 1.896 SNIP 1.176
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.066 SNIP 1.326 CiteScore 2.78
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.628 SNIP 1.598 CiteScore 2.59
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.761 SNIP 1.323 CiteScore 2.66
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.866 SNIP 1.562 CiteScore 2.31
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.659 SNIP 1.328 CiteScore 2.35
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.722 SNIP 1.239
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.755 SNIP 1.544
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.583 SNIP 1.716
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.724 SNIP 1.693
Scopus rating (2005): SJR 1.496 SNIP 1.472
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.482 SNIP 1.69
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.365 SNIP 1.737
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.04 SNIP 1.297
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.52 SNIP 1.195
Scopus rating (2000): SJR 1.351 SNIP 1.058
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.406 SNIP 1.281

Original language: English
DOIs:
Source: orbit
Source-ID: 61498
Polymer cantilever platform for dielectrophoretic assembly of carbon nanotubes
A polymer cantilever platform for dielectrophoretic assembly of carbon nanotubes has been designed and realized. Multi-walled carbon nanotubes from aqueous solution have been assembled between two metal electrodes that are separated by 2 μm and embedded in the polymer cantilever. The entire chip, except for the metallic electrodes and wiring, was fabricated in the photoresist SU-8. SU-8 allows for an inexpensive, flexible and fast fabrication method, and the cantilever platform provides a hydrophobic surface that should be well suited for nanotube assembly. The device can be integrated in a micro-total analysis system and has the potential to be used as a scanning sensor for biochemical applications.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Bioprobes
Authors: Johansson, A. (Intern), Calleja, M. (Ekstern), Dimaki, M. (Intern), Rasmussen, P. A. (Intern), Bøggild, P. (Intern), Boisen, A. (Intern)
Pages: 117-120
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensor Letters
Volume: 2
Issue number: 2
ISSN (Print): 1546-198X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.192 SJR 0.171
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.167 SNIP 0.234 CiteScore 0.43
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.155 SNIP 0.271 CiteScore 0.37
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.219 SNIP 0.454 CiteScore 0.59
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.228 SNIP 0.499 CiteScore 0.68
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.242 SNIP 0.48 CiteScore 0.62
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.242 SNIP 0.58 CiteScore 0.87
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.256 SNIP 0.279
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.235 SNIP 0.458
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.502 SNIP 0.766
Scopus rating (2007): SJR 0.58 SNIP 0.534
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.343 SNIP 0.45
Scopus rating (2005): SJR 0.242 SNIP 0.961
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Original language: English
dielectrophoresis, carbon nanotubes, SU-8, polymer cantilever, biosensor
Polymeric mechanical sensor with integrated strain gauge read-out based on a piezoresistive carbon-black polymer composite material

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Gammelgaard, L. (Intern), Rasmussen, P. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 20-21
Publication date: 2004

Host publication information
Title of host publication: Proceedings of EuroSensors
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61814
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Polymeric mechanical sensor with integrated strain gauge read-out based on a piezoresistive Su-8/carbon-black composite

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Gammelgaard, L. (Intern), Rasmussen, P. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 482-484
Publication date: 2004

Host publication information
Title of host publication: Proceedings of MicroTAS 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61825
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Polymeric micro channel system for easy sensitisation of micro cantilevers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Nordstrom, M. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 55-57
Publication date: 2004

Host publication information
Title of host publication: Proceedings of MicroTAS 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61822
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Rendering SU-8 hydrophilic to facilitate use in micro channel fabrication

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, NSE-Optofluidics Group, NanoSystemsEngineering Section, Nanoprobes Group
Authors: Nordström, M. (Ekstern), Marie, R. (Intern), Gomez, M. (Intern), Boisen, A. (Intern)
Pages: 1614-1617
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 14
Issue number: 12
ISSN (Print): 0960-1317
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.264 SNIP 2.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.165 SNIP 2.073
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.057 SNIP 1.881
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.416 SNIP 1.579
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.103 SNIP 1.507
Web of Science (2002): Indexed yes
**Self-Assembly of Sulfur Anchored Oligonucleotide.**
Book of Abstracts, L2 - Talk.

**General information**
State: Published
Organisations: Department of Chemistry, Department of Micro- and Nanotechnology
Authors: Wackerbarth, H. (Intern), Grubb, M. (Intern), Marie, R. C. W. (Intern), Boisen, A. (Intern), Ulstrup, J. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 159074
Publication: Research › Conference abstract for conference – Annual report year: 2004

**SU-8 cantilever sensor with integrated read-out**

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Johansson, A. (Intern), Gomez, M. (Intern), Rasmussen, P. (Intern), Marie, R. C. W. (Intern), Boisen, A. (Intern)
Pages: 488-490
Publication date: 2004

**Host publication information**
Title of host publication: Proceedings of MicroTAS 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61827
Publication: Research › Conference abstract for conference – Annual report year: 2004

**SU-8 cantilever platform for dielectrophoretic assembly of carbon nanotubes**

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Johansson, A. (Intern), Gomez, M. (Intern), Dimaki, M. (Intern), Rasmussen, P. (Intern), Bøggild, P. (Intern), Boisen, A. (Intern)
Pages: 117-120
Publication date: 2004
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Sensor Letters
ISSN (Print): 1546-198X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.192 SJR 0.171
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.167 SNIP 0.234 CiteScore 0.43
SU-8 cantilever sensor with integrated read-out

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Johansson, A. (Intern), Gomez, M. (Intern), Rasmussen, P. (Intern), Marie, R. C. W. (Intern), Boisen, A. (Intern)
Pages: 243-244
Publication date: 2004

Host publication information
Title of host publication: Proceedings of EuroSensors
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61810
Publication: Research - peer-review › Journal article – Annual report year: 2004

Temperature dependence of surface stress in nanocantilever mass detectors

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Bioprobes
Publication date: 2004
Event: Abstract from 2004 DFS annual meeting, Nyborg, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Temperature dependence of surface stress in nanocantilever mass detectors

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Sandberg, R. K. (Intern), Svendsen, W. E. (Intern), Boisen, A. (Intern), Johansson, A. (Intern), Rasmussen, P. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Proceedings of DFS annual meeting
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 155455
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Thiol- and Disulfide-modified Oligonucleotide Monolayer Structures on Polycrystalline and Single-Crystal Au(111) Surfaces

General information
State: Published
Organisations: Department of Chemistry, Department of Micro- and Nanotechnology, Department of Physics
Pages: 474-481
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Solid State Electrochemistry
Volume: 8
ISSN (Print): 1432-8488
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.674 SJR 0.661 CiteScore 2.37
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.26 SJR 0.678 SNIP 0.735
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.643 SNIP 0.68 CiteScore 2.18
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.831 SNIP 0.996 CiteScore 2.59
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.734 SNIP 0.918 CiteScore 2.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.875 SNIP 1 CiteScore 2.23
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Thiol- and disulfide-modified oligonucleotide monolayer structures on polycrystalline and single-crystal Au(111) surfaces

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Pages: 474–481
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Solid State Electrochemistry
ISSN (Print): 1432-8488
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.674 SJR 0.661 CiteScore 2.37
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.26 SJR 0.678 SNIP 0.735
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.643 SNIP 0.68 CiteScore 2.18
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.831 SNIP 0.996 CiteScore 2.59
Nano-resonators for high resolution mass detection

General information
State: Published
Organisations: Dynamic NEMS Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology, Silicon Microtechnology Group, MicroElectroMechanical Systems Section, Nanoprobes Group
Authors: Davis, Z. J. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Number of pages: 150
Publication date: Jun 2003

Publication information
ISBN (Print): 87-89935-58-6
Main Research Area: Technical/natural sciences
Electronic versions:
Davis.pdf
Source: orbit
Source-ID: 61507
Publication: Research - peer-review › Journal article – Annual report year: 2004

Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.734 SNIP 0.918 CiteScore 2.25
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.875 SNIP 1 CiteScore 2.23
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.868 SNIP 0.994 CiteScore 2.28
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.897 SNIP 0.97
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.849 SNIP 0.907
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.755 SNIP 0.725
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.778 SNIP 0.773
Scopus rating (2006): SJR 0.784 SNIP 0.976
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.634 SNIP 0.839
Scopus rating (2004): SJR 0.528 SNIP 0.764
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.545 SNIP 0.719
Scopus rating (2002): SJR 0.739 SNIP 0.8
Scopus rating (2001): SJR 0.757 SNIP 0.836
Scopus rating (2000): SJR 0.399 SNIP 0.613
Scopus rating (1999): SJR 0.634 SNIP 0.747
Original language: English
Source: orbit
Source-ID: 61507
Publication: Research - peer-review › Journal article – Annual report year: 2004

Nanoprobes Group
In Situ Scanning Tunneling Microscopy and Microcantilever Investigations of yeast cytochrome c on gold

**General information**

State: Published
Organisations: NanoChemistry, Department of Chemistry, Nanoprobes Group, NanoSystemsEngineering Section, Department of Micro- and Nanotechnology
Authors: Hansen, A. G. (Intern), Boisen, A. (Intern), Ulstrup, J. (Intern)
Publication date: Mar 2003

**Publication information**

Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
allan g hansen_phd_thesis.pdf
Source: orbit
Source-ID: 274503
Publication: Research › Ph.D. thesis – Annual report year: 2003

A cantilever-based sensor for thermal cycling in buffer solution

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Marie, R. C. W. (Intern), Thaysen, J. (Ekstern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Pages: 893-898
Publication date: 2003
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Microelectronic Engineering
Volume: 67
Issue number: 8
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Adsorption and Interfacial Electron Transfer of Saccharomyces Cerevisiae: Yeast Cytochrome c Monolayers on Au(111) Electrodes

We have studied the adsorption and electron-transfer dynamics of Saccharomyces cerevisiae (yeast) iso-l-cytochrome c adsorbed on Au(111) electrodes in aqueous phosphate buffer media. This cytochrome possesses a thiol group due to the protein surface (Cys102) suitable for linking the protein to gold without drastic protein unfolding. A comprehensive approach, based on linear sweep and differential pulse voltammetry, capacitance measurements, X-ray photoelectron spectroscopy (XPS), in situ scanning tunneling microscopy (STM), and microcantilever sensor (MCS) techniques has been used. The voltammetric data display a thiol reductive desorption signal corresponding to a sub-monolayer coverage. Reductive desorption is also reflected in a capacitance peak. Voltammetric signals from the heme group in both native and partially denatured states could also be detected. XPS shows clear Au-S band formation, but this observation is not conclusive for aqueous buffer conditions, as the protein is extensively unfolded under ultrahigh vacuum conditions needed for XPS. In situ STM disdoses de ar sub-monolayer coverage to molecular resolution. Imaging is robust in a 0.2 V electrochemical potential range negative of the equilibrium potential of YCC, where the protein is electrochemically functional. The MCS data show tensile differential stress signals when YCC is adsorbed on a gold-coated MCS, with distinguishable adsorption phases in the time range from <102 s to several thousand seconds. Comprehensive approaches to the mapping of adsorbed functional redox metalloproteins toward the single-molecule level, such as in the present study, will be important in the construction of nanoscale devices for multifarious biological and environmental screening.

General information
State: Published
Organisations: Department of Chemistry, Bioprobes, Department of Micro- and Nanotechnology, Department of Physics
Pages: 3419-3427
Publication date: 2003
AFM lithography of aluminum for fabrication of nanomechanical systems

Nanolithography by local anodic oxidation of surfaces using atomic force microscopy (AFM) has proven to be more reproducible when using dynamic, non-contact mode. Hereby, the tip/sample interaction forces are reduced dramatically compared to contact mode, and thus tip wear is greatly reduced. Anodic oxidation of Al can be used for fabricating nanomechanical systems, by using the Al oxide as a highly selective dry etching mask. In our experiments, areas as large as 2 μm x 3 μm have been oxidized repeatedly without any sign of tip-wear. Furthermore, line widths down to 10 nm have been routinely obtained, by optimization of AFM parameters, such as tip/sample distance, voltage and scan speed. Finally, AFM oxidation experiments have been performed on CMOS processed chips, demonstrating the first steps of fabricating fully functional nanomechanical devices. (C) 2003 Elsevier Science B.V. All rights reserved.
A longitudinal thermal actuation principle for mass detection using a resonant micro-cantilever in a fluid medium

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Grigorov, A. (Intern), Davis, Z. J. (Intern), Rasmussen, P. (Intern), Boisen, A. (Intern)
Pages: 430-431
Publication date: 2003

Host publication information
Title of host publication: Proceedings of Micro and nanoengineering (MNE)
Place of publication: Cambridge, UK
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 55754
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2003

An approach to a multi walled carbon nanotube based mass sensor

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Mateiu, R. V. (Intern), Davis, Z. J. (Intern), Madsen, D. N. (Intern), Mølhave, K. (Intern), Bøggild, P. (Intern), Rasmussen, A. (Ekstern), Brorson, M. (Ekstern), Jacobsen, C. (Ekstern), Boisen, A. (Intern)
Pages: 26-27
Atomic force microscope characterization of a resonating nanocantilever

An atomic force microscope (AFM) is used as a nanometer-scale resolution tool for the characterization of the electromechanical behaviour of a resonant cantilever-based mass sensor. The cantilever is actuated electrostatically by applying DC and AC voltages from a driver electrode placed closely parallel to the cantilever. In order to minimize the interaction between AFM probe and the resonating transducer cantilever, the AFM is operated in a dynamic noncontact mode, using oscillation amplitudes corresponding to a low force regime. The dependence of the static cantilever deflection on DC voltage and of the oscillation amplitude on the frequency of the AC voltage is measured by this technique and the results are fitted by a simple non-linear electromechanical model. (C) 2003 Elsevier Science B.V. All rights reserved.
Dry release of suspended nanostructures

Electronic transfer behaviour of biological macromolecules towards the single-molecule level

Electrochemists have been interested in the properties of redox metalloproteins immobilized on metallic surfaces in contact with aqueous biological media for many years. Redox metalloproteins films are currently being addressed by new approaches where biotechnology including modified and synthetic proteins is combined with state-of-the-art physical electrochemistry with emphasis on single-crystal, atomically planar electrode surfaces, in situ scanning tunnelling microscopy (STM) and other surface techniques. These approaches have brought bioelectrochemistry important steps forward towards the nanoscale and single-molecule levels.

