Real-time interferometric refractive index change measurement for the direct detection of enzymatic reactions and the
determination of enzyme kinetics

Back scatter interferometry (BSI) is a sensitive method for detecting changes in the bulk refractive index of a solution in a
microfluidic system. Here we demonstrate that BSI can be used to directly detect enzymatic reactions and, for the first
time, derive kinetic parameters. While many methods in biomedical assays rely on detectable biproducts to produce a
signal, direct detection is possible if the substrate or the product exert distinct differences in their specific refractive index
so that the total refractive index changes during the enzymatic reaction. In this study, both the conversion of glucose to
glucose-6-phosphate, catalyzed by hexokinase, and the conversion of adenosine-triphosphate to adenosine di-phosphate
and mono-phosphate, catalyzed by apyrase, were monitored by BSI. When adding hexokinase to glucose solutions
containing adenosine-triphosphate, the conversion can be directly followed by BSI, which shows the increasing refractive
index and a final plateau corresponding to the particular concentration. From the initial reaction velocities, K_M was found
to be 0.33 mM using Michaelis–Menten kinetics. The experiments with apyrase indicate that the refractive index also
depends on the presence of various ions that must be taken into account when using this technique. This study clearly
demonstrates that measuring changes in the refractive index can be used for the direct determination of substrate
concentrations and enzyme kinetics.
Back scattering interferometry revisited – A theoretical and experimental investigation

A refractive index based detector based on so called back scattering interferometry (BSI) has been described in the literature as a unique optical method for measuring biomolecular binding interactions in solution. In this paper, we take a detailed look at the optical principle underlying this technique to understand fully the constituents and behaviour of the fringe patterns generated. The simulated results are compared and validated with experimental measurements. Hereby, we show that BSI does not operate as a resonant cavity as often stated in the literature. Recently, we have questioned the claims made that BSI in general can be used to measure molecular bindings. Here we explore this topic further in three
cases using fluorescence spectroscopy as a reference method. Finally, we explore whether refractive index sensing can be used to measure the enzymatic phosphorylation of glucose to glucose-6-phosphate.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Department of Photonics Engineering, Aalborg University, Aalborg University Hospital
Contributors: Jørgensen, T. M., Jepsen, S. T., Sørensen, H. S., di Gennaro, A., Kristensen, S. R.
Pages: 1328-1337
Publication date: 2015
Peer-reviewed: Yes

**Publication information**

Journal: Sensors and Actuators B: Chemical
Volume: 220
ISSN (Print): 0925-4005
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.67 SJR 1.406 SNIP 1.453
Web of Science (2017): Impact factor 5.667
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): Impact factor 5.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.84 SJR 1.225 SNIP 1.484
Web of Science (2015): Impact factor 4.758
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.37 SJR 1.229 SNIP 1.658
Web of Science (2014): Impact factor 4.097
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.25 SJR 1.261 SNIP 1.638
Web of Science (2013): Impact factor 3.84
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.92 SJR 1.412 SNIP 1.674
Web of Science (2012): Impact factor 3.535
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 4.08 SJR 1.485 SNIP 1.752
Web of Science (2011): Impact factor 3.898
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): Impact factor 3.37
Web of Science (2010): Indexed yes
Evaluation of back scatter interferometry, a method for detecting protein binding in solution

Back Scatter Interferometry (BSI) has been proposed to be a highly sensitive and versatile refractive index sensor usable for analytical detection of biomarker and protein interactions in solution. However the existing literature on BSI lacks a physical explanation of why protein interactions in general should contribute to the BSI signal. We have established a BSI system to investigate this subject in further detail. We contribute with a thorough analysis of the robustness of the sensor including unwanted contributions to the interferometric signal caused by temperature variation and dissolved gasses. We report a limit of the effective minimum detectability of refractive index at the $10^{-7}$ level. Long term stability was examined by simultaneously monitoring the temperature inside the capillary revealing an average drift of $2.0 \times 10^{-7}$ per hour. Finally we show that measurements on protein A incubated with immunoglobulin G do not result in a signal that can be attributed to binding affinities as otherwise claimed in literature.
Demystifying back scatter interferometry: a sensitive refractive index detector.