We discuss here these advances with reference to two specific redox metalloproteins, the blue single-copper protein Pseudomonas aeruginosa azurin and the single-haem protein Saccharomyces cerevisiae yeast cytochrome c, and a short oligonucleotide. Both proteins can be immobilized on Au(111) by chemisorption via exposed sulfur-containing residues. Voltammetric, interfacial capacitance, x-ray photoelectron spectroscopy and microcantilever sensor data, together with in situ STM with single-molecule resolution, all point to a coherent view of monolayer organization with protein electron transfer (ET) function retained. In situ STM can also address the microscopic...
mechanisms for electron tunnelling through the biomolecules and offers novel notions such as coherent multi-ET between the substrate and tip via the molecular redox levels. This differs in important respects from electrochemical ET at a single metal/electrolyte interface. Similar data for a short oligonucleotide immobilized on Au(111) show that oligonucleotides can be characterized with comparable detail, with novel perspectives for addressing DNA electronic conduction mechanisms and for biological screening towards the single-molecule level.

**General information**

State: Published
Organisations: Department of Chemistry, Department of Micro- and Nanotechnology
Authors: Zhang, J. (Intern), Grubb, M. (Intern), Hansen, A. G. (Intern), Kuznetsov, A. (Ekstern), Boisen, A. (Intern), Wackerbarth, H. (Intern), Ulstrup, J. (Intern)
Pages: S1873-S1890
Publication date: 2003
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of physics-condensed matter
Volume: 15
Issue number: 18
ISSN (Print): 0953-8984
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.37 SJR 0.875 SNIP 0.921
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.89 SJR 1.553 SNIP 0.91
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.043 SNIP 0.889 CiteScore 1.65
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.284 SNIP 0.987 CiteScore 1.99
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.326 SNIP 1.022 CiteScore 2.11
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.688 SNIP 1.168 CiteScore 2.33
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.66 SNIP 1.161 CiteScore 2.31
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.663 SNIP 1.054
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.525 SNIP 1.015
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.467 SNIP 1.071
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.561 SNIP 1.143
Web of Science (2007): Indexed yes
FLEXIBLE STRUCTURE WITH INTEGRATED SENSOR/ACTUATOR
A polymer-based flexible structure with integrated sensing/actuator means is presented. Conventionally, silicon has been used as a piezo-resistive material due to its high gauge factor and thereby high sensitivity to strain changes in a sensor. By using the fact that e.g. an SU-8 based polymer is much softer than silicon and that e.g. a gold resistor is easily incorporated in SU-8 based polymer structure it has been demonstrated that a SU-8 based cantilever sensor is almost as sensitive to stress changes as the silicon piezo-resistive cantilever.

Hybridisation of short DNA molecules investigated with in situ atomic force microscopy
By introducing the complementary DNA (cDNA) strand to a molecular layer of short single stranded DNA (ssDNA), immobilised on a gold surface, we have investigated hybridisation between the two DNA strands through the technique of in situ atomic force microscopy (AFM). Before introduction of cDNA, the ssDNA molecular layer was modulated with the spacer molecule mercaptohexanol (MCH), which makes the ssDNA molecules more accessible for hybridisation.

With in situ AFM, we have monitored the formation of a smooth, mixed molecular layer containing ssDNA and MCH. Furthermore, the hybridisation between the two DNA strands has been studied. Introduction of the cDNA strand resulted in an increase in smoothness and thickness of the molecular layer. Both the increase in order and thickness of the molecular layer can be expected if hybridisation occurs, since double stranded DNA molecules have a more rigid and elongated structure than ssDNA molecules. (C) 2003 Elsevier Science B.V. All rights reserved.
Lift-off by local laser lithography for stamp manufacturing

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Forsén, E. S. (Intern), Carlberg, P. (Ekstern), Montelius, L. (Ekstern), Boisen, A. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Proceedings of the Second International Conference on Nanoimprint and Nanoprint Technology (NNT)
Place of publication: Boston, MA, USA
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 55752
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Monolithic integration of mass sensing nano-cantilevers with CMOS circuitry

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Abadal, G. (Ekstern), Helbo, B. (Intern), Hansen, O. (Intern), Campabadal, F. (Ekstern), Perez-Murano, F. (Ekstern), Esteve, J. (Ekstern), Figueras, E. (Ekstern), Verd, J. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern)
Pages: 311-319
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors and Actuators A-Physical
Volume: 105
Issue number: 3
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.79 SJR 0.699 SNIP 1.363
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.79 SJR 0.787 SNIP 1.627
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.826 SNIP 1.553 CiteScore 2.73
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.866 SNIP 1.771 CiteScore 2.41
Nanobubble trouble on gold surfaces

When analyzing surfaces related to biosensors with in situ atomic force microscopy (AFM), the existence of nanobubbles called for our attention. The bubbles seem to form spontaneously when gold surfaces are immersed in clean water and are probably a general phenomenon at water-solid interfaces. Besides from giving rise to undesired effects in, for example, biosensors, nanobubbles can also cause artifacts in AFM imaging. We have observed nanobubbles on unmodified gold surfaces, immersed in clean water, using standard silicon AFM probes. Nanobubbles can be made to disappear from contact mode AFM images and then to reappear by changing the scanning force. By combining contact mode AFM imaging and local force measurements, the interaction between the nanobubbles and the probe can be analyzed and give information about the characteristics of nanobubbles. A model of the forces between the AFM probe tip and the nanobubble indicates that a small tip cone angle and a relatively hydrophilic tip surface makes it possible to image nanobubbles with contact mode AFM even though the tip has penetrated the surface of the bubble.

General information
Nanocantilever based mass sensor integrated with CMOS circuitry

We have demonstrated the successful integration of a cantilever based mass detector with standard CMOS circuitry. The purpose of the circuitry is to facilitate the readout of the cantilever's deflection in order to measure resonant frequency shifts of the cantilever. The principle and design of the mass detector are presented showing that miniaturization of such cantilever based resonant devices leads to highly sensitive mass sensors, which have the potential to detect single molecules. The design of the readout circuitry used for the first electrical characterization of an integrated cantilever is described in detail. The integration of the cantilever is a post processing module and the full process sequence is discussed. One of the main challenges during the fabrication of the cantilevers is sticktion of the cantilever to the bottom substrate after underclothing. Two dry release techniques were used to solve the problem, namely freeze-drying and resist-assisted release. The fabrication results of cantilevers defined by laser and E-beam lithography are shown. Finally, an AFM based characterization setup is presented and the electrical characterization of a laser-defined cantilever fully integrated with CMOS circuitry is demonstrated. The electrical characterization of the device shows that the resonant behavior of the cantilever depends on the applied voltages, which corresponds to theory.

Nanopatterning by AFM nano-oxidation of thin aluminum layers as a tool for the prototyping of nanoelectromechanical systems

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Abadal, G. (Ekstern), Campabadal, F. (Ekstern), Figueras, E. (Ekstern), Esteve, J. (Ekstern), Verd, J. (Ekstern), Perez-Murano, F. (Ekstern), Borrise, X. (Ekstern), Nilsson, S. G. (Ekstern), Miximov, I. (Ekstern), Montelius, L. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern)
Pages: 496-499
Publication date: 2003

Host publication information
Title of host publication: Proceedings of the 12th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers)
Place of publication: Boston, USA
Publisher: IEEE
ISBN (Print): 0-7803-7731-1
Main Research Area: Technical/natural sciences
Conference: 12th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers), Boston, United States, 09/06/2003 - 09/06/2003
Electronic versions:
Davis.pdf

Bibliographical note
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Source: orbit
Source-ID: 55747
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003
Optimised cantilever biosensor with piezoresistive read-out

We present a cantilever-based biochemical sensor with piezoresistive read-out which has been optimised for measuring surface stress. The resistors and the electrical wiring on the chip are encapsulated in low-pressure chemical vapor deposition (LPCVD) silicon nitride, so that the chip is well suited for operation in liquids. The wiring is titanium silicide which—in contrast to conventional metal wiring—is compatible with the high-temperature LPCVD coating process.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Rasmussen, P. (Intern), Thaysen, J. (Ekstern), Hansen, O. (Intern), Eriksen, S. (Ekstern), Boisen, A. (Intern)
Pages: 371-376
Publication date: 2003
Conference: Fourth International Conference on Scanning Probe Microscopy, Sensors and Nanostructures, Las Vegas, NV, United States, 26/05/2002 - 26/05/2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Ultramicroscopy
Volume: 97
Issue number: 1-4
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.06 SJR 1.824 SNIP 1.317
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.82 SJR 1.896 SNIP 1.176
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.066 SNIP 1.326 CiteScore 2.78
Polymeric Cantilever Arrays for Biosensing Applications

We report the fabrication of arrays of polymeric cantilevers for biochemistry applications. The cantilevers are fabricated in the polymer SU-8. The use of a polymer as the component material for the cantilevers provides the sensors with very high sensitivity due to convenient mechanical material properties. The fabrication process is based on spin coating of the photosensitive polymer and near-ultraviolet exposure. The method allows obtaining well-controlled and uniform mechanical properties of the cantilevers. The elastic constant of the cantilevers was measured, and their dynamic response was studied. Characterization of the devices shows that they are suitable for both static and dynamic measurements for biochemical detection in either air or liquid environments. The sensor was applied to monitoring of the immobilization process of cystamine on a gold-coated SU-8 cantilever.
Polymeric Mechanical Sensors with Strain Gauge Readout in a Microfluidic System

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Calleja, M. (Ekstern), Tamayo, J. (Ekstern), Johansson, A. (Intern), Rasmussen, P. (Intern), Lechuga, L. (Ekstern), Boisen, A. (Intern)
Pages: 20-24
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensor Letters
Volume: 1
Issue number: 1
ISSN (Print): 1546-198X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.192 SJR 0.171
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.167 SNIP 0.234 CiteScore 0.43
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.155 SNIP 0.271 CiteScore 0.37
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.219 SNIP 0.454 CiteScore 0.59
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.228 SNIP 0.499 CiteScore 0.68
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.242 SNIP 0.48 CiteScore 0.62
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.242 SNIP 0.58 CiteScore 0.87
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.256 SNIP 0.279
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.235 SNIP 0.458
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.502 SNIP 0.766
Scopus rating (2007): SJR 0.58 SNIP 0.534
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.343 SNIP 0.45
Scopus rating (2005): SJR 0.242 SNIP 0.961
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Original language: English
DOIs:
10.1166/sl.2003.010
Source: orbit
Source-ID: 154109
Publication: Research - peer-review › Journal article – Annual report year: 2003
Polymeric mechanical sensor with piezoresistive read-out integrated in a microfluidic system

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Gomez, M. (Intern), Rasmussen, P. (Intern), Johansson, A. (Intern), Boisen, A. (Intern)
Pages: 207-210
Publication date: 2003

Host publication information
Title of host publication: Proceedings of μTAS 2003, 7th International Conference on Micro Total Analysis Systems
Main Research Area: Technical/natural sciences
Conference: The Seventh International Conference on Miniaturized Chemical and Biochemical Analysis Systems (MicroTAS), Squaw Valley, United States, 05/10/2003 - 05/10/2003
Source: orbit
Source-ID: 39263
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Adsorption kinetics and mechanical properties of thiol-modified DNA-oligos on gold investigated by microcantilever sensors

Immobilised DNA-oligo layers are scientifically and technologically appealing for a wide range of sensor applications such as DNA chips. Using microcantilever-based sensors with integrated readout, we demonstrate in situ quantitative studies of surface-stress formation during self-assembly of a 25-mer thiol-modified DNA-oligo layer. The self-assembly induces a surface-stress change, which closely follows Langmuir adsorption model. The adsorption results in compressive surface-stress formation, which might be due to intermolecular repulsive forces in the oligo layer. The rate constant of the adsorption depends on the concentration of the oligo solution. Based on the calculated rate constants a surface free energy of the thiol-modified DNA-oligo adsorption on gold is found to be -32.4 kJ mol(-1). The adsorption experiments also indicate that first a single layer of DNA-oligos is assembled on the gold surface after which a significant unspecific adsorption takes place on top of the first DNA-oligo layer. The cantilever-based sensor principle has a wide range of applications in real-time local monitoring of chemical and biological interactions as well as in the detection of specific DNA sequences, proteins and particles. (C) 2002 Elsevier Science B.V. All rights reserved.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Marie, R. C. W. (Intern), Jensenius, H. (Intern), Thaysen, J. (Intern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Pages: 29-36
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Ultramicroscopy
Volume: 91
Issue number: 1-4
ISSN (Print): 0304-3991
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
AFM characterization of a resonating nanocantilever

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Pérez-Murano, F. (Ekstern), Davis, Z. J. (Intern), Abadal, G. (Ekstern), Hansen, O. (Intern), Borrisé, X. (Ekstern), Boisen, A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of Nano-7/Ecoss-21
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61335
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

A mass sensor with atto-gram sensitivity using resonating nanocantilevers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Barniol, N. (Ekstern), Abadal, G. (Ekstern), Borrisé, X. (Ekstern), Pérez-Murano, F. (Ekstern), Verd, J. (Ekstern), Villarroya, M. (Ekstern), Davis, Z. J. (Intern), Boisen, A. (Intern), Campabadal, F. (Ekstern), Figueras, E. (Ekstern), Esteve, J. (Ekstern), Monserrat, J. (Ekstern), Nilsson, S. (Ekstern), Maximov, I. (Ekstern), Sarwe, E. (Ekstern), Montelius, L. (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the Nano-7/Ecoss-21
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 59011
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Cantilever Biosensor with Integrated Read-out Optimised for Operation in Liquid

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Rasmussen, P. (Intern), Thaysen, J. (Intern), Hansen, O. (Intern), Eriksen, S. C. (Intern), Boisen, A. (Intern)
Pages: 705-706
Publication date: 2002

Host publication information
Title of host publication: Proceedings of Eurosensors XVI
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 59663
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

DNA immobilisator on gold surface for biosensors and microsystems; a fluorescence scanning study

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Marie, R. C. W. (Intern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the Micro- and nanoengineering (MNE)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 59658
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002
DNA immobiliser on gold surface for biosensors and microsystems; a fluorescence scanning study

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Marie, R. C. W. (Intern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the Medicon Valley Academy
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 59659
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Formation of self-assembled monolayers of short DNA molecules, investigated with in situ Atomic Force Microscopy

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Holmberg, M. (Intern), Kühle, A. (Ekstern), Garnæs, J. (Ekstern), Boisen, A. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of Scanning Probe Microscopy, Sensors and Nanostructures (SPM)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61332
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

In situ STM and Nanoscale Electronic Function of Redox Metalloprotein Monolayers on Single-Crystal Au(111)-surfaces
Book of Abstract., 98.

General information
State: Published
Organisations: Department of Chemistry, Department of Micro- and Nanotechnology
Authors: Hansen, A. G. (Intern), Boisen, A. (Intern), Zhang, J. (Intern), Wackerbarth, H. (Intern), Andersen, J. E. T. (Intern), Ulstrup, J. (Intern)
Publication date: 2002
Event: Abstract from 21st European Congress on Surface Science and 7th International Conference on Nanometer-scale Science and Technology, Malmö, Sweden.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 39248
Publication: Research › Conference abstract for conference – Annual report year: 2002

In Situ STM and nanoscale electronic function of redox metalloprotein monolayers on single-crystal Au(111)-surfaces

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Department of Chemistry
Authors: Hansen, A. G. (Intern), Boisen, A. (Intern), Zhang, J. (Ekstern), Wackerbarth, H. (Ekstern), Andersen, J. (Ekstern), Ulstrup, J. (Intern)
Publication date: 2002

Host publication information
Title of host publication: Proceedings of Nano-7/Ecoss-21
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61330
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002
Optimization of sensitivity and noise in piezoresistive cantilevers

In this article, the sensitivity and the noise of piezoresistive cantilevers were systematically investigated with respect to the piezoresistor geometry, the piezoresistive materials, the doping dose, the annealing temperature, and the operating biased voltage. With the noise optimization results, dimension optimized array cantilevers were designed and fabricated by using single-crystal silicon, low-pressure chemical-vapor deposition (LPCVD) amorphous silicon and microcrystalline silicon as piezoresistive layers. Measurement results have shown that the smallest Hooge factor (alpha) was $3.2 \times 10^{-6}$, the biggest gauge factors was 95, and the minimum detectable deflection (MDD) at 6 V and 200 Hz-measurement bandwidth was 0.3 nm for a single-crystal silicon cantilever. Of the two LPCVD silicon piezoresistive cantilevers, amorphous silicon piezoresistors had relatively lower 1/f noise. The MDD for a LPCVD silicon cantilever at a 200 Hz-measurement bandwidth was 0.4 nm. For all kinds of piezoresistive cantilevers, the 1/f noises were decreased by 35%-50% and the gauge factors were decreased by 60-70% if the doping dose were increased by ten times. The annealing at 1050 degreesC for 30 min decreased 1/f noise by about 65% compared with the 950 degreesC for 10 min treatments. The cantilevers with a relatively higher-doping dose gave smaller MDD even though the gauge factors of them were decreased by nearly a factor of 1.8. The higher-biased voltages had no great improvements on the MDD due to the 1/f noise dominance.
Scanning microscopic four-point conductivity probes

A method for fabricating microscopic four-point probes is presented. The method uses silicon-based microfabrication technology involving only two patterning steps. The last step in the fabrication process is an unmasked deposition of the conducting probe material, and it is thus possible to select the conducting material either for a silicon wafer or a single probe unit. Using shadow masking photolithography an electrode spacing (pitch) down to 1.1 μm was obtained, with cantilever separation down to 200 nm. Characterisation measurements have shown the microscopic probes to be mechanically very flexible and robust. Repeated conductivity measurements on polythiophene films in the same surface area are reproduced within an accuracy of 3%. Automated nanoresolution position control allows scanning across millimetre sized areas, in order to create high spatial resolution maps of the in-plane conductivity.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Petersen, C. L. (Intern), Hansen, T. M. (Intern), Bøggild, P. (Intern), Boisen, A. (Intern), Hansen, O. (Intern), Hassenkam, T. (Ekstern), Grey, F. (Intern)
Pages: 53-58
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors and actuators a-physical
Volume: 96
Issue number: 1
ISSN (Print): 0924-4247
Ratings:
    BFI (2018): BFI-level 2
    Web of Science (2018): Indexed yes
    BFI (2017): BFI-level 2
    Scopus rating (2017): CiteScore 2.79 SJR 0.699 SNIP 1.363
    Web of Science (2017): Indexed yes
    BFI (2016): BFI-level 2
    Scopus rating (2016): CiteScore 2.79 SJR 0.787 SNIP 1.627
    Web of Science (2016): Indexed yes
    BFI (2015): BFI-level 2
    Scopus rating (2015): SJR 0.826 SNIP 1.553 CiteScore 2.73
    BFI (2014): BFI-level 2
    Scopus rating (2014): SJR 0.866 SNIP 1.771 CiteScore 2.41
    Web of Science (2014): Indexed yes
    BFI (2013): BFI-level 2
    Scopus rating (2013): SJR 0.819 SNIP 1.762 CiteScore 2.53
    ISI indexed (2013): ISI indexed yes
    Web of Science (2013): Indexed yes
    BFI (2012): BFI-level 2
    Scopus rating (2012): SJR 0.91 SNIP 2.113 CiteScore 2.34
    ISI indexed (2012): ISI indexed yes
    Web of Science (2012): Indexed yes
    BFI (2011): BFI-level 1
    Scopus rating (2011): SJR 0.909 SNIP 2.103 CiteScore 2.5
    ISI indexed (2011): ISI indexed yes
    Web of Science (2011): Indexed yes
    BFI (2010): BFI-level 1
    Scopus rating (2010): SJR 1.11 SNIP 1.85
    Web of Science (2010): Indexed yes
    BFI (2009): BFI-level 1
    Scopus rating (2009): SJR 1.019 SNIP 1.666
    Web of Science (2009): Indexed yes
Translating molecular interaction into a nanomechanical signal

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Thaysen, J. (Intern), Boisen, A. (Intern)
Pages: 167-171
Publication date: 2002

Host publication information
Title of host publication: Proceedings of Mesomechanics 1
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 59666
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Adsorption mechanisms for differently treated thiolmodified ssDNA on Au

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Mortensen, M. W. (Intern), Kühle, A. (Ekstern), Garnæs, J. (Ekstern), Christensen, C. B. V. (Intern), Boisen, A. (Intern)
Publication date: 2001

Host publication information
Title of host publication: Proceedings of STM '01
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61284
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

A Microcantileverbased detection principle for MTAS

General information
Cantilever-based bio-chemical sensor integrated in a microliquid handling system

The cantilevers have integrated piezoresistive readout which, compared to optical readout, enables simple measurements on even non-transparent liquids, such as blood. First, we introduce a simple theory for using piezoresistive cantilevers as surface stress sensors. Then, the sensor fabrication based on conventional microfabrication is described and the sensor characterization is discussed. During the characterization we found a stress sensitivity of $(\Delta R/R)=4.6 \times 10^{-4}$ $(N/m)^{-1}$ and a minimum detectable surface stress change of 2.6 mN/m. Aqua regia etch of gold on top of the cantilevers has been monitored, and immobilization of single-stranded thiol modified DNA-oligos has been detected by the sensor. Finally, it is demonstrated that it is possible to analyze two samples simultaneously by utilizing the laminar flow in the microliquid handling system.

Electromechanical model of a resonating nano-cantilever-based sensor for high-resolution and high-sensitivity mass detection

A simple linear electromechanical model for an electrostatically driven resonating cantilever is derived. The model has been developed in order to determine dynamic quantities such as the capacitive current flowing through the cantilever-driver system at the resonance frequency, and it allows us to calculate static magnitudes such as position and voltage of collapse or the voltage versus deflection characteristic. The model is used to demonstrate the theoretical sensitivity on the attogram scale of a mass sensor based on a nanometre-scale cantilever, and to analyse the effect of an extra feedback loop in the control circuit to increase the Q factor.
High mass and spatial resolution mass sensor based on resonating nano-cantilevers integrated with CMOS

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Abadal, G. (Ekstern), Helbo, B. (Ekstern), Hansen, O. (Intern), Campabadal, F. (Ekstern), Pérez-Murano, F. (Ekstern), Esteve, J. (Ekstern), Figueras, E. (Ekstern), Ruiz, R. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern)
Pages: 72-75
Publication date: 2001

Host publication information
Title of host publication: Proceeding of Transducers '01
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61244
Publication: Research - peer-review › Article in proceedings – Annual report year: 2001

Light propagation studies on laser modified waveguides using scanning near-field optical microscopy
By means of direct laser writing on Al, a new method to locally modify optical waveguides is proposed. This technique has been applied to silicon nitride waveguides, allowing modifications of the optical propagation along the guide. To study the formed structures, a scanning near-field optical microscope (SNOM) has been used. The laser modifications locally changes the optical properties of the waveguide. The change in the effective refractive index is attributed to a TE to TM mode conversion, Thus, the laser modification might be a new way to fabricate optical mode converters.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Borrise, X. (Ekstern), Berini, A. G. (Intern), Jimenez, D. (Ekstern), Perez-Murano, F. (Ekstern), Barniol, N. (Ekstern), Davis, Z. J. (Intern), Boisen, A. (Intern)
Pages: 809-811
Publication date: 2001
Main Research Area: Technical/natural sciences
Modular design of AFM probe with sputtered silicon tip

We present an atomic force microscopy (AFM) probe with integrated piezoresistive read-out. The probe consists of a micromachined cantilever with a tip at the end. The cantilever is a multilayer structure with its thickness defined by etch-stop and the bending controlled by fitting the thicknesses of the thin films constituting the cantilever. The AFM probe has an integrated tip made of a thick sputtered silicon layer, which is deposited after the probe has been defined and just before the cantilevers are released. The tips are so-called rocket tips made by reactive ion etching. We present probes with polysilicon resistors for demonstrating the fabrication principle. The probes have been characterised with respect to noise and deflection sensitivity and have been applied in AFM imaging.
Stress Formation During Self-Assembly of Alkanethiols on Differently Pre-Treated Gold Surfaces