BACKGROUND: Back Scatter Interferometry (BSI) is a sensitive method for detecting changes of the refractive index (RI) in small capillaries. The method was originally developed as an off-axial column detector for use in Liquid Chromatography or Capillary Electrophoresis systems, but it has been proposed that this method can also be used to detect molecular binding in a label-free manner. Recent work proposes BSI to be a unique sensor for detecting protein binding with various ligands and other protein interactions in order to obtain relevant binding kinetics. We hypothesize that BSI is actually acting like a common-path interferometer.

METHODS: A HeNe laser is directed at a glass capillary with inner diameter of 1.4 mm and reflected light from air/glass and liquid/glass interfaces interfere to form an RI dependent intensity fringe pattern at a CCD detector. The fringe shift relative to the change of RI of the sample; i.e. the sensitivity; is controlled by the physical interaction length between the interferometric sample beam and the sample itself. Using optical ray-tracing we calculate the sensitivity. We validate these theoretical findings by determining the RI increment (dn/dc) from a set of NaCl standard solutions.

RESULTS: Ray-tracing show that the basic interference pattern recorded with BSI can be fully...
described by two beams, one reflected from the surface of the capillary and a beam reflected from the back of the capillary wall. In accordance we find that the interferometric interaction length is given by twice the diameter of the capillary. Experimentally we find a sensitivity of 4700 rad/(g/ml) and estimate dn/dc for NaCl to be 0.169 ml/g, which is in accordance with literature. Furthermore we report a minimum detectability of 7x10^{-7} RI Units. CONCLUSIONS: BSI works like a common-path interferometer. The sensitivity of the BSI system is given by twice the inner diameter of the capillary times the wavenumber of the light source. Our results suggest that Back Scatter Interferometry does not provide a unique measurement principle for sensing biochemical bindings compared to what should be possible using many commercial available refractometers.

**General information**
- **State:** Published
- **Organisations:** Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, Department of Photonics Engineering, Aalborg University Hospital
- **Contributors:** Jepsen, S. T., Jørgensen, T. M., Trydal, T., Sørensen, H. S., Kristensen, S. R.
- **Publication date:** 2014
- **Peer-reviewed:** Yes

**Publication information**
- **Journal:** Clinical Chemistry and Laboratory Medicine
- **Volume:** 52
- **Issue number:** Supplement
- **Article number:** S215
- **ISSN (Print):** 1434-6621
- **Ratings:**
  - BFI (2019): BFI-level 1
  - Web of Science (2019): Indexed yes
  - BFI (2018): BFI-level 1
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 1
  - Scopus rating (2017): CiteScore 2.34 SJR 1.114 SNIP 1.188
  - Web of Science (2017): Impact factor 3.556
  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 1
  - Scopus rating (2016): CiteScore 2.21 SJR 1.039 SNIP 1.134
  - Web of Science (2016): Impact factor 3.432
  - BFI (2015): BFI-level 1
  - Scopus rating (2015): CiteScore 2.1 SJR 0.883 SNIP 1.059
  - Web of Science (2015): Impact factor 3.017
  - BFI (2014): BFI-level 1
  - Scopus rating (2014): CiteScore 2.17 SJR 0.872 SNIP 1.117
  - Web of Science (2014): Impact factor 2.707
  - Web of Science (2014): Indexed yes
  - BFI (2013): BFI-level 1
  - Scopus rating (2013): CiteScore 2.41 SJR 0.884 SNIP 1.058
  - Web of Science (2013): Impact factor 2.955
  - BFI (2012): BFI-level 1
  - Scopus rating (2012): CiteScore 2.5 SJR 0.864 SNIP 1.036
  - Web of Science (2012): Impact factor 3.009
  - BFI (2011): BFI-level 1
  - Scopus rating (2011): CiteScore 1.93 SJR 0.639 SNIP 0.957
  - Web of Science (2011): Impact factor 2.15
  - BFI (2010): BFI-level 1
  - Scopus rating (2010): SJR 0.675 SNIP 0.887
  - Web of Science (2010): Impact factor 2.069
  - BFI (2009): BFI-level 1
  - Scopus rating (2009): SJR 0.656 SNIP 0.92
  - BFI (2008): BFI-level 1
  - Scopus rating (2008): SJR 0.581 SNIP 0.803
Refractive index based measurements

A refractive index based measurement of a property of a fluid is measured in an apparatus comprising a variable wavelength coherent light source (16), a sample chamber (12), a wavelength controller (24), a light sensor (20), a data recorder (26) and a computation apparatus (28), by:
- directing coherent light having a wavelength along an input light path,
- producing scattering of said light from each of a plurality of interfaces within said apparatus including interfaces between said fluid and a surface bounding said fluid, said scattering producing an interference pattern formed by said scattered light,
- cyclically varying the wavelength of said light in said input light path over a 1 nm to 20nm wide range of wavelengths a rate of from 10Hz to 50 KHz, - recording variation of intensity of the interfering light with change in wavelength of the light at an angle of observation, and - calculating a said property from said variation.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Sørensen, H. S., Jørgensen, T. M.
Publication date: 2014

Publication information
IPC: G01N21/85
Patent number: WO2014147086
Date: 25/09/2014
Priority date: 21/03/2013
Priority number: EP20130160344
Original language: English
Research output: Research › Patent – Annual report year: 2014

Refractive index based measurements

In a method for performing a refractive index based measurement of a property of a fluid such as chemical composition or temperature by observing an apparent angular shift in an interference fringe pattern produced by back or forward scattering interferometry, ambiguities in the measurement caused by the apparent shift being consistent with one of a number of numerical possibilities for the real shift which differ by 2n are resolved by combining measurements performed on the same sample using light paths therethrough of differing lengths.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Sørensen, H. S., Jørgensen, T. M.
Publication date: 2014

Publication information
Refractive index based measurements
In a method for performing a refractive index based measurement of a property of a fluid such as chemical composition or temperature, a chirp in the local spatial frequency of interference fringes of an interference pattern is reduced by mathematical manipulation of the recorded light intensity in the interference pattern or by the physical positioning and arrangement of a detector used for capturing the interference pattern.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Sørensen, H. S., Jørgensen, T. M.
Publication date: 2014

Publication information
IPC: G01N21/85
Patent number: WO2014147088
Date: 25/09/2014
Priority date: 21/03/2013
Priority number: EP20130160346
Original language: English
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2011

Biomologic Sensing
General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Risø Innovation, Department of Photonics Engineering, Optical Microsensors and Micromaterials, Terahertz Technologies and Biophotonics
Contributors: Hillestrøm, A., Sørensen, H. S., Jørgensen, T. M.
Publication date: 2011
Peer-reviewed: Yes
URLs:
http://www.medtechinvestmentday.com/

Bibliographical note
Oral presentation.
Biomologic Sensing

**General information**

State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Risø Innovation, Department of Photonics Engineering, Optical Microsensors and Micromaterials, Terahertz Technologies and Biophotonics
Contributors: Hillestrøm, A., Sørensen, H. S., Jørgensen, T. M.
Publication date: 2011
Peer-reviewed: Yes

**Bibliographical note**

Oral presentation.

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Biomologic Sensing

**General information**

State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Risø Innovation, Department of Photonics Engineering, Optical Microsensors and Micromaterials, Terahertz Technologies and Biophotonics
Contributors: Hillestrøm, A., Sørensen, H. S., Jørgensen, T. M.
Publication date: 2011
Peer-reviewed: Yes
Event: Abstract from European Venture Contest Semi Final Healthcare, Aarhus, Denmark, .

**Bibliographical note**

Oral presentation.

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Biomologic Sensing

**General information**

State: Published
Organisations: Department of Photonics Engineering, Optical Microsensors and Micromaterials, Risø National Laboratory for Sustainable Energy, Risø Innovation, Terahertz Technologies and Biophotonics
Contributors: Sørensen, H. S., Hillestrøm, A., Jørgensen, T. M.
Publication date: 2011
Peer-reviewed: Yes
Event: Abstract from European Venture Summit, Düsseldorf, Germany, .

**Bibliographical note**

Oral presentation.