Micromachined cantilevers can be applied as highly sensitive surface stress sensors and have been used to study the stress formation in self-assembled alkanethiol layers on gold. We have investigated ways of cleaning the gold surface before adsorption of gaseous hexanethiol in order to optimise the rate and reproducibility of the adsorption process. Further objectives have been to maximise the stress signal during adsorption and to develop a method for removing sulphur immobilised molecules. Before each adsorption experiment the gold surface was cleaned in aqua regia, or in oxygen plasma. Adsorption of alkanethiols caused changes in surface stress, which closely followed Langmuir type kinetics. Cleaning with aqua regia generally provides higher adsorption rates and a larger stress change than cleaning with oxygen plasma. Based on AFM imaging, we propose that this is related to a larger surface roughness induced by aqua regia etching, resulting in a higher density of adsorption sites. Surfaces cleaned with oxygen plasma, however, give more reproducible stress change curves. The stress change curves of surfaces cleaned with aqua regia become less stable after three subsequent cleanings, exhibiting oscillatory stress curves.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Department of Chemistry, Danish Fundamental Metrology
Authors: Hansen, A. G. (Intern), Mortensen, M. W. (Intern), Andersen, J. E. T. (Intern), Ulstrup, J. (Intern), Kühle, A. (Ekstern), Garnæs, J. (Ekstern), Boisen, A. (Intern)
Pages: 139-149
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Probe Microscopy
Volume: 2
Issue number: 2
ISSN (Print): 1355-185X
Ratings:
BFI (2008): BFI-level 1
Scopus rating (2004): SJR 0.529 SNIP 0.936
AFM probe with piezoresistive read-out and highly symmetrical Wheatstone bridge arrangement

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Thaysen, J. (Intern), Boisen, A. (Intern), Hansen, O. (Intern), Bouwstra, S. (Intern)
Pages: 47-53
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Sensors and Actuators
Volume: 83
Issue number: 83
ISSN (Print): 1054-6693
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Web of Science (2006): Indexed yes
Original language: English
Source: orbit
Source-ID: 177057
Publication: Research - peer-review › Journal article – Annual report year: 2000

A microcantilever-based alcohol vapor sensor-application and response model
A recently developed microcantilever probe with integrated piezoresistive readout has been applied as a gas sensor. Resistors, sensitive to stress changes, are integrated on the flexible cantilevers. This makes it possible to monitor the cantilever deflection electrically and with an integrated reference cantilever background noise is subtracted directly in the measurement. A polymer coated cantilever has been exposed to vapors of various alcohols and the resulting cantilever response has been interpreted using a simple evaporation model. The model indicates that the cantilever response is a direct measure of the molecular concentration of alcohol vapor. On the basis of the model the detection limit of this cantilever-based sensor is determined to be below 10 ppm for alcohol vapor measurements. Furthermore, the time response of the cantilever can be used to distinguish between different alcohols due to a difference in the evaporation rates. (C) 2000 American Institute of Physics.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Silicon Microtechnology Group, MicroElectroMechanical Systems Section, Nanoprobes Group, NanoSystemsEngineering Section
Authors: Jensenius, H. (Intern), Thaysen, J. (Intern), Rasmussen, A. A. (Intern), Veje, L. H. (Intern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 2615-2617
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Volume: 76
Issue number: 18
ISSN (Print): 0003-6951
Ratings:
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<th>Year</th>
<th>BFI Level</th>
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<th>Web of Science</th>
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<td>Indexed yes</td>
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<td>2017</td>
<td>BFI-level 2</td>
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<td>2011</td>
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<td>SJR 2.894 SNIP 1.82</td>
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<td>2010</td>
<td>BFI-level 2</td>
<td>SJR 3.012 SNIP 1.916</td>
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<td>2009</td>
<td>BFI-level 2</td>
<td>SJR 3.459 SNIP 2.288</td>
<td>Indexed yes</td>
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<td>BFI-level 2</td>
<td>SJR 3.755 SNIP 2.353</td>
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<td>2007</td>
<td>BFI-level 2</td>
<td>SJR 3.992 SNIP 2.367</td>
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<td>2006</td>
<td>BFI-level 2</td>
<td>SJR 3.897 SNIP 2.275</td>
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<td>2005</td>
<td>BFI-level 2</td>
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<td>2004</td>
<td>BFI-level 2</td>
<td>SJR 4.281 SNIP 2.22</td>
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<td>2003</td>
<td>BFI-level 2</td>
<td>SJR 4.178 SNIP 2.017</td>
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<td>2002</td>
<td>BFI-level 2</td>
<td>SJR 4.173 SNIP 2.066</td>
<td>Indexed yes</td>
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Original language: English
Environmental sensors based on micromachined cantilevers with integrated read-out
An AFM probe with integrated piezoresistive read-out has been developed and applied as a cantilever-based environmental sensor. The probe has a built-in reference cantilever, which makes it possible to subtract background drift directly in the measurement. Moreover, the integrated read-out facilitates measurements in liquid. The probe has been successfully implemented in gaseous as well as in liquid experiments. For example, the probe has been used as an accurate and minute thermal sensor and as a humidity sensor. In liquid, the probe has been used to detect the presence of alcohol in water. (C) 2000 Elsevier Science B.V. All rights reserved.
Fabrication and characterization of nano-resonating devices for mass detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Davis, Z. (Ekstern), Abadal, G. (Ekstern), Kuhn, O. (Intern), Hansen, O. (Intern), Grey, F. (Intern), Boisen, A. (Intern)
Pages: 612-612
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Vacuum Science & Technology B
Volume: 18
Issue number: 2
ISSN (Print): 1071-1023
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.631 SJR 0.467 CiteScore 1.25
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
In Situ Nanoscale Biochemistry Probed by SPM-based Technologies

General information
State: Published
Organisations: Department of Chemistry
Authors: Andersen, J. E. T. (ed.) (Intern), Boisen, A. (ed.) (Intern), Ulstrup, J. (ed.) (Intern)
Publication date: 2000
In Situ Nanoscale Biochemistry Probed by SPM-Based Technologies

General information
State: Published
Organisations: Department of Chemistry
Authors: Andersen, J. E. T. (ed.) (Intern), Boisen, A. (ed.) (Intern), Ulstrup, J. (Intern)
Publication date: 2000

Host publication information
Title of host publication: Probe Microscopy, Special Issue
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 176689
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Nanocantilever devices for mass detection - fabrication and characterization

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Davis, Z. J. (Intern), Abadal, G. (Ekstern), Helbo, B. (Ekstern), Hansen, O. (Intern), Grey, F. (Intern), Boisen, A. (Intern)
Pages: 81-89
Publication date: 2000

Host publication information
Title of host publication: Proceedings of 1st euspen topical conference on fabrication and metrology in nanotechnology
Place of publication: Copenhagen, Denmark
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 177093
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Nanocantilever integrated with CMOS circuitry for high sensitivity mass detection

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Abadal, G. (Ekstern), Barniol, N. (Ekstern), Boisen, A. (Intern), Campabadal, F. (Ekstern), Davis, Z. J. (Intern), Esteve, J. (Ekstern), Figueras, E. (Ekstern), Helbo, B. (Ekstern), Perez-Murano, F. (Ekstern), Ruiz, R. (Ekstern)
Publication date: 2000

Host publication information
Title of host publication: Proceedings of Ibersensor Buenos Aires
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 177083
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

Nanomechanical devices for mass detection realized by laser and atomic force microscopy and compatible with CMOS technology

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Abadal, G. (Ekstern), Davis, Z. J. (Intern), Helbo, B. (Ekstern), Ruiz, R. (Ekstern), Pérez-Murano, F. (Ekstern), Campabadal, F. (Ekstern), Esteve, J. (Ekstern), Figueras, E. (Ekstern), Boisen, A. (Intern), Barniol, N. (Ekstern)
Piezoresistive atomic force microscopy probe with sputtered silicon tip

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Rasmussen, P. (Intern), Thaysen, J. (Intern), Bouwstra, S. (Intern), Boisen, A. (Intern)
Pages: 637-640
Publication date: 2000

Host publication information
Title of host publication: Proceedings of Eurosensors XIV
Place of publication: Copenhagen, Denmark
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 177084
Publication: Research - peer-review › Article in proceedings – Annual report year: 2000

AFM probe with piezoresistive read-out and highly symmetrical wheatstone bridge arrangement.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Thaysen, J. (Intern), Boisen, A. (Intern), Hansen, O. (Intern), Bouwstra, S. (Intern)
Pages: 1852-1855
Publication date: 1999

Host publication information
Title of host publication: AFM probe with piezoresistive read-out and highly symmetrical wheatstone bridge arrangement.
Publisher: The Institute of Electrical Engineers of Japan
Main Research Area: Technical/natural sciences
Conference: 10th International Conference on Solid-State Sensors and Actuators (Transducers ’99), Sendai, Japan, 01/01/1999
Source: orbit
Source-ID: 175427
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Combined laser and atomic force microscope lithography on aluminum: Mask fabrication for nanoelectromechanical systems

A direct-write laser system and an atomic force microscope (AFM) are combined to modify thin layers of aluminum on an oxidized silicon substrate, in order to fabricate conducting and robust etch masks with submicron features. These masks are very well suited for the production of nanoelectromechanical systems (NEMS) by reactive ion etching. In particular, the laser-modified areas can be subsequently locally oxidized by AFM and the oxidized regions can be selectively removed by chemical etching. This provides a straightforward means to define the overall conducting structure of a device by laser writing, and to perform submicron modifications by AFM oxidation. The mask fabrication for a nanoscale suspended resonator bridge is used to illustrate the advantages of this combined technique for NEMS. (C) 1999 American Institute of Physics. [S0003-6951(99)00221-1].

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes Group, NanoSystemsEngineering Section, Dynamic NEMS Group, Silicon Microtechology Group, MicroElectroMechanical Systems Section
Authors: Berini, A. G. (Intern), Boisen, A. (Intern), Davis, Z. J. (Intern), Hansen, O. (Intern), Grey, F. (Intern)
Pages: 3206-3208
<table>
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<th>Year</th>
<th>BFI (level)</th>
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<th>Web of Science</th>
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<td>2019</td>
<td>BFI-level 2</td>
<td>SJR 1.499 SNIP 1.226 CiteScore 2.47</td>
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<td>2018</td>
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<td>BFI-level 2</td>
<td>SJR 2.894 SNIP 1.82</td>
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<td>2012</td>
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<td>SJR 3.755 SNIP 2.353</td>
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<td>2011</td>
<td>BFI-level 2</td>
<td>SJR 3.992 SNIP 2.367</td>
<td>Indexed yes</td>
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<td>2010</td>
<td>BFI-level 2</td>
<td>SJR 4.018 SNIP 2.414</td>
<td>Indexed yes</td>
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<td>2009</td>
<td>BFI-level 2</td>
<td>SJR 4.031 SNIP 2.414</td>
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<td>SJR 4.031 SNIP 2.414</td>
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<td>2007</td>
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<td>2006</td>
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<td>2005</td>
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<td>SJR 4.031 SNIP 2.414</td>
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<td>2002</td>
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<td>Indexed yes</td>
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Gas sensor based on micromachined cantilevers with integrated read-out.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Jensenius, H. (Intern), Thaysen, J. (Intern), Rasmussen, A. (Ekstern), Veje, L. (Ekstern), Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 586-587
Publication date: 1999

Host publication information
Title of host publication: Gas sensor based on micromachined cantilevers with integrated read-out.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175424
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Images of analytical chemistry

General information
State: Published
Organisations: Department of Chemistry
Authors: Andersen, J. E. T. (Intern), Zhang, J. (Intern), Chi, Q. (Intern), Hansen, A. G. (Intern), Nielsen, J. U. (Intern), Ulstrup, J. (Intern), Boisen, A. (Intern), Jensenius, H. (Intern)
Pages: 22-25
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication Information
Journal: Chemistry in Denmark
Volume: 80
Original language: Danish
Source: orbit
Source-ID: 174177
Publication: Research › Journal article – Annual report year: 1999

In Situ Scanning Probe Microscopy and New Perspectives in Analytical Chemistry
Laser and AFM lithography on aluminum: a toolbox for fabrication of nanoelectromechanical structures.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Abadal, G. (Ekstern), Davis, Z. (Ekstern), Hansen, O. (Intern), Grey, F. (Intern)
Pages: 337-338
Publication date: 1999

Host publication information
Title of host publication: Laser and AFM lithography on aluminum: a toolbox for fabrication of nanoelectromechanical structures.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175425
Publication: Research - peer-review › Article in proceedings – Annual report year: 1999

Noise in piezoresistive atomic force microscopy

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Hansen, O. (Intern), Boisen, A. (Intern)
Pages: 51-60
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Nanotechnology
Volume: 10
Issue number: 1
ISSN (Print): 0957-4484
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.01 SJR 1.079 SNIP 0.788
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.87 SJR 1.339 SNIP 0.945
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.257 SNIP 1.035 CiteScore 3.07
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.497 SNIP 1.269 CiteScore 3.09
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Fabrication of submicron suspended structures by laser and AFM lithography on aluminium combined with reactive ion etching

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Birkelund, K. (Intern), Hansen, O. (Intern), Grey, F. (Intern)
Pages: 2977-2981
Publication date: 1998
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Vacuum Science & Technology B
Volume: 16
Issue number: 6 Nov/Dec
ISSN (Print): 1071-1023
Fabrication of submicron suspended structures by laser and AFM lithography on aluminum combined with reactive ion etching.