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**Injection molded chips with integrated conducting polymer electrodes for electroporation of cells**

We present the design-concept for an all polymer injection molded single use microfluidic device. The fabricated devices comprise integrated conducting polymer electrodes and Luer fitting ports to allow for liquid and electrical access. A case study of low voltage electroporation of biological cells in suspension is presented. The working principle of the electroporation device is based on a focusing of the electric field by means of a constriction in the flow channel for the
cells. We demonstrate the use of AC voltage for electroporation by applying a 1 kHz, +/- 50 V square pulse train to the electrodes and show delivery of polynucleotide fluorescent dye in 46% of human acute monocytic leukemia cells passing the constriction.

**General information**

State: Published
Organisations: Polymer Microsystems for Electrophysiology Group, Polymer Micro and Nano Engineering Section, Department of Micro- and Nanotechnology, Polymer Microsystems for Cell Processing Group, Department of Photonics Engineering, Optical Microsensors and Micromaterials, Amphiphilic polymers in biological sensing Group, Self-organizing materials for nanotechnology Section
Pages: 55010
Publication date: 2010
Peer-reviewed: Yes

**Publication information**

Journal: Journal of Micromechanics and Microengineering
Volume: 20
Issue number: 5
ISSN (Print): 0960-1317
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
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): Impact factor 1.888
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): Impact factor 1.794
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.96 SJR 0.687 SNIP 1.265
Web of Science (2015): Impact factor 1.768
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.84 SJR 0.802 SNIP 1.316
Web of Science (2014): Impact factor 1.731
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.74 SJR 0.737 SNIP 1.233
Web of Science (2013): Impact factor 1.725
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.92 SJR 0.936 SNIP 1.491
Web of Science (2012): Impact factor 1.79
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.43 SJR 1.036 SNIP 1.443
Web of Science (2011): Impact factor 2.105
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Biosensing with backscattering interferometry

Monitoring biochemical interactions can serve as the basis for many diagnostic techniques.

**General information**

State: Published
Organisations: Optical Microsensors and Micromaterials, Department of Photonics Engineering, Terahertz Technologies and Biophotonics, Polymer Microsystems for Cell Processing Group, Polymer Micro and Nano Engineering Section, Department of Micro- and Nanotechnology, Vanderbilt University, Copenhagen University Hospital
Contributors: Sørensen, H. S., Andersen, P. E., Larsen, N. B., Hansen, P. R., Bornhop, D. J.
Publication date: 2009
Peer-reviewed: No

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Journal: SPIE Newsroom
ISSN (Print): 1818-2259
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
DOIs:
10.1117/2.1200905.1673
URLs:
http://spie.org/x35268.xml?ArticleID=x35268
Chip based interferometric method for in situ detection of cardiac markers

General information
State: Published
Organisations: Optical Microsensors and Micromaterials, Department of Photonics Engineering, Rise National Laboratory for Sustainable Energy, Terahertz Technologies and Biophotonics
Contributors: Sørensen, H. S., Jepsen, S. T., Richter, V., Andersen, P. E.
Publication date: 2008

Host publication information
Title of host publication: Book of Abstracts
Place of publication: Illinois
Publisher: Association for Laboratory Automation
URLs:
http://www.risoe.dtu.dk/rispubl/art/2008_73.pdf
Source: orbit
Source-ID: 239470
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

Back-scattering Interferometry studies of label-free molecular interactions

Free-solution, label-free molecular interactions were investigated with back-scattering interferometry in a simple optical train composed of a helium-neon laser, a microfluidic channel, and a position sensor. Molecular binding interactions between proteins, ions and protein, and small molecules and protein, were determined with high dynamic range dissociation constants (K-d spanning six decades) and unmatched sensitivity (picomolar K-d's and detection limits of 10,000s of molecules). With this technique, equilibrium dissociation constants were quantified for protein A and immunoglobulin G, interleukin-2 with its monoclonal antibody, and calmodulin with calcium ion Ca2+, a small molecule inhibitor, the protein calcineurin, and the M13 peptide. The high sensitivity of back-scattering interferometry and small volumes of microfluidics allowed the entire calmodulin assay to be performed with 200 picomoles of solute.