**General information**
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Birkelund, K. (Intern), Hansen, O. (Intern), Grey, F. (Intern)
Pages: 2977-81
Publication date: 1998
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Journal of Vacuum Science & Technology B
Volume: 16
Issue number: 6
ISSN (Print): 1071-1023
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.631 SJR 0.467 CiteScore 1.25
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.08 SJR 0.595 SNIP 0.691
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.533 SNIP 0.641 CiteScore 0.66
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.509 SNIP 0.601 CiteScore 0.61
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.55 SNIP 0.631 CiteScore 0.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.691 SNIP 0.717 CiteScore 0.85
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.868 SNIP 0.857 CiteScore 1.22
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.9 SNIP 0.852
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.929 SNIP 0.955
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.998 SNIP 0.941
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.267 SNIP 1.02
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.285 SNIP 1.211
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.248 SNIP 1.026
Web of Science (2005): Indexed yes
AFM probes with directly fabricated tips

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Hansen, O. (Intern), Bouwstra, S. (Intern)
Publication date: 1996
Pages: 58-62
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Micromechanics and Microengineering
Volume: 6
ISSN (Print): 0960-1317
Ratings:

BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.554 SNIP 0.968
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.63 SNIP 1.067
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.687 SNIP 1.265 CiteScore 1.96
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.802 SNIP 1.316 CiteScore 1.84
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.737 SNIP 1.233 CiteScore 1.74
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.936 SNIP 1.491 CiteScore 1.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.036 SNIP 1.443 CiteScore 2.43
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.013 SNIP 1.637
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.144 SNIP 1.5
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.243 SNIP 1.616
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.422 SNIP 1.815
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.264 SNIP 2.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.165 SNIP 2.073
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.057 SNIP 1.881
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.416 SNIP 1.579
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.103 SNIP 1.507
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.763 SNIP 1.651
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.741 SNIP 1.011
Scopus rating (1999): SJR 0.742 SNIP 1.052
Indirect tip fabrication for scanning probe microscopy

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Authors: Boisen, A. (Intern), Rasmussen, J. P. (Intern), Hansen, O. (Intern), Bouwstra, S. (Intern)
Pages: 579-582
Publication date: 1996
Main Research Area: Technical/natural sciences

Publication information
Journal: Microelectronic Engineering
Volume: 30
ISSN (Print): 0167-9317
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.87 SJR 0.604 SNIP 0.937
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.69 SJR 0.589 SNIP 0.949
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.507 SNIP 0.796 CiteScore 1.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.586 SNIP 0.86 CiteScore 1.44
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.595 SNIP 0.964 CiteScore 1.45
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.737 SNIP 0.949 CiteScore 1.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.813 SNIP 1.148 CiteScore 1.8
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.934 SNIP 1.093
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.834 SNIP 1.098
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.027 SNIP 1.06
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.045 SNIP 1.138
Effects of small-angle scattering on Weiss oscillations in a GaAs lateral superlattice

We introduce small-angle scattering into the interpretation of the low-field magnetoresistance and the Weiss oscillations of a periodically modulated two-dimensional electron gas. Comparison between our experiments and a Monte Carlo simulation determines the small-angle scattering rate versus the carrier density and the periodic modulation of the carrier density.

General information
State: Published
Organisations: University of Copenhagen
Authors: Bøggild, P. (Intern), Boisen, A. (Intern), Birkelund, K. (Intern), Sørensen, C. B. (Ekstern), Taboryski, R. J. (Intern), Lindelof, P. E. (Intern)
Pages: 7333-7336
Publication date: 1995
Main Research Area: Technical/natural sciences

Publication information
Journal: Physical Review B
Volume: 51
Issue number: 11
ISSN (Print): 2469-9950
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Indexed yes
Scopus rating (2015): SJR 2.377 SNIP 1.13 CiteScore 2.8
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 2.762 SNIP 1.316 CiteScore 3.3
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 2.813 SNIP 1.326 CiteScore 3.55
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 3.173 SNIP 1.378 CiteScore 3.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 3.326 SNIP 1.423 CiteScore 3.61
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 3.318 SNIP 1.447
Web of Science (2010): Indexed yes
Web of Science (2009): Indexed yes
Scopus rating (2008): SJR 2.923 SNIP 1.516
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.892 SNIP 1.588
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.62 SNIP 1.468
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.126 SNIP 1.156
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.012 SNIP 1.103
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.184 SNIP 1.179
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.856 SNIP 1.841
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.132 SNIP 1.727
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.84 SNIP 1.603
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.789 SNIP 1.541
Original language: English
DOIs:
10.1103/PhysRevB.51.7333
Source: orbit
Source-ID: 277150
Publication: Research - peer-review › Journal article – Annual report year: 1995

Projects:

3D printing of micro-container for oral delivery of probiotics
Department of Micro- and Nanotechnology
Period: 01/09/2018 → 31/08/2021
Number of participants: 4
Phd Student:
Chang, Tien-Jen (Ekstern)
Supervisor:
Hwu, En Te (Intern)
Nielsen, Line Hagner (Intern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Evaluating microcontainers for oral delivery of probiotics
Department of Micro- and Nanotechnology
Period: 01/09/2018 → 31/08/2021
Number of participants: 4
Phd Student:
Christfort, Juliane Fjelrad (Ekstern)
Supervisor:
Nielsen, Line Hagner (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Microcontainers for Oral Delivery of Probiotics
Department of Micro- and Nanotechnology
Period: 15/06/2018 → 14/06/2021
Number of participants: 4
Phd Student:
Kamguyan, Khorshid (Intern)
Supervisor:
Nielsen, Line Hagner (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Fonde
Project: PhD

Microcontainers for oral drup delivery
Department of Micro- and Nanotechnology
Period: 01/02/2018 → 31/01/2021
Number of participants: 3
Phd Student:
Hansen, Stine Egebro (Intern)
Supervisor:
Nielsen, Line Hagner (Intern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Development of Highly sensitive raman spectroscopy system for monitoring of multicomponent drug mixtures in the PPM Concentration range
Department of Micro- and Nanotechnology
Period: 01/11/2017 → 31/10/2020
Number of participants: 4
Phd Student:
Slipets, Roman (Intern)
Supervisor:
Ilchenko, Oleksii (Intern)
Rindzevicius, Tomas (Intern)
Main Supervisor:
Boisen, Anja (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

**Optical Sensor Disc**

Department of Micro- and Nanotechnology
Period: 01/10/2017 → 30/09/2020
Number of participants: 4
Phd Student:
Serioli, Laura (Intern)
Supervisor:
Rindzevicius, Tomas (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

**Sensors on disc**

Department of Micro- and Nanotechnology
Period: 01/05/2017 → 30/04/2020
Number of participants: 4
Phd Student:
Thoppe Rajendran, Sriram (Intern)
Supervisor:
Rindzevicius, Tomas (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

**Fabrication of biodegradable microcontainers for oral drug delivery**

Department of Micro- and Nanotechnology
Period: 01/03/2017 → 29/02/2020
Number of participants: 4
Phd Student:
Abid, Zarmeena (Intern)
Supervisor:
Boisen, Anja (Intern)
Petersen, Ritika Singh (Intern)
Main Supervisor:
Keller, Stephan Sylvest (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Grundforskningsfonden
Project: PhD
Drug transport in in vitro intestine models
Department of Micro- and Nanotechnology
Period: 15/12/2016 → 14/12/2019
Number of participants: 4
Phd Student:
Jepsen, Morten Leth (Intern)
Supervisor:
Boisen, Anja (Intern)
Nielsen, Line Hagner (Intern)
Main Supervisor:
Dufva, Martin (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Grundforskningsfonden
Project: PhD

Nanomechanical Sensors
Department of Micro- and Nanotechnology
Period: 01/10/2016 → 30/09/2019
Number of participants: 5
Phd Student:
Padmanabhan Rangacharya, Varadarajan (Intern)
Supervisor:
Larsen, Peter Emil (Intern)
Rindzevicius, Tomas (Intern)
Wu, Kaiyu (Intern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Mucoadhesive microcontainers for oral drug delivery
Department of Micro- and Nanotechnology
Period: 15/09/2016 → 17/08/2020
Number of participants: 4
Phd Student:
Mosgaard, Mette Dalskov (Intern)
Supervisor:
Andersen, Alina Joukainen (Intern)
Müllertz, Anette (Ekstern)
Main Supervisor:
Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Fonde
Project: PhD

Development of Surface-Enhanced Raman Scattering Sensors
Department of Micro- and Nanotechnology
Period: 01/09/2016 → 31/08/2019
Number of participants: 4
Phd Student: Viehrig, Marlitt (Intern)
Supervisor: Rindzevicius, Tomas (Intern)
Zor, Kinga (Intern)
Main Supervisor: Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Fonde
Project: PhD

Miniaturization of food safety analysis
National Food Institute
Period: 15/03/2016 → 14/03/2019
Number of participants: 3
Phd Student: Zhai, Demi Shuang (Intern)
Supervisor: Boisen, Anja (Intern)
Main Supervisor: Smedsgaard, Jørn (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Additive Manufacturing and Characterization of Mini Devices for Oral Drug Delivery
Department of Micro- and Nanotechnology
Period: 01/03/2016 → 28/02/2019
Number of participants: 4
Phd Student: Vaut, Lukas (Intern)
Supervisor: Jensen, Kristian Ejlebjærg (Intern)
Tosello, Guido (Intern)
Main Supervisor: Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Loading of microcontainers for oral drug delivery
Department of Micro- and Nanotechnology
Period: 15/01/2016 → 14/01/2019
Number of participants: 3
Phd Student: Mazzoni, Chiara (Intern)
Supervisor: Nielsen, Line Hagner (Intern)
Main Supervisor: Boisen, Anja (Intern)

Financing sources
Source: Internal funding (public)
Carbon Based Micromechanical Sensors

Department of Micro- and Nanotechnology
Period: 15/12/2015 → 14/12/2018
Number of participants: 4
PhD Student: Nguyen, Quang Long (Intern)
Supervisor: Boisen, Anja (Intern)
Schmid, Silvan (Intern)
Main Supervisor: Keller, Stephan Sylvest (Intern)

Financing Sources
Source: Internal funding (public)

Targeting Approaches to Oral Drug Delivery with Microcontainers

Department of Micro- and Nanotechnology
Period: 01/12/2015 → 30/11/2018
Number of participants: 4
PhD Student: Tentor, Fabio (Intern)
Supervisor: Almdal, Kristoffer (Intern)
Bose-Goswami, Sanjukta (Intern)
Main Supervisor: Boisen, Anja (Intern)

Financing Sources
Source: Internal funding (public)

Microcontainers for Oral Vaccine Delivery

Department of Micro- and Nanotechnology
Period: 01/09/2015 → 31/08/2018
Number of participants: 7
PhD Student: von Halling Laier, Christoffer (Intern)
Supervisor: Nielsen, Line Hagner (Intern)
Rades, Thomas (Ekstern)
Main Supervisor: Boisen, Anja (Intern)
Examiner: Larsen, Niels Bent (Intern)
Christensen, Dennis (Ekstern)
Lavelle, Ed (Ekstern)

Financing Sources
Source: Internal funding (public)
Chemical/Biological sensing using CMUTs
Department of Micro- and Nanotechnology
Period: 01/05/2015 → 21/06/2018
Number of participants: 6
Phd Student:
Mølgaard, Mathias Johannes Grøndahl (Intern)
Supervisor:
Jakobsen, Mogens Havsteen (Intern)
Main Supervisor:
Thomsen, Erik Vilain (Intern)
Examiner:
Boisen, Anja (Intern)
Dossi, Eleftheria (Ekstern)
Virzonis, Darius (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

SERS based Sensing and Centrifugal Microfluidics
Department of Micro- and Nanotechnology
Period: 15/01/2015 → 03/05/2018
Number of participants: 8
Phd Student:
Durucan, Onur (Intern)
Supervisor:
Matteucci, Marco (Intern)
Rindzevicius, Tomas (Intern)
Schmidt, Michael Stenbæk (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Smedsgaard, Jørn (Intern)
Golcuk, Kurtulus (Ekstern)
Hakonen, Aron (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Surface-Enhanced Raman Spectroscopy Integrated Centrifugal Microfluidics Platform
Project: PhD

Disc System for Cellular Studios
Department of Micro- and Nanotechnology
Period: 01/12/2014 → 07/03/2018
Number of participants: 7
Phd Student:
Morelli, Lidia (Intern)
Supervisor:
Rindzevicius, Tomas (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Svendsen, Winnie Edith (Intern)
Ducree, Jens (Ekstern)
Sandahl, Margareta (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering

Relations
Publications:
SERS-based detection methods for screening of genetically modified bacterial strains
Project: PhD

Agglutination based Sensing and Centrifugal Microfluidics
Department of Micro- and Nanotechnology
Period: 01/11/2014 → 07/02/2018
Number of participants: 7
Phd Student:
Uddin, Rokon (Intern)
Supervisor:
Burger, Robert (Intern)
Donolato, Marco (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Wolff, Anders (Intern)
Kallio, Pasi J. (Ekstern)
Turner, Anthony P. F. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Magnetic Bead-Based Biosensing on an Automated & Integrated Lab-on-a-Disc Platform
Project: PhD

Electrochemical/Agglutination based Sensing and Centrifugal Microfluidics
Department of Micro- and Nanotechnology
Period: 01/09/2014 → 11/01/2018
Number of participants: 7
Phd Student:
Sanger, Kuldeep (Intern)
Supervisor:
Heiskanen, Arto (Intern)
Zor, Kinga (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Taboryski, Rafael J. (Intern)
Turner, Anthony P. F. (Ekstern)
Zebgerle, Roland (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Relations
Publications:
Design and development of electrochemical polymer-based lab-on-a-disc devices for biological applications
Project: PhD

Cantilever sensor on a rotating disc
Department of Micro- and Nanotechnology
Period: 01/04/2014 → 23/08/2017
Number of participants: 7
Phd Student:
Casci Ceccacci, Andrea (Intern)
Supervisor:
Bosco, Filippo (Intern)
Cagliani, Alberto (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Almdal, Kristoffer (Intern)
Davis, Zachary James (Intern)
Jeon, Sangmin (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Hollow Cantilever-like sensors on a rotating disc
Department of Micro- and Nanotechnology
Period: 01/02/2014 → 10/05/2017
Number of participants: 7
Phd Student:
Kurek, Maksymilian (Intern)
Supervisor:
Burger, Robert (Intern)
Schmid, Silvan (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Thomsen, Erik Vilain (Intern)
Seonghwan, Kim (Ekstern)
Tamayo, Javier (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering

Relations
Publications:
Photothermal IR spectroscopy with perforated membrane micromechanical resonators
Project: PhD

Electromechanical sensors on a rotating disc
Department of Micro- and Nanotechnology
Period: 15/08/2013 → 10/05/2017
Number of participants: 7
Phd Student:
Andreasen, Sune Zoëga (Intern)
Towards a fully automated lab-on-a-disc system integrating sample enrichment and detection of analytes from complex matrices
Project: PhD

Surface Plasmon based sensors using nanopillar arrays
Department of Micro- and Nanotechnology
Period: 15/08/2013 → 08/02/2017
Number of participants: 7
Phd Student:
Thilsted, Anil Haraksingh (Intern)
Supervisor:
Rindzveicius, Tomas (Intern)
Schmidt, Michael Stenbæk (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hübner, Jörg (Intern)
Ariese, Freek (Ekstern)
Pedersen, Jens Engholm (Intern)

Understanding Optical Properties of nanopillar arrays
Department of Micro- and Nanotechnology
Period: 01/05/2013 → 17/08/2016
Number of participants: 6
Phd Student:
Wu, Kaiyu (Intern)
Supervisor:
Schmidt, Michael Stenbæk (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hübner, Jörg (Intern)
Dmitriev, Alexander (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

Relations
Publications:
Engineering Plasmonic Nanopillar Arrays for Surface-enhanced Raman Spectroscopy
Project: PhD

nanostructuring of solar cell surfaces
Department of Micro- and Nanotechnology
Period: 01/11/2012 → 15/06/2016
Number of participants: 7
Phd Student:
Davidsen, Rasmus Schmidt (Intern)
Supervisor:
Boisen, Anja (Intern)
Schmidt, Michael Stenbæk (Intern)
Main Supervisor:
Hansen, Ole (Intern)
Examiner:
Jørgensen, Anders Michael (Intern)
Balling, Peter (Ekstern)
Marstein, Erik Stensrud (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

SERS as tool for monitoring lung infections
Department of Micro- and Nanotechnology
Period: 01/11/2012 → 08/02/2017
Number of participants: 7
Phd Student:
Lauridsen, Rikke Kragh (Intern)
Supervisor:
Molin, Søren (Intern)
Rindzevicius, Tomas (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Bohr, Jakob (Intern)
Gilchrist, Francis J. (Ekstern)
Turner, Anthony P. F. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering

Relations
Publications:
SERS detection of pneumonia in breath of children with cystic fibrosis
Project: PhD
Fabrication of biopolymer micro-container for oral drug delivery
Department of Micro- and Nanotechnology
Period: 15/09/2012 → 09/12/2015
Number of participants: 6
Phd Student:
Petersen, Ritika Singh (Intern)
Supervisor:
Keller, Stephan Sylvest (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Taboryski, Rafael J. (Intern)
Lehr, Claus-Michael (Ekstern)
Worgull, Matthias (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

Development of a micromechanical Photothermal Spectrometer
Department of Micro- and Nanotechnology
Period: 01/09/2012 → 16/03/2016
Number of participants: 6
Phd Student:
Larsen, Peter Emil (Intern)
Supervisor:
Schmid, Silvan (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Thomsen, Erik Vilain (Intern)
Thundat, Thomas G. (Ekstern)
Wiegerink, Remco John (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

High-throughput Gene Expression profiling (HT GenExp) technology for assessing heterogeneity in human stem cells
Department of Micro- and Nanotechnology
Period: 15/08/2012 → 17/08/2016
Number of participants: 6
Phd Student:
Poulsen, Carl Esben (Intern)
Supervisor:
Dufva, Martin (Intern)
Main Supervisor:
Wolff, Anders (Intern)
Examiner:
Boisen, Anja (Intern)
Ducre, Jens (Ekstern)
Hollfelder, Florian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
**Surface chemistry for cantilever-like end SERS sensors for DVD-based platform**

Department of Micro- and Nanotechnology  
Period: 15/08/2012 → 09/12/2015  
Number of participants: 7  
Phd Student:  
Frøhling, Kasper Bayer (Intern)  
Supervisor:  
Bache, Michael (Intern)  
Boisen, Anja (Intern)  
Main Supervisor:  
Jakobsen, Mogens Havsteen (Intern)  
Examiner:  
Rozlosnik, Noemi (Intern)  
Engelsen, Søren Balling (Ekstern)  
Merkoçi, Arben (Ekstern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Forskningsrådsfinansiering  
Project: PhD

**Cantilever-like sensors for DVD Platform**

Department of Micro- and Nanotechnology  
Period: 01/08/2012 → 09/11/2015  
Number of participants: 7  
Phd Student:  
Brøgger, Anna Line (Intern)  
Supervisor:  
Burger, Robert (Intern)  
Schmidt, Michael Stenbæk (Intern)  
Main Supervisor:  
Boisen, Anja (Intern)  
Examiner:  
Hübner, Jörg (Intern)  
Bell, Steven E. J. (Ekstern)  
Liz-Marzán, Luis Manuel (Ekstern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet  
Project: PhD

**Loading of micro-containers for oral drug delivery**

Department of Micro- and Nanotechnology  
Period: 01/02/2011 → 14/05/2014  
Number of participants: 7  
Phd Student:  
Marizza, Paolo (Intern)  
Supervisor:  
Keller, Stephan Sylvest (Intern)  
Müllertz, Anette (Ekstern)  
Main Supervisor:  
Boisen, Anja (Intern)  
Examiner:  
Skov, Anne Ladegaard (Intern)
Rantanen, Jukka Tapio (Ekstern)
Schneider, Marc (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

**Nanoparticles and Health**
Department of Micro- and Nanotechnology
Period: 01/04/2010 → 15/06/2016
Number of participants: 6
Phd Student:
Yamada, Shoko (Intern)
Supervisor:
Schmid, Silvan (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Melhave, Kristian (Intern)
Amiot, Fabien (Intern)
Jeon, Sangmin (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed

**Relations**
Publications:
Analyzing Engineered Nanoparticles using Photothermal Infrared Spectroscopy
Project: PhD

**Development of Mechanical Biosensor for Metabolomics**
Department of Micro- and Nanotechnology
Period: 01/02/2010 → 26/11/2013
Number of participants: 7
Phd Student:
Quan, Xueling (Intern)
Supervisor:
Heiskanen, Arto (Intern)
Tenje, Maria (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Emnéus, Jenny (Intern)
Ruzgas, Tautgirdas (Ekstern)
Thundat, Thomas G. (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

**Fabrication and characterization of drug delivery vehicles**
Department of Micro- and Nanotechnology
Period: 01/01/2010 → 18/04/2013
Number of participants: 6
Phd Student:
Nagstrup, Johan (Intern)
Supervisor:
Keller, Stephan Sylvest (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:

Hansen, Hans Nørgaard (Intern)
Sandler, Niklas Olavi (Ekstern)
Schift, Helmut (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Programbevilling
Project: PhD

Temperature Stable Mass Sensors
Department of Micro- and Nanotechnology
Period: 01/12/2009 → 21/02/2013
Number of participants: 6
Phd Student:
Khan, Faheem (Intern)
Supervisor:
Schmid, Silvan (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Okkels, Fridolin (Intern)
Jeon, Sangmin (Ekstern)
Stemme, Göran (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Programbevilling
Project: PhD

Micro-scale temperature sensors for calorimetry and cantilever based sensing
Department of Micro- and Nanotechnology
Period: 01/10/2009 → 18/12/2012
Number of participants: 6
Phd Student:
Larsen, Tom (Intern)
Supervisor:
Schmid, Silvan (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Svendsen, Winnie Edith (Intern)
Finot, Eric (Ekstern)
Thundat, Thomas G. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Cantilever-based sensors for explosives detection
Department of Micro- and Nanotechnology
Period: 01/11/2008 → 16/01/2012
Number of participants: 5
Phd Student:
Bosco, Filippo (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Kutter, Jörg Peter (Intern)
Hegner, Martin (Ekstern)
Thundat, Thomas G. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Programbevilling
Project: PhD

High frequency bulk resonators for bio/chemical diagnostics and monitoring applications
Department of Micro- and Nanotechnology
Period: 01/10/2008 → 16/01/2012
Number of participants: 6
Phd Student:
Cagliani, Alberto (Intern)
Supervisor:
Davis, Zachary James (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hansen, Ole (Intern)
Del Monte, Aránzazu U. (Ekstern)
Roukes, Michael L. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Micro-calorimetric sensors for explosives detection
Department of Micro- and Nanotechnology
Period: 01/08/2008 → 28/09/2011
Number of participants: 5
Phd Student:
Olsen, Jesper Kenneth (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hvilsted, Søren (Intern)
Bouwstra, Siebe (Ekstern)
P. Hernández-Rivera, Samuel (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Development of cantilever sensors for ion Detetion
Department of Micro- and Nanotechnology
Period: 01/01/2008 → 23/02/2011
Number of participants: 6
Micromechanical Pathogen Sensor System
Department of Micro- and Nanotechnology
Period: 01/10/2007 → 24/11/2010
Number of participants: 6
PhD Student:
Noeth, Nadine-Nicole (Intern)
Supervisor:
Keller, Stephan Sylvest (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Mogensen, Klaus Bo (Intern)
Heinzelmann, Harry (Ekstern)
Ruano-Lopez, Jesus M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

3D nanolithography for self-aligned nano- and microstructures
Department of Micro- and Nanotechnology
Period: 01/02/2007 → 22/09/2010
Number of participants: 6
PhD Student:
Greve, Anders (Intern)
Supervisor:
Svendsen, Winnie Edith (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
De Grave, Arnaud (Intern)
Berger, Rüdiger (Ekstern)
Hierold, Christofer (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

High Frequency Resonators for Liquid based Bio/Chemical Diagnostics and Monitoring Applications
Department of Micro- and Nanotechnology
Period: 01/02/2006 → 20/05/2009
Number of participants: 6
Phd Student:
Hales, Jan Harry (Intern)
Supervisor:
Boisen, Anja (Intern)
Main Supervisor:
Davis, Zachary James (Intern)
Examiner:
Krozer, Viktor (Intern)
Berini, Gabriel Abadal (Ekstern)
Brugger, Jürgen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Activation of SU8 Polymer Cantilever Systems for the Detection of Methicillin-Resistant Staphylococcus aureus (MRSA)

Department of Micro- and Nanotechnology
Period: 15/11/2005 → 22/04/2009
Number of participants: 6
Phd Student:
Chang, Chia-Wen (Intern)
Supervisor:
Pallesen, Lars (Ekstern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Larsen, Niels Bent (Intern)
Ingmer, Hanne (Ekstern)
Mckendry, Rachel (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Autonomous Diagnostic Array for Biomedical Applications