General information
State: Published
Organisations: Laser Systems and Optical Materials, Optics and Plasma Research Department, Rise National Laboratory for Sustainable Energy
Contributors: Bornhop, D., Latham, J., Kussrow, A., Markov, D., Jones, R., Sørensen, H.
Pages: 1732-1736
Publication date: 2007
Peer-reviewed: Yes

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Journal: Science
Volume: 317
Issue number: 5845
ISSN (Print): 0036-8075
Ratings:
BFI (2019): BFI-level 3
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 15.85 SJR 14.142 SNIP 7.154
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 14.39 SJR 13.745 SNIP 7.547
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 13.12 SJR 12.872 SNIP 7.606
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 12.68 SJR 12.052 SNIP 8.129
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 12.43 SJR 12.41 SNIP 7.809
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 12.39 SJR 13.318 SNIP 8.087
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 11.97 SJR 14.238 SNIP 8.277
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 13.481 SNIP 7.773
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 11.897 SNIP 7.056
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 11.277 SNIP 6.075
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 10.072 SNIP 6.017
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 11.09 SNIP 6.563
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 11.428 SNIP 7.488
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 10.987 SNIP 6.94
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 15.245 SNIP 7.042
Web of Science (2000): Indexed yes
Self Calibrating Interferometric Sensor

This thesis deals with the development of an optical sensor based on micro interferometric backscatter detection (MIBD). A price-effective, highly sensitive and ready for mass production platform is the goal of this project. The thesis covers three areas. The first part of the thesis deals with theoretical models for describing the optical phenomena utilized in this technique. A model based on ray-tracing has been developed and shown to be a valuable tool for describing certain features in the fringe pattern. The MIBD measurement technique has been expanded to do absolute determination of the refractive index, with an experimental precision of \(2.5 \times 10^{-4}\), using this newly discovered feature. As the MIBD has been used as a biosensor for detecting molecular scaled species, a model valid for changes in system sizes below the geometrical optics regime has been developed. Modeling based on solutions to Maxwell’s equations has with high accuracy described the optical effects when binding events occur on the inside of a capillary. It is of paramount importance to find a practical stop criteria for the else infinite summation used to find the scattering constants, which is the basis for the model. Different geometries have been modeled, including semicircular, circular and rectangular flow channels. Theoretical work has shown that the sensitivity of the rectangular geometry is caused by diffraction off the corners. The second part of the thesis deals with the fabrication of injection molded polymer microflow chips. The MIBD technology has been transferred to a chip based platform with a close-to-capillary like geometry. These assembled chips have in the MIBD setup shown detection limits of \(\Delta n = 4 \cdot 10^{-6}\). The fabrication has been done by isotropic etching in silicon through a silicon nitride sacrificial mask. The fabricated microstructures have been electroplated for later injection molding, showing the potential of the MIBD sensor to be mass produced with high reproducibility and sensitivity. In part three MIBD experiments on vital biological systems are described. Label-free binding studies of biomolecules have been performed in easy to fabricate micro flow channels in elastomer material (PDMS), both surface bound and in free solution. Thermodynamic binding constants for protein–protein interactions has been found and validated by other techniques. The detection limit obtained from these experiments were 9 attomole Human IgG in a 495 pL measurement volume. The free solution protein binding experiments and results places MIBD in a unique position with comparable thermodynamic capabilities with the golden standard ITC, but orders of magnitude faster and less analyte sample consuming. The completion of a Lab-on-a-chip device making a complete blood analysis will be a paradigm shift moving the analysis from the laboratories closer to the bedside.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Sørensen, H. S.
Number of pages: 176
Publication date: Jun 2006

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
ISBN (Print): 87-550-3495-0
Original language: English
Keywords: Risø-PhD-19(EN), Risø-PhD-0019
Electronic versions: ris-phd-19[1].pdf
Source: orbit
Source-ID: 269474
Research output: Research › Ph.D. thesis – Annual report year: 2006

Proteinmåler
General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Sørensen, H. S.
Publication date: 2006
Peer-reviewed: No
Event: Abstract from Møde i Dansk Optisk Selskab, Risø, Denmark.
Label-free interferometric sensing of biochemical interactions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Sørensen, H. S.
Publication date: 2004
Peer-reviewed: No
Event: Abstract from Biomedical optics '04, Lyngby, Denmark.
Source: orbit
Source-ID: 307442
Research output: Research › Conference abstract for conference – Annual report year: 2004

Microstructure fabrication for an optical polymer based bio-chip sensor

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Sørensen, H. S.
Publication date: 2003
Peer-reviewed: No
Event: Abstract from Biomedical optics '03, Lyngby, Denmark.
Source: orbit
Source-ID: 306338
Research output: Research › Conference abstract for conference – Annual report year: 2003

Projects:

Microinterferometer Flow Channel Systems using Backscatter Detection for Biological and Physical Applications
Sørensen, H. S., PhD Student, Department of Management Engineering
Rasmussen, H. K., Main Supervisor
Andersen, P. E., Supervisor
Bornhop, D. J., Supervisor
Larsen, N. B., Supervisor
Skettrup, T., Examiner
Rubahn, H., Examiner
Lading, L., Examiner
Risø (Løn)
01/10/2002 → 30/06/2006
Award relations: Microinterferometer Flow Channel Systems using Backscatter Detection for Biological and Physical Applications
Project: PhD

On-chip BSI: On-chip Backscattering Interferometry
Sørensen, H. S., Project Manager, Department of Photonics Engineering
Jørgensen, T. M., Project Participant, Department of Photonics Engineering
Andersen, P. E., Project Participant, Department of Photonics Engineering, Diode Lasers and LED Systems
Larsen, N. B., Project Participant, Department of Micro- and Nanotechnology
Hillestrøm, A., Project Participant, Office for Innovation & Sector Services
Project ID: 70496
Forskningsprojekter - Andre ministerier og styrelser: DKK750,000.00
01/07/2009 → 30/06/2011
Collaborators: Technical University of Denmark, DTU Administration, Office for Private and Public Services,
Award relations: On-chip Backscattering Interferometry
Project: Research
Optisk biosensor
Sørensen, H. S., Project Manager, Department of Photonics Engineering, Optical Microsensors and Micromaterials
Jørgensen, T. M., Project Participant, Department of Photonics Engineering, Terahertz Technologies and Biophotonics
Hillestrøm, A., Project Participant, Office for Innovation & Sector Services
Project ID: 70668
Forsk. Andre offentlige og private - Nordiske: DKK696,125.00
07/02/2011 → 06/08/2011
Collaborators: DTU Administration, Office for Private and Public Services, Technical University of Denmark
Award relations: Optisk biosensor
Project: Research

CSI: Chip Scale Inferometry - a new optical in situ method for complete analysis of cardiac markers : 1705124 CSI Hjertemarkør
Sørensen, H. S., Project Manager, Department of Photonics Engineering
Project ID: 70495
Forsk. Andre statslige danske i øvrigt
15/06/2006 → 31/03/2010
Award relations: Chip Scale Inferometry - a new optical in situ method for complete analysis of cardiac markers : 1705124
CSI Hjertemarkør
Project: Research

Activities:

**HS Innovation: RightLight**
Period: 4 Dec 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

**HS Innovation: RightLight**
Period: 27 Nov 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

**Venture Cup Idea: BikePole**
Period: 25 Nov 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Description
Venture Cup Idea: BikePole
Related event
**Venture Cup Idea: BikePole**
25/11/2013 → …
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Venture Cup Idea: Diabuddy**
Period: 25 Nov 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Description
Venture Cup Idea: DiaBuddy
Links:
http://www.venturecup.dk/

Related event
Venture Cup Idea: Diabuddy
25/11/2013 → …
Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Hackathon
Period: 13 Nov 2013
Henrik Schiøtt Sørensen (Invited speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
Hackathon 2013: Hacking Mobile Health
08/11/2013 → 13/11/2013
Roskilde, Denmark
Activity: Talks and presentations › Conference presentations

Hackathon
Period: 8 Nov 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
Hackathon 2013: Hacking Mobile Health
08/11/2013 → 13/11/2013
Roskilde, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

HS Innovation: BikePole, IMirror
Period: 4 Nov 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

HS Innovation: IMirror
Period: 24 Oct 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other
HS Innovation: IMirror
Period: 23 Oct 2013
Henrik Schiøtt Sørensen (Speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

IDA ledelsesforum
Period: 27 Sep 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
IDA ledelsesforum: Ledelse der styrker
27/09/2013 → …
København, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Lysforskningen i Danmark
Period: 12 Mar 2013
Henrik Schiøtt Sørensen (Lecturer)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Finansiering af biotek 2013
Period: 5 Feb 2013
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
Finansiering af biotek 2013: Dansk Biotek
05/02/2013 → 05/02/2014
Søborg, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Innovationsaktivitet: Møde med Christer Zoffmann Bisgaard, Thomas Nikolajsen; FOSS Labs
Period: 10 Sep 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other
Backscatter Interferometry
Period: 16 Aug 2012
Henrik Schiøtt Sørensen (Lecturer)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
FOSS Leap seminar
16/08/2012 → …
Hillerød, Denmark
Activity: Talks and presentations › Conference presentations

Innovationsaktivitet: Møde med Alex MacPherson, UCB Pharma
Period: 10 Jul 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Årsmøde i Dansk Biotek
Period: 8 May 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
Årsmøde i Dansk Biotek
08/05/2012 → …
Bagsværd, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Innovationsaktivitet: Møde med Alex MacPherson, UCB Pharma
Period: 14 Mar 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Innovationsaktivitet: Møde med Fritz Poulsen, Novo Nordisk A/S
Period: 29 Feb 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Innovationsaktivitet: Biomologic Sensing sparring med Innogen
Period: 21 Feb 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Innovationsaktivitet: Møde med William Rich, Molecular Sensing Inc
Period: 9 Feb 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Innovationsaktivitet: Møde med Søren Mouritsen, RomoWind
Period: 6 Feb 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Biomologic Sensing: Back Scatter Interferometry
Period: 2 Feb 2012
Henrik Schiøtt Sørensen (Lecturer)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Description
Innovation Clinic, British Embassy, Kastelsvej 36-40, 2100 Ø

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Medtech Innovation Soirée - British embassy
Period: 2 Feb 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event

Medtech Innovation Soirée - British embassy
02/02/2012 → …
Gentoft, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Finansiering af biotekseskaber på vej mod 2020
Period: 31 Jan 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event

Finansiering af biotekseskaber på vej mod 2020: DANSK BIOTEK inviterer til seminar tirsdag den den 31. januar 2012 kl. 15.00 hos DANSKE BANK
31/01/2012 → 31/01/2012
København K., Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Innovationsaktivitet: D&D Møde med Etteplan
Period: 12 Jan 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Medico Bazar
Period: 10 Jan 2012
Henrik Schiøtt Sørensen (Invited speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related event
Medico Bazar
10/01/2012 → …
Kgs. Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Innovationsaktivitet: Etablering af BSI prototype på Aalborg Sygehus
Period: 2 Jan 2012 → 5 Jan 2012
Henrik Schiøtt Sørensen (Participant)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Activity: Other

Next Generation Micro fluidics: -Case: Back-Scattering Interferometry
Period: 25 Jun 2009
Henrik Schiøtt Sørensen (Speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials
Description
Place: Vanderbilt University, Nashville TN

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Optical Biosensor for Point-of-care Cardiac Marker Detection
Period: 17 Jun 2009
Henrik Schiøtt Sørensen (Speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations
Optical Biosensor for Point-of-Care Cardiac Marker Detection: Oral Presentation of paper
Period: 17 Jun 2009
Henrik Schiøtt Sørensen (Speaker)
Department of Photonics Engineering
Optical Microsensors and Micromaterials

Description
Place: European Conferencees on Biomedical Optics (ECBO) at ICM-International Congress Centre Munich, Germany

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Press clippings:

Kan man se det usynlige 'stelnummer' i et kunstigt ben?: Politiken
Henrik Schiøtt Sørensen
19/09/2010
Department of Photonics Engineering, Optical Microsensors and Micromaterials

Media contribution (1)

Kan man se det usynlige 'stelnummer' i et kunstigt ben?: Politiken
19/09/2010
Denmark, Print
http://www.e-pages.dk/politikenviden/53/2
PUB-OA
Henrik Schiøtt Sørensen
Department of Photonics Engineering, Optical Microsensors and Micromaterials
Press/Media: Press / Media