Department of Micro- and Nanotechnology
Period: 01/05/2005 → 29/08/2008
Number of participants: 6
Phd Student:
Keller, Stephan Sylvest (Intern)
Supervisor:
Häfliger, Daniel (Ekstern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Almdal, Kristoffer (Intern)
Despont, Michel (Ekstern)
Grutter, Peter H. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD
Micro and Nanomechanical Sensors Realised in Functionalised Polymers

Department of Micro- and Nanotechnology
Period: 01/03/2005 → 29/08/2008
Number of participants: 5
Phd Student:
Lillemose, Michael (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Almdal, Kristoffer (Intern)
Berger, Rüdiger (Ekstern)
Gomez, Montserrat (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD

Piezoresistivity for Microsystems

Department of Micro- and Nanotechnology
Period: 01/01/2005 → 29/05/2008
Number of participants: 7
Phd Student:
Richter, Jacob (Intern)
Supervisor:
Christensen, Carsten (Intern)
Hansen, Ole (Intern)
Main Supervisor:
Thomsen, Erik Vilain (Intern)
Examiner:
Boisen, Anja (Intern)
Gravesen, Peter (Ekstern)
Paul, Oliver (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU, Samfinansiering
Project: PhD

Nanoskala multi-punkts prober fabrikeret ved elektron-stråle litografi

Department of Micro- and Nanotechnology
Number of participants: 7
Phd Student:
Gammelgaard, Lauge (Intern)
Supervisor:
Boisen, Anja (Intern)
Petersen, Peter Rasmus Ebsen (Intern)
Main Supervisor:
Bøggild, Peter (Intern)
Examiner:
Horch, Sebastian (Intern)
Brugger, Jürgen (Ekstern)
Gravesen, Peter (Ekstern)

Financing sources
Packaging of Bioprobe Cantilevers

Department of Micro- and Nanotechnology
Period: 01/03/2004 → 05/02/2007
Number of participants: 5
Phd Student: Johansson, Alicia Charlotte (Intern)
Supervisor: Geschke, Oliver (Intern)
Main Supervisor: Boisen, Anja (Intern)
Examiner: Staufer, Urs (Ekstern)
Thundat, Thomas G. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

Fabrication of Polymeric Cantilevers with Integrated Optical Read-Out

Department of Micro- and Nanotechnology
Period: 15/02/2004 → 28/06/2007
Number of participants: 7
Phd Student: Tenje, Maria (Intern)
Supervisor: Gomez, Montserrat (Intern)
Hübner, Jörg (Intern)
Main Supervisor: Boisen, Anja (Intern)
Examiner: Kutter, Jörg Peter (Intern)
López, Jesús Miguel Ruano (Ekstern)
Nordin, Gregory P. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Investigation of Nano-resonators for Mass Detection

Department of Micro- and Nanotechnology
Period: 01/09/2003 → 30/03/2007
Number of participants: 6
Phd Student: Dohn, Søren (Intern)
Supervisor: Hansen, Ole (Intern)
Main Supervisor: Boisen, Anja (Intern)
Examiner: Sigmund, Ole (Intern)
Bouwstra, Siebe (Ekstern)
Design, fabrication and implementation of a highly Versatile High Resolution Mass Sensor

Department of Micro- and Nanotechnology
Period: 15/02/2003 → 06/09/2006
Number of participants: 5
Phd Student:
Grigorov, Alexander Vladimirov (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hansen, Ole (Intern)
Berini, Gabriel Abadal (Ekstern)
Montelius, Lars (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Polymeric cantilever for bio-chemical sensing

Department of Micro- and Nanotechnology
Period: 13/01/2003 → 31/08/2006
Number of participants: 1
Project ID: 65104
Project Manager, organisational:
Boisen, Anja (Intern)

Financing sources
Source: Forskningsrådene - STVF
Name of research programme: Forskningsrådene - STVF
Amount: 1,800,000.00 Danish Kroner
Project:

Investigation and realigation of a Mass Sensor with NanoElectroMechanicalSystem (NEMS)

Department of Micro- and Nanotechnology
Period: 01/10/2002 → 30/03/2006
Number of participants: 6
Phd Student:
Mateiu, Ramona Valentina (Intern)
Supervisor:
Bøggild, Peter (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hansen, Ole (Intern)
Berini, Gabriel Abadal (Ekstern)
Brugger, Jürgen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD
Fabrication and Characterization of Nano-Resonators for Mass Detection

Department of Micro- and Nanotechnology
Period: 01/07/2002 → 23/01/2006
Number of participants: 4
Phd Student:
Forsén, Esko Sebastian (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Andreani, Pietro (Intern)
Tamayo, Javier (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Nanoresonators with integrated circuitry for high sensitivity and high resolution mass detection

Department of Micro- and Nanotechnology
Universitat Autonoma de Barcelona
Consejo Superior de Investigaciones Cientificas
Lund University
Number of participants: 1
Project ID: 65080
Project participant:
Boisen, Anja (Intern)

Financing sources
Source: Forsk. EU - Rammeprogram
Name of research programme: Forsk. EU - Rammeprogram
Amount: 3,652,787.00 Danish Kroner

Optiske bistabilitet i integreret optik

Department of Micro- and Nanotechnology
Period: 01/09/2001 → 29/08/2005
Number of participants: 6
Phd Student:
Sandberg, Rasmus Kousholt (Intern)
Supervisor:
Svendsen, Winnie Edith (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Hansen, Ole (Intern)
Berger, Rüdiger (Ekstern)
Gomez, Montserrat (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD
Nucleic acid Reactions Investigated by Cantilever Based Sensors

Department of Micro- and Nanotechnology
Period: 01/01/2001 → 12/05/2004
Number of participants: 5
Phd Student:
Marie, Rodolphe (Intern)
Supervisor:
Christensen, Claus Bo Vöge (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Pedersen, Lars Hag (Intern)
Gómez, Laura M. Lechuga (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Organiske og Biologiske molekullag på funktionelle sensor-overflader studeret med atomic force mikroskopi

Department of Micro- and Nanotechnology
Period: 01/12/2000 → 05/03/2004
Number of participants: 7
Phd Student:
Hansen, Maria Svendsmark (Intern)
Supervisor:
Garnæs, Jørgen (Ekstern)
Kyhle, Anders (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Ulstrup, Jens (Intern)
Pedersen, Lars Hag (Intern)
Williams, Philip Michael (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Project: PhD

Cantilever-based sensors for surface stress measurements

Department of Micro- and Nanotechnology
Period: 01/08/2000 → 10/02/2004
Number of participants: 4
Phd Student:
Rasmussen, Peter Andreas (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Scheeper, Patrick Richard (Intern)
Vettiger, Peter (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD
Nanoresonators for high resolution mass detection
Department of Micro- and Nanotechnology
Period: 01/02/2000 → 30/06/2003
Number of participants: 6
PhD Student:
Davis, Zachary James (Intern)
Supervisor:
Hansen, Ole (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Sigmund, Ole (Intern)
Brand, Oliver (Ekstern)
Brugger, Jürgen (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Anden EU-finansiering
Project: PhD

Nanocantilevers for mass detection
Cantilevers with dimensions in the submicron regime can be used as very sensitive mass sensors by detecting changes in the resonant frequency of the cantilever. The objective of the project is to fabricate nanometer sized resonating cantilevers with integrated read-out. The cantilevers will be fabricated using AFM and laser lithography on aluminium and the cantilever deflection will be detected by integrated capacitive read-out using a built in CMOS circuit.

Department of Micro- and Nanotechnology
Period: 01/07/1999 → 01/03/2000
Number of participants: 4
Project participant:
Hansen, Ole (Intern)
Kuhn, Oliver (Intern)
Grey, Francois (Intern)
Project Manager, organisational:
Boisen, Anja (Intern)

Elektrokemi og in situ scanning tunnel mikroskopi af biologisk betydningsfulde overgangsmetalkomplekser
Department of Chemistry
Period: 01/06/1999 → 14/03/2003
Number of participants: 5
PhD Student:
Hansen, Allan Glargaard (Intern)
Supervisor:
Boisen, Anja (Intern)
Main Supervisor:
Ulstrup, Jens (Intern)
Examiner:
Quaade, Ulrich (Intern)
Raiteri, Robert (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Fabrication, characterization and implementation of cantilevers for biochemical sensing
Department of Micro- and Nanotechnology
Period: 01/01/1999 → 16/11/2001
Number of participants: 7
Phd Student:
Thaysen, Jacob (Intern)
Supervisor:
Bouwstra, Siebe (Ekstern)
Grey, Francois (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Frans de Rooij, Nicolaas (Ekstern)
Brugger, Jürgen (Ekstern)
Sigmund, Ole (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Molecular Dynamics Simulations of Proteins, Biomembrane Systems, and Interfaces
Department of Micro- and Nanotechnology
Period: 01/01/1999 → 30/08/2002
Number of participants: 5
Phd Student:
Jensenius, Henriette (Intern)
Supervisor:
Grey, Francois (Intern)
Main Supervisor:
Boisen, Anja (Intern)
Examiner:
Ulstrup, Jens (Intern)
Berger, Rüdiger (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Microcantilevers as biosensors
Microcantilevers are very sensitive to small changes of mass or surface stress. The resulting bending of the cantilever can be detected by changes in a piezoresistor integrated on the cantilever. The objective of this project is to use such microcantilevers as biosensors, to detect attachment of specific biomolecules on a cantilever that has been pre-coated with a suitable reactive species.

Department of Micro- and Nanotechnology
Department of Chemistry
Period: 01/06/1998 → 01/01/2002
Number of participants: 4
Project participant:
Jensenius, Henriette (Intern)
Thaysen, Jacob (Intern)
Hansen, Allan Glargaard (Intern)
Project Manager, organisational:
Boisen, Anja (Intern)

Packaging of integrated optical components
Department of Photonics Engineering
Period: 01/09/1997 → 31/08/2001  
Number of participants: 7  
Phd Student:  
Zenth, Karin (Intern)  
Supervisor:  
Andersen, Lars-Ulrik Aaen (Intern)  
Hansen, Ole (Intern)  
Main Supervisor:  
Kristensen, Martin (Intern)  
Examiner:  
Bøttiger, Jørgen (Intern)  
Andersen, Bo Asp Møller (Intern)  
Boisen, Anja (Intern)  

Financing sources  
Source: Internal funding (public)  
Name of research programme: Erhvervsforskerordningen  
Project: PhD

Nanolithography on aluminium thin films  
It has been found that thin aluminium films on silicon can be modified by a focused laser beam or by an Atomic Force Microscope (AFM), to form either a positive or negative mask for lithographic processing of silicon. The objective of this research is to develop alternatives to electron beam lithography for rapid prototyping of micro- and nanomechanical devices. With a 7nm thick aluminum film, structures with 100nm resolution have been defined by AFM, and larger scale structures can be connected to these by laser processing of the aluminium. The specific advantage of aluminium is that it is an excellent mask for Reactive Ion Etching of high-aspect ratio structures, and that it is CMOS compatible.

Department of Micro- and Nanotechnology  
Period: 01/06/1997 → 01/01/2000  
Number of participants: 5  
Project participant:  
Boisen, Anja (Intern)  
Birkelund, Karen (Intern)  
Hansen, Ole (Intern)  
Kuhn, Oliver (Intern)  
Project  
Grey, Francois (Intern)  
Manager, organisational:  

Mikro-systemer til (bio-) kemisk analyse  
Technical University of Denmark  
Period: 01/09/1996 → 16/12/1999  
Number of participants: 4  
Phd Student:  
Østergaard, Steen (Intern)  
Supervisor:  
Boisen, Anja (Intern)  
Main Supervisor:  
Telleman, Pieter (Intern)  
Examiner:  
Søndergaard, Ib (Intern)  

Financing sources  
Source: Internal funding (public)  
Name of research programme: Mic-Finansieret-SU  
Project: PhD

Dyrkning af Si 1-x Ge x heterostrukturer med UHV-CVD  
Department of Micro- and Nanotechnology
AFM probes
The primary goal is to develop a technology for versatile shapes of tips integrated with AFM cantilevers, so-called passive probes with external read-out. For this we have developed a process sequence for direct tips, where tips are obtained by etching the surrounding material, and a process sequence for indirect tips, formed by electroplating in etched holes, where the substrate is subsequently etched. In the direct method we have developed a novel tip shape, which we have named rocket-tips. The different tip shapes integrated with cantilevers have been demonstrated on several test samples. The second goal is to develop a demonstrator active probe, i.e. with integrated read-out, for a wide range of applications. After comparing different transduction principles we have chosen for piezoresistive read-out, using single-crystalline silicon piezoresistors on oxide. Modelling has yielded a design for optimum signal-to-noise ratio. A process sequence has been developed. A demonstrator is now under construction. For ultrahigh-vacuum applications an AFM probe with capacitive read-out is under development. The fabrication technology is based on electroplating in anisotropically etched cavities in silicon.

Department of Micro- and Nanotechnology
DME - Danish Micro Engineering A/S
Aarhus University
Period: 01/04/1994 → …
Number of participants: 6
Project participant:
Boisen, Anja (Intern)
Hansen, Ole (Intern)
Johansen, Leif (Intern)
Ginnerup, Morten (Intern)
Thaysen, Jacob (Intern)
Project Manager, organisational:
Bouwstra, Siebe (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 180,000.00 Danish Kroner
Project

Spm-probes
Department of Micro- and Nanotechnology
Period: 01/04/1994 → …
Number of participants: 2
Phd Student:
Boisen, Anja (Intern)
Main Supervisor:
Bouwstra, Siebe (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Erhvervsforskerordningen
Activities:

**Pyrolytic carbon for MEMS string resonators**
Period: 11 Jun 2018
Quang Long Nguyen (Speaker)
Peter Emil Larsen (Other)
Anja Boisen (Other)
Stephan Sylvest Keller (Invited speaker)
Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Department of Micro- and Nanotechnology
Nanoprobes
Biomaterial Microsystems

**Description**
C-MEMS 2018 oral presentation
Degree of recognition: International
Documents:
Abstract_CMEMS_2018

**Related event**
**International Conference on Expanding Frontiers of Carbon MEMS**
10/06/2018 → 12/06/2018
San Diego, United States
Activity: Talks and presentations › Conference presentations

**3D printed system for testing intestinal drug transport**
Period: 21 Mar 2018
Morten Leth Jepsen (Other)
Line Hagner Nielsen (Other)
Kristoffer Almdal (Other)
Anja Boisen (Other)
Martin Dufva (Other)
Department of Micro- and Nanotechnology
Fluidic Array Systems and Technology
Nanoprobes
Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Department of Applied Mathematics and Computer Science

**Related event**
**11th World Meeting on Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology**
21/03/2018 → …
Granada, Spain
Activity: Talks and presentations › Conference presentations

**Loading of poorly soluble drugs by supercritical CO2 impregnation into microcontainers for oral drug delivery**
Period: 19 Mar 2018 → 22 Mar 2018
Chiara Mazzoni (Other)
Anastasia Antalaki (Other)
Rasmus Due Jacobsen (Other)
Related event

11th World Meeting on Pharmaceutics, Biopharmaceutics and Pharmaceutical Technology
21/03/2018 → …
Granada, Spain
Activity: Talks and presentations › Conference presentations

3D printed system for based on hydrogels for drug transport
Period: 29 Jan 2018
Morten Leth Jepsen (Other)
Line Hagner Nielsen (Other)
Kristoffer Almdal (Other)
Anja Boisen (Other)
Martin Dufva (Other)
Department of Micro- and Nanotechnology
Fluidic Array Systems and Technology
Nanoprobes
Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Department of Applied Mathematics and Computer Science

Description
3D printed system for based on hydrogels for drug transport

Related external organisation

University of Southern Denmark
Niels Bohrs Allé 1, Niels Bohrs Allé 1, Niels Bohrs Allé 1, Niels Bohrs Allé 1, Niels Bohrs Allé 1, 5230, Odense, Denmark
Activity: Talks and presentations › Conference presentations

Loading of poorly soluble drugs by supercritical CO2 impregnation into microcontainers for oral drug delivery
Period: 29 Jan 2018 → 31 Jan 2018
Chiara Mazzoni (Speaker)
Anastasia Antalaki (Other)
Rasmus Due Jacobsen (Other)
Jacob Mortensen (Other)
Fabio Tentor (Other)
Roman Slipets (Other)
Oleksii Ilchenko (Other)
Stephan Sylvest Keller (Other)
Line Hagner Nielsen (Other)
Anja Boisen (Other)
A nanofiltration technique for analyte extraction from complex matrix and surface enhanced Raman spectroscopy based sensing

**Period:** 20 Sep 2017

**Onur Durucan (Guest lecturer)**

**Tomas Rindzevicius (Other)**

**Michael Stenbæk Schmidt (Other)**

**Oleksii Ilchenko (Other)**

**Anja Boisen (Other)**

Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics

Department of Micro- and Nanotechnology

Nanoprobes

**Description**

Our novel proof-of-concept centrifugal microfluidics sensing platform (Fig.1), allows to perform fast and facile purification (nanofiltration) of the complex sample by incorporating inertial (centrifugal) and capillary forces. Furthermore, integrated in the platform, highly uniform Au capped Si nanopillar (NP) substrates for surface enhanced Raman spectroscopy (SERS) are capable to detect analyte molecules in trace amounts [1]. However, in most of the cases SERS based sensing applications are accompanied with complicated sample manipulation and external purification steps. This can be addressed to various experimental difficulties of SERS based measurements when handling real-life complex samples. Therefore, we believe that combination with the nanofiltration technique would sufficiently increase sensitivity and applicability of SERS based sensors. In addition to that, the nanofiltration of the sample and SERS based sensing of analyte is carried out on the same chip (Au NP surface) which provides robustness to the platform.

**Degree of recognition:** International

**Related event**

43rd International conference on Micro and Nano Engineering

**Period:** 18/09/2017 → 22/09/2017

**Braga, Portugal**

Activity: Talks and presentations › Conference presentations

**Structural aspects of hydrates – insight into phase transformations using nanomechanical sensors**

**Period:** 28 Jun 2017 → 30 Jun 2017

**Peter Ouma Okeyo (Guest lecturer)**

**Peter Emil Larsen (Guest lecturer)**

**Oleksii Ilchenko (Guest lecturer)**

**Tomas Rindzevicius (Guest lecturer)**

**Roman Slipets (Guest lecturer)**

**Anja Boisen (Guest lecturer)**

**Thomas Rades (Guest lecturer)**

**Jukka Rantanen (Guest lecturer)**

Department of Micro- and Nanotechnology

Nanoprobes
Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Degree of recognition: International

Related event

11th annual meeting of the Pharmaceutical Solid State Research Cluster
28/06/2017 → 30/06/2017
Graz, Austria
Activity: Talks and presentations › Conference presentations

Integration of Nanopillar SERS Substrates in a Microfluidic Platform for Analyte Separation and Quantitative Sensing
Period: 11 Jun 2017 → 17 Jun 2017
Onur Durucan (Guest lecturer)
Lidia Morelli (Guest lecturer)
Kaiyu Wu (Guest lecturer)
Marlitt Viehrig (Guest lecturer)
Oleksii Ilchenko (Guest lecturer)
Kinga Zor (Guest lecturer)
Marco Matteucci (Guest lecturer)
Tommy Sonne Alstrøm (Guest lecturer)
Tomas Rindzevicius (Guest lecturer)
Michael Stenbæk Schmidt (Guest lecturer)
Anja Boisen (Guest lecturer)

Department of Micro- and Nanotechnology
Nanoprobes

Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics
Department of Applied Mathematics and Computer Science
Cognitive Systems

Related event

9th International Conference on Advanced Vibrational Spectroscopy
11/06/2017 → 17/06/2017
Victoria, Canada
Activity: Talks and presentations › Conference presentations

SERS combiner for high-speed and high-sensitive quantitative analysis
Period: 11 Jun 2017 → 17 Jun 2017
Oleksii Ilchenko (Guest lecturer)
Tomas Rindzevicius (Guest lecturer)
Onur Durucan (Guest lecturer)
Michael Stenbæk Schmidt (Guest lecturer)
Roman Slipets (Other)
Lidia Morelli (Guest lecturer)
Anja Boisen (Guest lecturer)

Department of Micro- and Nanotechnology
Nanoprobes

Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics

Related event

9th International Conference on Advanced Vibrational Spectroscopy
11/06/2017 → 17/06/2017
Victoria, Canada
Activity: Talks and presentations › Conference presentations
SERS combiner for high-speed and high-sensitive quantitative analysis
Period: 11 Jun 2017 → 17 Jun 2017
Oleksii Ilchenko (Guest lecturer)
Tomas Rindzevicius (Guest lecturer)
Michael Stenbæk Schmidt (Guest lecturer)
Roman Slipets (Guest lecturer)
Onur Durucan (Guest lecturer)
Lidia Morelli (Guest lecturer)
Anja Boisen (Guest lecturer)
Department of Micro- and Nanotechnology
Nanoprobes
Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics

Related event
9th International Conference on Advanced Vibrational Spectroscopy
11/06/2017 → 17/06/2017
Victoria, Canada
Activity: Talks and presentations › Conference presentations

Annual Conference on Commercialization of Micro and Nano Systems
Period: 30 Aug 2009 → 4 Sep 2009
Anja Boisen (Participant)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group

Description
Annual Conference on Commercialization of Micro and Nano Systems (COMS); 14: Acetone vapor sensing using a vertical cavity surface emitting laser diode coated with polystyrene

We report theoretical and experimental on a new vapor sensor, using a single-mode vertical-cavity surface-emitting laser (VCSEL) coated with a polymer sensor coating, which can detect acetone vapor at a volume fraction of 2.5%. The sensor provides the advantage of standard packaging, small form-factor, mechanical stability and low cost when combined with a monolithically integrated photodiode detector.

Place: Copenhagen, Denmark

Related event
Annual Conference on Commercialization of Micro and Nano Systems
30/08/2009 → 04/09/2009
Copenhagen, Denmark
Activity: Attending an event › Participating in or organising a conference

Detection of multiple bacteria cells using cantilever based mass sensors
Period: 20 May 2009 → 22 May 2009
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group

Description
Place: Presented at International workshop on Nano-mechanical cantilever sensors, Jeju, Korea

Related external organisation
Talk about "Micro and Nanomechanical sensors; new materials and read-out methods" presented at ICMEMS 2009
Period: 3 Jan 2009 → 5 Jan 2009
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobe Group

Description
Place: Chennai, India

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

The 5th International Workshop on Nano Mechanical Sensing
Period: 2008 → …
Anja Boisen (Participant)
NanoSystemsEngineering Section
Nanoprobe Group
Department of Micro- and Nanotechnology

Description
Talk about "Advances in the fabrication og cantilever-based sensors with the polymer SU-8" Presented at 3rd International workshop on Nanomechanical sensors
Place: Mainz, Germany
Degree of recognition: International

Related event
The 5th International Workshop on Nano Mechanical Sensing
19/05/2008 → 21/05/2008
Mainz, Germany
Activity: Attending an event › Participating in or organising a conference

Talk about "New Materials and read-out methods for Cantilever-based sensing" Presented at Instute of Physics, Academia Sinica
Period: 29 Oct 2008
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobe Group

Description
Place: Taiwan

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Talk about "Nanomechanical Sensors" Presented at National Cheng Kung University
Period: 28 Oct 2008
Talk about "Fabrication of Cantilevers by Nanoimprint Lithography" Presented at "International Workshop on Cantilever sensors"
Period: 19 May 2008 → 21 May 2008
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group
Description
Place: Mainz, Germany
Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Talk about "Laser self-mixing interferometry in VCSELs - an ultra-compact and massproducible deflection detection system for Nanomechanical Polymer cantilever sensors" Presented at "International workshop on cantilever Sensors"
Period: 19 May 2008 → 21 May 2008
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group
Description
Place: Mainz, Germany
Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Rapid Methods Europe 2008
Period: 21 Jan 2008 → 23 Jan 2008
Anja Boisen (Participant)
NanoSystemsEngineering Section
Nanoprobes Group
Department of Micro- and Nanotechnology
Description
Talk about "Rapid molecular detection of food and waterborne diseases" Presented at Radip Methods, Europe
Place: Bilthoven, Netherlands
Related event

Rapid Methods Europe 2008: for Food and Feed Safety and Quality
21/01/2008 → 23/01/2008
Bilthoven, Netherlands
Activity: Attending an event › Participating in or organising a conference

Talk about "Development in materials and read-out methods for cantilever-based sensing" Presented at "IEEE International Conference and Nano/Micro Engineered and Molecular Systems
Period: 6 Jan 2008 → 9 Jan 2008
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group

Description
Place: Sanya, Hainan, China

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

2008 3rd IEEE International Conference on Nano/Micro Engineered and Molecular Systems
Period: 1 Jan 2008 → …
Anja Boisen (Participant)
NanoSystemsEngineering Section
Nanoprobes Group
Department of Micro- and Nanotechnology

Description
Au Nanoparticle Detection using Silicon Micro/Nano mechanical devices with Intergrated Strain Gauge Readout

Place: IEEE NEMS 2008. Sanya, China
Degree of recognition: International

Related event

2008 3rd IEEE International Conference on Nano/Micro Engineered and Molecular Systems
06/01/2008 → 09/01/2008
Sanya, China
Activity: Attending an event › Participating in or organising a conference

Talk about "Sensors Based on Miniature Bridges, Diving Boards and Lids" presented at "21st Century Medicine conference: Breakthroughs and Challenges".
Period: 1 Jan 2008 → …
Anja Boisen (Speaker)
Department of Micro- and Nanotechnology
NanoSystemsEngineering Section
Nanoprobes Group

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations