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Organisations

Department of Photonics Engineering
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Publications:

Strain tuning of optical properties in Bi$_2$Se$_3$
Based on symmetry principles we determine the most general Hamiltonian for the low energy physics of Bi$_2$Se$_3$, including contributions due to a static electric field and strain. The full three-dimensional model is projected into the surface states at $k=0$, giving an effective two-dimensional Hamiltonian for the surface states. Contributions from the strain tensor breaks the anisotropy of the surface state spectrum, giving an elliptical Dirac cone. Within this model we calculate the absorption spectrum for an ultra-thin film. We show that the fundamental absorption edge can be effectively tuned by application of uniaxial strain.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Authors: Jensen, M. R. (Intern), Mørk, J. (Intern), Willatzen, M. (Intern)
Number of pages: 2
Pages: 85-86
Publication date: 11 Aug 2017

Host publication information
Title of host publication: 17th International Conference on Numerical Simulation of Optoelectronic Devices, NUSOD 2017
Publisher: IEEE Computer Society Press
Article number: 8010003
ISBN (Electronic): 9781509053230
Main Research Area: Technical/natural sciences
Conference: 17th International Conference on. Numerical Simulation of Optoelectronic Devices, Lyngby, Denmark, 24/07/2017 - 24/07/2017
DOIs: 10.1109/NUSOD.2017.8010003
Source: Scopus
Source-ID: 85028594554
Publication: Research - peer-review → Article in proceedings – Annual report year: 2017

3D continuum phonon model for group-IV 2D materials
A general three-dimensional continuum model of phonons in two-dimensional materials is developed. Our first-principles derivation includes full consideration of the lattice anisotropy and flexural modes perpendicular to the layers and can thus be applied to any two-dimensional material. In this paper, we use the model to not only compare the phonon spectra among the group-IV materials but also to study whether these phonons differ from those of a compound material such as molybdenum disulfide. The origin of quadratic modes is clarified. Mode coupling for both graphene and silicene is obtained, contrary to previous works. Our model allows us to predict the existence of confined optical phonon modes for the group-IV materials but not for molybdenum disulfide. A comparison of the long-wavelength modes to density-functional results is included.

General information
State: Published
Organisations: Department of Photonics Engineering, University of West Georgia, King Abdullah University of Science and Technology
Authors: Willatzen, M. (Intern), Lew Yan Voon, L. C. (Ekstern), Gandi, A. N. (Ekstern), Schwingenschlogl, U. (Ekstern)
Pages: 1345-1356
In this paper we investigate theoretically the influence of piezoelectric coupling on phonon dispersion relations. Specifically we solve dispersion relations for a fully coupled zinc-blende freestanding quantum well for different orientations of the crystal unit cell. It is shown that the phonon mode density in GaAs can change by a factor of approximately 2–3 at $q \times a = 1$ for different crystal-growth directions relative to the slab thickness direction. In particular, it is found that optical and acoustic phonon modes are always piezoelectrically coupled, independent of the crystal-growth direction, and will be jointly excited by electrical stimulus. We demonstrate this for an electrically excited freestanding slab for two cases of high-symmetry crystal-growth directions and finally show the impact of the Drude model for permittivity on the phonon dispersion. In particular, it is verified that the piezoelectric effect leads to a drastically enhanced coupling of acoustic and optical phonon modes and increase in the local phonon density of states near the plasma frequency where the permittivity approaches zero.
Acousto-optical phonon excitation in piezoelectric wurtzite slabs and crystal growth orientation effects

This paper presents a theoretical investigation of phonon dispersion in piezoelectric slabs of hexagonal crystal symmetry (wurtzite). Specifically, we solve the fully coupled dispersion relations in a GaN free-standing quantum well by varying the crystal growth direction from the [001] axis to the [010] axis. Accounting for the Drude model in solving the fully-coupled dispersion relations, phonon modes will generate an additional phonon band, with a high local density of phonon states, close to the plasma frequency. As opposed to cubic crystals with isotropic permittivity, the location of this band varies with crystal orientation. We also find that the phonon mode dependence on the crystal orientation is more pronounced for small in-plane wavenumbers.
A valence force field-Monte Carlo algorithm for quantum dot growth modeling

We present a novel kinetic Monte Carlo version for the atomistic valence force fields algorithm in order to model a self-assembled quantum dot growth process. We show our atomistic model is both computationally favorable and capture more details compared to traditional kinetic Monte Carlo models based on continuum elastic models. We anticipate the model will be useful to experimentalists in understanding better the growth dynamics of quantum dot systems.

General information
State: Published
Organisations: Department of Photonics Engineering, Center for Electron Nanoscopy, Nanophotonic Devices, Centre of Excellence for Silicon Photonics for Optical Communications, University of Rome Tor Vergata, National Research Council of Italy
Authors: Barettin, D. (Ekstern), Willatzen, M. (ed.) (Intern), Kadkhodazadeh, S. (Intern), Pecchia, A. (Ekstern), Auf der Maur, M. (Ekstern), Semenova, E. (Intern)
Number of pages: 2
Pages: 117-118
Publication date: 2017

Host publication information
Title of host publication: 2017 International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD)
Publisher: IEEE
ISBN (Electronic): 978-1-5090-5323-0
Main Research Area: Technical/natural sciences
Conference: 17th International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD17), Kgs. Lyngby, Denmark, 24/07/2017 - 24/07/2017
DOI: 10.1109/NUSOD.2017.8010019
Source: FindIt
Source-ID: 2373491803
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

Efficient Modeling of Excitons in Type-II Nanowire Quantum Dots - Presented at: CLEO®/Europe-EQEC 2017, 2017, Munich

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Authors: Taherkhani, M. (Intern), Gregersen, N. (Intern), Mørk, J. (Intern), Willatzen, M. (Intern)
Number of pages: 1
Publication date: 2017
Event:
Main Research Area: Technical/natural sciences
Electronic versions:
CLEO2_NG.pdf
Source: PublicationPreSubmission
Source-ID: 133790957
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Fundamentals of Silicene, Authors: Guzmán-Verri Gian G., Lok C. Lew Yan Voon and Willatzen Morten
Silicene is a single atomic layer of silicon (Si) much like graphene, the first example of an elemental twodimensional (2D) nanomaterial whose study led to the 2010 Nobel Prize in Physics.2 Until 2010 or so, the only known crystalline form of elemental silicon was the one with the so-called diamond structure (a threedimensional cubic structure with sp3-bonded Si atoms). That silicon could potentially form a 2D structure was first postulated by Takeda and Shiraishi.3,4 This early work and others, both theoretical3–7 and experimental8,9 went mostly unnoticed until the prediction that silicene could have similar exotic properties as graphene by Guzmán-Verri and Lew Yan Voon in 2007,1 and silicene nanoribbons were reported to have been fabricated on a silver substrate by Kara et al. in 2009.10 Since then, the study of silicene has exploded, mainly theoretically11–527 but also experimentally.528–612 The interest in silicene is exactly the same as that for graphene:2 in being two-dimensional and possessing a linear band structure, the so-called Dirac cone.1 One advantage relies on its possible application in electronics, whereby its natural compatibility with the current Si technology might make fabrication much more of an industrial reality. We will concentrate this tutorial on the properties of a single freestanding silicene sheet. Freestanding means that the silicene sheet is not chemically or physically bonded to any other material. The feat with graphene was the ability to peel off a single layer of graphene from a piece of graphite, a process known as mechanical exfoliation. Such a
A close analogue, though, is calcium disilicide, indeed a layered material and the related process of chemical exfoliation has been tried, with only partial success as the resulting product was mostly multilayers and functionalized. Not surprisingly, a number of review articles have already appeared that includes extensive discussions of silicone. The current review is more tutorial in nature.

**General information**
State: Published
Organisations: Department of Photonics Engineering
Authors: Guzman-Verri, G. G. (Ekstern), Voon, L. C. L. Y. (Ekstern), Willatzen, M. (Intern)
Pages: 107-148
Publication date: 2017

**Host publication information**
Title of host publication: Silicon Nanomaterials Sourcebook Low-Dimensional Structures Nanopowders, Nanowires
Publisher: CRC Taylor and Francis Group
ISBN (Print): 978-1-4987-6377-6
Chapter: 5
Main Research Area: Technical/natural sciences

**Numerical simulations of nanostructured gold films**
We present an approach to analyse near-field effects on nanostructured gold films by finite element simulations. The studied samples are formed by fabricating gold films near the percolation threshold and then applying laser damage. Resulting samples have complicated structures, which then was captured using scanning transmission electron microscopy (STEM) and the obtained dark field images are used to set up COMSOL simulations corresponding to actual structures.

**General information**
State: Published
Organisations: Department of Photonics Engineering, Plasmonics and Metamaterials, Center for Nanostructured Graphene, Structured Electromagnetic Materials, University of Southern Denmark
Authors: Repän, T. (Intern), Frydendahl, C. (Intern), Novikov, S. M. (Ekstern), Beermann, J. (Ekstern), Bozhevolnyi, S. I. (Ekstern), Mortensen, N. A. (Intern), Stenger, N. (Intern), Willatzen, M. (Intern), Lavrinenko, A. (Intern)
Number of pages: 2
Publication date: 2017

**Piezoelectric and deformation potential effects of strain-dependent luminescence in semiconductor quantum well structures**
The mechanism of strain-dependent luminescence is important for the rational design of pressure-sensing devices. The interband momentum-matrix element is the key quantity for understanding luminescent phenomena. We analytically solved an infinite quantum well (IQW) model with strain, in the framework of the $6 \times 6$ $k \cdot p$ Hamiltonian for the valence states, to directly assess the interplay between the spin-orbit coupling and the strain-induced deformation potential for the interband momentum-matrix element. We numerically addressed problems of both the infinite and IQWs with piezoelectric fields to elucidate the effects of the piezoelectric potential and the deformation potential on the strain-dependent luminescence. The experimentally measured photoluminescence variation as a function of pressure can be qualitatively explained by the theoretical results.

**General information**
State: Published
We present a numerical investigation of the exciton energy and oscillator strength in type-II nanowire quantum dots. For a single quantum dot, the poor overlap of the electron part and the weakly confined hole part of the excitonic wave function leads to a low oscillator strength compared to type-I systems. To increase the oscillator strength, we propose a double quantum dot structure featuring a strongly localized exciton wave function and a corresponding fourfold relative enhancement of the oscillator strength, paving the way towards efficient optically controlled quantum gate applications in the type-II nanowire system. The simulations are performed using a computationally efficient configuration-interaction method suitable for handling the relatively large nanowire structures.

Type-II quantum-dot-in-nanowire structures with large oscillator strength for optical quantum gate applications

We present a numerical investigation of the exciton energy and oscillator strength in type-II nanowire quantum dots. For a single quantum dot, the poor overlap of the electron part and the weakly confined hole part of the excitonic wave function leads to a low oscillator strength compared to type-I systems. To increase the oscillator strength, we propose a double quantum dot structure featuring a strongly localized exciton wave function and a corresponding fourfold relative enhancement of the oscillator strength, paving the way towards efficient optically controlled quantum gate applications in the type-II nanowire system. The simulations are performed using a computationally efficient configuration-interaction method suitable for handling the relatively large nanowire structures.
Type-II Quantum Dot Nanowire Structures with Large Oscillator Strengths for Optical Quantum Gating Applications

The exciton oscillator strength (OS) in type-II quantum dot (QD) nanowires is calculated by using a fast and efficient method. We propose a new structure in Double-Well QD (DWQD) nanowire that considerably increases OS of type-II QDs which is a key parameter in optical quantum gating in the stimulated Raman adiabatic passage (STIRAP) process [1] for implementing quantum gates.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Authors: Taherkhani, M. (Intern), Gregersen, N. (Intern), Willatzen, M. (Intern), Mørk, J. (Intern)
Pages: 7-8
Publication date: 2017
A theory of generalized Bloch oscillations

Bloch oscillations of electrons are shown to occur for cases when the energy spectrum does not consist of the traditional evenly-spaced ladders and the potential gradient does not result from an external electric field. A theory of such generalized Bloch oscillations is presented and an exact calculation is given to confirm this phenomenon. Our results allow for a greater freedom of design for experimentally observing Bloch oscillations. For strongly coupled oscillator systems displaying Bloch oscillations, it is further demonstrated that reordering of oscillators leads to destruction of Bloch oscillations. We stipulate that the presented theory of generalized Bloch oscillations can be extended to other systems such as acoustics and photonics.
Dark-field hyperlens for high-contrast sub-wavelength imaging

By now superresolution imaging using hyperbolic metamaterial (HMM) structures – hyperlenses – has been demonstrated both theoretically and experimentally. The hyperlens operation relies on the fact that HMM allows propagation of waves with very large transverse wavevectors, which would be evanescent in common isotropic media (thus giving rise to the diffraction limit). However, nearly all hyperlenses proposed so far have been suitable only for very strong scatterers – such as holes in a metal film. When weaker scatterers, dielectric objects for example, are imaged then incident light forms a very strong background, and weak scatterers are not visible due to a poor contrast. We propose a so-called dark-field hyperlens, which would be suitable for imaging of weakly scattering objects. By designing parameters of the HMM, we managed to obtain its response in such way that the hyperlens structure exhibits a cut-off for waves with small transverse wavevectors (low-k waves). This allows the structure to filter out the background illumination, which is contained in low-k waves. We numerically demonstrate that our device achieves superresolution imaging while providing the strong contrast for weak dielectric scatterers. These findings hold a great promise for dark-field superresolution, which could be important in real-time dynamic nanoscopy of label-free biological objects for example. © (2016) COPYRIGHT Society of Photo-Optical Instrumentation Engineers (SPIE). Downloading of the abstract is permitted for personal use only.
Efficient Modeling of Coulomb Interaction Effect on Exciton in Crystal-Phase Nanowire Quantum Dot
The binding energy and oscillation strength of the ground-state exciton in type-II quantum dot (QD) is calculated by using a post Hartree-Fock method known as the configuration interaction (CI) method which is significantly more efficient than conventional methods like ab initio method. We show that the Coulomb interaction between electron and holes in these structures considerably affects the transition dipole moment which is the key parameter of optical quantum gating in STIRAP (stimulated Raman adiabatic passage) process for implementing quantum gates [1], [2].

Parity-Time Synthetic Phononic Media
Classical systems containing cleverly devised combinations of loss and gain elements constitute extremely rich building units that can mimic non-Hermitian properties, which conventionally are attainable in quantum mechanics only. Parity-time (PT ) symmetric media, also referred to as synthetic media, have been devised in many optical systems with the ground breaking potential to create nonreciprocal structures and one-way cloaks of invisibility. Here we demonstrate a feasible approach for the case of sound where the most important ingredients within synthetic materials, loss and gain, are achieved through electrically biased piezoelectric semiconductors. We study first how wave attenuation and amplification can be tuned, and when combined, can give rise to a phononic PT synthetic media with unidirectional suppressed reflectance, a feature directly applicable to evading sonar detection.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Bristol
Authors: Taherkhani, M. (Intern), Gregersen, N. (Intern), Mørk, J. (Intern), McCutcheon, D. (Ekstern), Willatzen, M. (Intern)
Number of pages: 2
Publication date: 2016

Host publication information
Title of host publication: Proceedings of the 16th International Conference on Numerical Simulation of Optoelectronic Devices
Publisher: IEEE
ISBN (Print): 9781467386036
Main Research Area: Technical/natural sciences
DOIs:
10.1109/NUSOD.2016.7547003
Source: PublicationPreSubmission
Source-ID: 125528507
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
Theoretical study of the electromechanical efficiency of a loaded tubular dielectric elastomer actuator

The electromechanical efficiency of a loaded tubular dielectric elastomer actuator (DEA) is investigated theoretically. In previous studies, the external system, on which the DEA performs mechanical work, is implemented implicitly by prescribing the stroke of the DEA in a closed operation cycle. Here, a more generic approach, modelling the external system by a frequency-dependent mechanical impedance which exerts a certain force on the DEA depending on its deformation, is chosen. It admits studying the dependence of the electromechanical efficiency of the DEA on the external system. A closed operation cycle is realized by exciting the DEA electrically by a sinusoidal voltage around a bias voltage. A detailed parametric study shows that the electromechanical efficiency is highly dependent on the frequency, amplitude, and bias of the excitation voltage and the mechanical impedance of the external system as well. Efficiencies of up to 93% can be observed for the Danfoss PolyPower tubular DEA if the mechanical impedance of the external system is adjusted to the mechanical impedance of the DEA or vice versa. The study shows that a tubular DEA can be dimensioned and operated such that it performs most efficiently for a given application.
Band parameters of phosphorene

Phosphorene is a two-dimensional nanomaterial with a direct band-gap at the Brillouin zone center. In this paper, we present a recently derived effective-mass theory of the band structure in the presence of strain and electric field, based upon group theory. Band parameters for this theory are computed using a first-principles theory based upon the generalized-gradient approximation to the density-functional theory. These parameters and Hamiltonian will be useful for modeling physical properties of phosphorene.

General information

State: Published
Organisations: Department of Photonics Engineering, University of North Carolina, South Carolina Governor's School for Science and Mathematics
Authors: Lew Yan Voon, L. C. (Ekstern), Wang, J. (Ekstern), Zhang, Y. (Ekstern), Willatzen, M. (Intern)
Number of pages: 6
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Physics: Conference Series
Volume: 633
Issue number: 1
Article number: 012042
ISSN (Print): 1742-6596
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
Effective Hamiltonians for phosphorene and silicene

We derived the effective Hamiltonians for silicene and phosphorene with strain, electric field and magnetic field using the method of invariants. Our paper extends the work of Geissler et al 2013 (NewJ. Phys. 15 085030) on silicene, and Li and Appelbaum 2014 (Phys. Rev. B 90, 115439) on phosphorene. Our Hamiltonians are compared to an equivalent one for graphene. For silicene, the expression for band warping is obtained analytically and found to be of different order than for graphene. We prove that a uniaxial strain does not open a gap, resolving contradictory numerical results in the literature. For phosphorene, it is shown that the bands near the Brillouin zone center only have terms in even powers of the wave vector. We predict that the energies change quadratically in the presence of a perpendicular external electric field but linearly in a perpendicular magnetic field, as opposed to those for silicene which vary linearly in both cases. Preliminary ab initio calculations for the intrinsic bandstructures have been carried out in order to evaluate some of the $k \cdot p$ parameters.
Isogeometric analysis of sound propagation through laminar flow in 2-dimensional ducts

We consider the propagation of sound through a slowly moving fluid in a 2-dimensional duct. A detailed description of a flow-acoustic model of the problem using B-spline based isogeometric analysis is given. The model couples the non-linear, steady-state, incompressible Navier-Stokes equation in the laminar regime for the flow field, to a linear, time-harmonic acoustic equation in the low Mach number regime for the sound signal. B-splines are used both to represent the duct geometry and to approximate the flow and sound fields. This facilitates an exact representation of complex duct geometries, as well as high continuity approximations of state variables. Acoustic boundary conditions on artificial truncation boundaries are treated using a mode matching formulation. We validate the model against known acoustic modes for a uniform flow through a straight duct. Improved error convergence rates are found when the acoustic pressure is approximated by higher order polynomials. Based on the model, we examine how the acoustic signal varies with sound frequency, flow speed and duct geometry. A combination of duct geometry and sound frequency is identified for which the acoustic signal is particularly sensitive to the flow speed.
Mechanical Properties of Laminate Materials: From Surface Waves to Bloch Oscillations

We propose hitherto unexplored and fully analytical insights into laminate elastic materials in a true condensed-matter-physics spirit. Pure mechanical surface waves that decay as evanescent waves from the interface are discussed, and we demonstrate how these designer Scholte waves are controlled by the geometry as opposed to the material alone. The linear surface wave dispersion is modulated by the crystal filling fraction such that the degree of confinement can be engineered without relying on narrow-band resonances but on effective stiffness moduli. In the same context, we provide a theoretical recipe for designing Bloch oscillations in classical plate structures and show how mechanical Bloch oscillations can be generated in arrays of solid plates when the modal wavelength is gradually reduced. The design recipe describes how Bloch oscillations in classical structures of arbitrary dimensions can be generated, and we demonstrate this numerically for structures with millimeter and centimeter dimensions in the kilohertz to megahertz range. Analytical predictions agree entirely with full wave simulations showing how elastodynamics can mimic quantum-mechanical condensed-matter phenomena.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials, Shenzhen University
Authors: Liang, Z. (Ekstern), Willatzen, M. (Intern), Christensen, J. (Intern)
Number of pages: 8
Publication date: 2015
Main Research Area: Technical/natural sciences
On the $\kappa^2$-dependence of $\{\varepsilon_r\}$ and/or $\{\mu_r\}$ for optimum absorption efficiency of electrically small homogeneous spheres with $\{\varepsilon_r\}$ and/or $\{\mu_r\} = -2$

The absorption efficiency of a homogenous sphere illuminated by a plane electromagnetic wave can be found exactly using Lorenz-Mie theory and the Optical Theorem. The solution is expressed in terms of an infinite sum of spherical modes (see e.g. C. F. Bohren and D. Huffman, Absorption and scattering of light by small particles, Wiley, 1983, Chap. 4).

Purcell effect of asymmetric dipole source distributions in nanowire resonators

Metal nanowire resonators allow subwavelength mode confinement and thereby the strong Purcell effect. Recent progress in fabrication of plasmonic nanowire lasers requires reliable approaches in studying resonators, where metal nanowire is an essential constitutive element. A semi-analytic study, capable of treating finite-length axially-symmetric nanowire configurations, was reported in. In some nanolaser configurations, however, one needs to treat asymmetric source distributions, e.g. the single quantum dot placed at some distance from the nanowire axis. We investigate the Purcell effect of the asymmetric source distributions in proximity to the metal nanowire in two configurations: a metal cylinder truncated by the PEC plates and finite metal cylinder in free-space. In order to evaluate Purcell factor the mode eigenvalues are precalculated using Comsol Multiphysics radio frequency module. We compare the eigenfrequency and Purcell factor values calculated in PEC-truncated model against an analytic theory, which accounts for the fundamental surface plasmon - polariton mode in the form of a standing wave between two PEC planes.
Tunable Broadband Acoustic Gain in Piezoelectric Semiconductors at ε-Near-Zero Response

Piezoelectric semiconductors have emerged as materials capable to amplify sound waves when electrons are set to drift at supersonic speeds. Several experiments have demonstrated this behaviour at moderate amplification levels for some intrinsic semiconductors and carrier concentrations. On a theoretical basis we show that amplification of sound can be significantly enhanced when the materials are operated close to the plasma frequency. If the drifting carriers collectively oscillate with the plasma the electromechanical coupling is enhanced since the permittivity is related inversely proportional to the mechanical stress and vanishes near the bulk plasma frequency. By optically or electrically doping GaAs and InSb as exemplified in this work, we predict that amplification of sound can be achieved effectively for a bandwidth exceeding several decades making this active system very attractive for loss-compensation in metamaterials and applicable for sensing such as nonlinear devices. The paper contains a detailed derivation and discussion of transmission and reflection coefficients for pressure pulses impinging on a semiconductor slab and the acoustic gain enhancement that can be achieved by dynamic switching of the electric field as well as tuning flexibility through dynamic control of the carrier density.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials
Authors: Christensen, J. (Intern), Willatzen, M. (Intern)
Pages: 986 – 992
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: Acustica United with Acta Acustica
Volume: 101
ISSN (Print): 1610-1928
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.451 SNIP 0.834 CiteScore 1.12
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.617 SNIP 1.093 CiteScore 1.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.615 SNIP 1.071 CiteScore 0.89
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.597 SNIP 1.6 CiteScore 1.05
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.602 SNIP 0.963 CiteScore 0.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.515 SNIP 0.918 CiteScore 0.65
ISI indexed (2011): ISI indexed yes
Unified treatment of coupled optical and acoustic phonons in piezoelectric cubic materials

A unified treatment of coupled optical and acoustic phonons in piezoelectric cubic materials is presented whereby the lattice displacement vector and the internal ionic displacement vector are found simultaneously. It is shown that phonon couplings exist in pairs only; either between the electric potential and the lattice displacement coordinate perpendicular to the phonon wave vector or between the two other lattice displacement components. The former leads to coupled acousto-optical phonons by virtue of the piezoelectric effect. We then establish three new conjectures that entirely stem from piezoelectricity in a cubic structured material slab. First, it is shown that isolated optical phonon modes generally cannot exist in piezoelectric cubic slabs. Second, we prove that confined acousto-optical phonon modes only exist for a discrete set of in-plane wave numbers in piezoelectric cubic slabs. Third, it is shown that coupled acousto-optical phonons do not exist at the longitudinal-optical (LO) phonon frequency where the dielectric constant vanishes.
Acoustic gain in piezoelectric semiconductors at \( \varepsilon \)-near-zero response

We demonstrate strong acoustic gain in electric-field biased piezoelectric semiconductors at frequencies near the plasmon frequency in the terahertz range. When the electron drift velocity produced by an external electric field is higher than the speed of sound, Cherenkov radiation of phonons generates amplification of sound. It is demonstrated that this effect is particularly effective at \( \varepsilon \)-near-zero response, leading to giant levels of acoustic gain. Operating at conditions with strong acoustic amplification, we predict unprecedented enhancement of the scattered sound field radiated from an electrically controlled piezoelectric slab waveguide. This extreme sound field enhancement in an active piezo material shows potential for acoustic sensing and loss compensation in metamaterials and nonlinear devices.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials
Authors: Willatzen, M. (Intern), Christensen, J. (Intern)
Number of pages: 5
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Volume: 89
Article number: 041201
Acoustic wave propagation and stochastic effects in metamaterial absorbers

We show how stochastic variations of the effective parameters of anisotropic structured metamaterials can lead to increased absorption of sound. For this, we derive an analytical model based on the Bourret approximation and illustrate the immediate connection between material disorder and attenuation of the averaged field. We demonstrate numerically that broadband absorption persists at oblique irradiation and that the influence of red noise comprising short spatial correlation lengths increases the absorption beyond what can be archived with a structured but ordered system.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials
Authors: Christensen, J. (Intern), Willatzen, M. (Intern)
Number of pages: 5
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Volume: 105
Article number: 043508
ISSN (Print): 0003-6951
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.132 SNIP 0.996
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.085 SNIP 0.983 CiteScore 2.47
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.799 SNIP 1.462 CiteScore 3.25
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.149 SNIP 1.652 CiteScore 3.77
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.554 SNIP 1.754 CiteScore 3.76
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.805 SNIP 1.94 CiteScore 4.04
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.926 SNIP 1.789
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.857 SNIP 1.848
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
An Adaptable Robot Vision System Performing Manipulation Actions With Flexible Objects

This paper describes an adaptable system which is able to perform manipulation operations (such as Peg-in-Hole or Laying-Down actions) with flexible objects. As such objects easily change their shape significantly during the execution of an action, traditional strategies, e. g., for solve path-planning problems, are often not applicable. It is therefore required to integrate visual tracking and shape reconstruction with a physical modeling of the materials and their deformations as well as action learning techniques. All these different submodules have been integrated into a demonstration platform, operating in real-time. Simulations have been used to bootstrap the learning of optimal actions, which are subsequently improved through real-world executions. To achieve reproducible results, we demonstrate this for casted silicone test objects of regular shape. Note to Practitioners-The aim of this work was to facilitate the setup of robot-based automation of delicate handling of flexible objects consisting of a uniform material. As examples, we have considered how to optimally maneuver flexible objects through a hole without colliding and how to place flexible objects on a flat surface with minimal introduction of internal stresses in the object. Given the material properties of the object, we have demonstrated in these two applications how the system can be programmed with minimal requirements of human intervention. Rather than being an integrated system with the drawbacks in terms of lacking flexibility, our system should be viewed as a library of new technologies that have been proven to work in close to industrial conditions. As a rather basic, but necessary part, we provide a technology for determining the shape of the object when passing on, e. g., a conveyor belt prior to being handled. The main technologies applicable for the manipulated objects are: A method for real-time tracking of the flexible objects during manipulation, a method for model-based offline prediction of the static deformation of grasped, flexible objects and, finally, a method for optimizing specific tasks based on both simulated and real-world executions.

**General information**

State: Published
Organisations: Department of Photonics Engineering, University of Southern Denmark, Teknologisk Institut, University of Kiel
Pages: 749-765
Publication date: 2014
Main Research Area: Technical/natural sciences

**Publication information**

Journal: IEEE Transactions on Automation Science and Engineering
Volume: 11
Issue number: 3
ISSN (Print): 1545-5955
Ratings:
Differential Geometry Applied to Rings and Möbius Nanostructures

Nanostructure shape effects have become a topic of increasing interest due to advancements in fabrication technology. In order to pursue novel physics and better devices by tailoring the shape and size of nanostructures, effective analytical and computational tools are indispensable. In this chapter, we present analytical and computational differential geometry methods to examine particle quantum eigenstates and eigenenergies in curved and strained nanostructures. Example studies are carried out for a set of ring structures with different radii and it is shown that eigenstate and eigenenergy changes due to curvature are most significant for the groundstate eventually leading to qualitative and quantitative changes in physical properties. In particular, the groundstate in-plane symmetry characteristics are broken by curvature effects, however, curvature contributions can be discarded at bending radii above 50 nm. In the second part of the chapter, a more complicated topological structure, the Möbius nanostructure, is analyzed and geometry effects for eigenstate properties are discussed including dependencies on the Möbius nanostructure width, length, thickness, and strain.
Epitaxial growth of quantum dots on InP for device applications operating at the 1.55 μm wavelength range

The development of epitaxial technology for the fabrication of quantum dot (QD) gain material operating in the 1.55 μm wavelength range is a key requirement for the evolution of telecommunication. High performance QD material demonstrated on GaAs only covers the wavelength region 1-1.35 μm. In order to extract the QD benefits for the longer telecommunication wavelength range the technology of QD fabrication should be developed for InP based materials. In our work, we take advantage of both QD fabrication methods Stranski-Krastanow (SK) and selective area growth (SAG) employing block copolymer lithography. Due to the lower lattice mismatch of InAs/InP compared to InAs/GaAs, InP based QDs have a larger diameter and are shallower compared to GaAs based dots. This shape causes low carrier localization and small energy level separation which leads to a high threshold current, high temperature dependence, and low laser quantum efficiency. Here, we demonstrate that with tailored growth conditions, which suppress surface migration of adatoms during the SK QD formation, much smaller base diameter (13.6nm versus 23nm) and an improved aspect ratio are achieved. In order to gain advantage of non-strain dependent QD formation, we have developed SAG, for which the growth occurs only in the nano-openings of a mask covering the wafer surface. In this case, a wide range of QD composition can be chosen. This method yields high purity material and provides significant freedom for reducing the aspect ratio of QDs with the possibility to approach an ideal QD shape.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonic Devices, Center for Electron Nanoscopy, Programmable Phase Optics, Department of Micro- and Nanotechnology, Nanointegration, Amphiphilic Polymers in Biological Sensing, University of Rome
Number of pages: 9
Publication date: 2014
Main Research Area: Technical/natural sciences
Exergy costing for energy saving in combined heating and cooling applications

The aim of this study is to provide a price model that motivates energy saving for a combined district heating and cooling system. A novel analysis using two thermoeconomic methods for apportioning the costs to heating and cooling provided simultaneously by an ammonia heat pump is demonstrated. In the first method, referred to as energy costing, a conventional thermoeconomic analysis is used. Here the ammonia heat pump is subject to a thermodynamic analysis with mass and energy balance equations. In the second method referred to as exergy costing, an exergy based economic analysis is used, where exergy balance equations are used in conjunction with mass and energy balance equations. In both costing methods the thermodynamic analysis is followed by an economic analysis which includes investment and operating costs. For both methods the unit costs of heating and cooling are found and compared. The analysis shows that the two methods yield significantly different results. Rather surprisingly, it is demonstrated that the exergy costing method results in about three times higher unit cost for heating than for cooling as opposed to equal unit costs when using the energy method. Further the exergy-based cost for heating changes considerably with the heating temperature while that of cooling is much less affected.

General information
State: Published
Organisations: Department of Photonics Engineering, University of Southern Denmark, Fjernvarme Fyn A/S
Authors: Nguyen, C. (Forskerdatabase), Veje, C. T. (Ekstern), Willatzen, M. (Intern), Andersen, P. (Ekstern)
Pages: 349-355
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Energy Conversion and Management
Volume: 86
Extraordinary absorption of sound in porous lamella-crystals

We present the design of a structured material supporting complete absorption of sound with a broadband response and functional for any direction of incident radiation. The structure which is fabricated out of porous lamellas is arranged into a low-density crystal and backed by a reflecting support. Experimental measurements show that strong all-angle sound absorption with almost zero reflectance takes place for a frequency range exceeding two octaves. We demonstrate that lowering the crystal filling fraction increases the wave interaction time and is responsible for the enhancement of intrinsic material dissipation, making the system more absorptive with less material.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials, Universidad Politecnica de Valencia, Institut de Ciències Fotòniques, University of Southern Denmark
Authors: Christensen, J. (Intern), Romero-García, V. (Ekstern), Picó, R. (Ekstern), Cebrecos, A. (Ekstern), de Abajo, F. J. G. (Ekstern), Mortensen, N. A. (Intern), Willatzen, M. (Intern), Sánchez-Morcillo, V. J. (Ekstern)
Number of pages: 5
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Scientific Reports
Volume: 4
Article number: 4674
ISSN (Print): 2045-2322
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.63 SJR 1.625 SNIP 1.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.057 SNIP 1.684 CiteScore 5.3
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.103 SNIP 1.544 CiteScore 4.75
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.886 SNIP 1.51 CiteScore 4.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.458 SNIP 0.896 CiteScore 2.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Original language: English
Electronic versions:
SREP_14_01833_Revised_PDF_5.pdf
DOIs:
10.1038/srep04674
Source: FindIt
Source-ID: 255110435
Publication: Research - peer-review › Journal article – Annual report year: 2014

Geometry optimization of tubular dielectric elastomer actuators with anisotropic metallic electrodes

This paper presents an experimentally verified static three-dimensional model for core free tubular dielectric elastomer actuators with anisotropic compliant metal electrodes. Due to the anisotropy of the electrodes, the performance (force versus voltage, force versus stroke, and stroke versus voltage) of the actuators depends strongly on their geometry. Based on the three-dimensional model, the performance of the actuators is optimized by means of the length of the axes of their inner elliptical cross section and their wall thickness.
Maximum absorption by homogeneous magneto-dielectric sphere

In order to obtain a benchmark for electromagnetic energy harvesting, we investigate the maximum absorption efficiency by a magneto-dielectric homogeneous sphere illuminated by a plane wave, and we arrive at several novel results. For electrically small spheres we show that the optimal relative permeability and permeability of materials where $\mu_r, \mu'\geq 1$ is $(1+i3)$ independent of sphere size, while that of metamaterials is $(-2+i\delta)$, where the imaginary part $\delta$ decreases strongly with decreasing sphere size. For larger spheres we show that while maximum absorption efficiency occurs at the resonances of the spherical modes, there exists a wide plateau of high absorption efficiency when material intrinsic impedance is constant; in the case of free-space intrinsic impedance and electrical radius $\kappa=1$, the absorption efficiency becomes $2.8$. The investigation is analytic/numerical and based on the Lorenz–Mie theory combined with the optical theorem.
Minimal model for spoof acoustoelastic surface states

Similar to textured perfect electric conductors for electromagnetic waves sustaining artificial or spoof surface plasmons we present an equivalent phenomena for the case of sound. Aided by a minimal model that is able to capture the complex wave interaction of elastic cavity modes and airborne sound radiation in perfect rigid panels, we construct designer acoustoelastic surface waves that are entirely controlled by the geometrical environment. Comparisons to results obtained by full-wave simulations confirm the feasibility of the model and we demonstrate illustrative examples such as resonant transmissions and waveguiding to show a few examples of many where spoof elastic surface waves are useful.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials, Shenzhen University
Authors: Christensen, J. (Intern), Liang, Z. (Ekstern), Willatzen, M. (Intern)
Number of pages: 7
Publication date: 2014
Main Research Area: Technical/natural sciences

Modelling the acoustical response of lossy lamella-crystals.

The sound propagation properties of lossy lamella-crystals are analysed theoretically utilizing a rigorous wave expansion formalism and an effective medium approach. We investigate both sup- ported and free-standing crystal slab structures and predict high absorption for a broad range of frequencies. A detailed derivation of the formalism is presented, and we show how the results obtained in the subwavelength and superwavelength regimes qualitatively can be reproduced by homogenizing the lamella-crystals. We come to the conclusion that treating this structure within the metamaterial limit only makes sense if the crystal filling fraction is sufficiently large to satisfy an effective medium approach.

General information
State: Published
Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials
Authors: Christensen, J. (Intern), Mortensen, N. A. (Intern), Willatzen, M. (Intern)
Number of pages: 6
Publication date: 2014
Main Research Area: Technical/natural sciences
We investigate the modification (enhancement and suppression) of the spontaneous emission rate of a dipole emitter in two configurations: inside a finite-length semiconductor nanowire surrounded by bulk metal and in the vicinity of a finite metal nanowire. Our analysis is based on a first-principle approach, which is reduced to a seminumeric one in the limit of large nanowire aspect ratios. The numerical calculations are carried out for an emitter in a GaAs nanowire embedded in Ag or Au and for that nearby an Ag or Au nanowire in vacuum or dielectric. We consider in detail the Purcell and β factors as functions of the cylinder radius, the emitter position, and the transition frequency for both configurations. We contrast the results for finite-length nanowires with those obtained in the infinite-length approximation and find considerable differences in the Purcell factor magnitude.
An Electromechanical Model for a Dielectric ElectroActive Polymer Generator

Smart electroactive materials have attracted much of the scientific interest over the past few years, as they reflect a quite promising alternative to conservative approaches used nowadays in various transducer applications. Especially Dielectric ElectroActive Polymers (DEAPs), which are constantly gaining momentum due to their superior low-speed performance, light-weighted nature and higher energy density when compared with competing technologies. In this paper an electromechanical model for a DEAP generator is presented, accounting for both the visco-hyperelastic characteristics of the polymer material, as well as the later one's experimentally determined stretch-capacitance dependence. Apart from the visco-hyperelastic model validation via purely mechanical experiments, the model's electromechanical coupling is verified as well, via experiments conducted under all three distinct energy harvesting cycles; namely the Constant Charge (CC), Constant Voltage (CV) and Constant E-field (CE) cycles.

General information
State: Published
Organisations: Department of Photonics Engineering, Aalborg University, University of Southern Denmark
Authors: Dimopoulos, E. (Ekstern), Trintis, I. (Forskerdatabase), Munk-Nielsen, S. (Forskerdatabase), Rechenbach, B. (Ekstern), Willatzen, M. (Intern), Lassen, B. (Ekstern)
Number of pages: 10
Publication date: 2013

Host publication information
Title of host publication: 2013 15th European Conference on Power Electronics and Applications (EPE)
Publisher: IEEE
Main Research Area: Technical/natural sciences
Conference: 15th European Conference on Power Electronics and Applications (EPE), Lille, France, 02/09/2013 - 02/09/2013
DOIs: 10.1109/EPE.2013.6634468
Source: dtu
Source-ID: n::oai:DTIC-ART:iel/409574996::33091
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013
Design optimization of a linear actuator
The mechanical contacting of a dielectric elastomer actuator is investigated. The actuator is constructed by coiling the dielectric elastomer around two parallel metal rods, similar to a rubber band stretched by two index fingers. The goal of this paper is to design the geometry and the mechanical properties of a polymeric interlayer between the elastomer and the rods, gluing all materials together, so as to optimize the mechanical durability of the system. Finite element analysis is employed for the theoretical study which is linked up to experimental results performed by Danfoss PolyPower A/S.
We show that the acoustic response of perforated and elastically filled rigid screens can give rise to a broad landscape of tunable devices. We begin presenting deep-subwavelength transmission properties of a structured plate and demonstrate the immediate relationship to truly bound surface modes. We extend our theoretical model to analyze structured metal-fluid-metal wave guides for the confinement of sound and present exact expressions for the dispersion relations which describe the hybridization of resonances. We discuss the validity of our analytical model by direct comparison to full-wave simulations and use this technique in the search for broadband response in composite structures where the effective mass density and bulk modulus are simultaneously negative and exhibiting weak influences by viscous losses.
Near infrared photoacoustic detection of heptane in synthetic air
Trace contaminations of n-heptane in synthetic air is measured in the parts-per-billion (ppb) range using near infrared photoacoustic detection. We describe the fundamental theory used in the design of the photoacoustic cell for trace gas analysis and determine the detection limit of the cell. On the basis of a modified procedure from the American Clinical and Laboratory Standards Institute for the case that it is practically impossible to produce perfectly blank samples, a residual detection limit of 3 ppm n-heptane is confirmed. We investigate theoretically the impact of changing the buffer diameter on the window generated signal and find good correlation with previously reported experimental results.
We study spontaneous emission enhancement of a two-level atomic emitter placed in a dielectric medium near a finite-length cylindrical metal nanowire. We calculate the dependence of the Purcell factor and the normalized decay rate to a continuous spectrum on the nanowire radius for several emitter transition wavelengths and different orientations of the transition dipole moment. For a particular transition wavelength we calculate the dependence of these quantities as well as the $\beta$-factor on the emitter distance from the nanowire and the nanowire radius. The obtained results demonstrate that the spontaneous emission characteristics exhibit significant differences as compared to the case of an infinite wire.
Computational Methods for Electromechanical Fields in Self-Assembled Quantum Dots

A detailed comparison of continuum and valence force field strain calculations in quantum-dot structures is presented with particular emphasis to boundary conditions, their implementation in the finite-element method, and associated implications for electronic states. The first part of this work provides the equation framework for the elastic continuum model including piezoelectric effects in crystal structures as well as detailing the Keating model equations used in the atomistic valence force field calculations. Given the variety of possible structure shapes, a choice of pyramidal, spherical and cubic-dot shapes is made having in mind their pronounced shape differences and practical relevance. In this part boundary conditions are also considered; in particular the relevance of imposing different types of boundary conditions is highlighted and discussed. In the final part, quantum dots with inhomogeneous indium concentration profiles are studied in order to highlight the importance of taking into account the exact In concentration profile for real quantum dots. The influence of strain, electric-field distributions, and material inhomogeneity of spherical quantum dots on electronic wavefunctions is briefly discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, University of Southern Denmark
Authors: Filonenko, K. (Ekstern), Willatzen, M. (Intern), Bordo, V. (Ekstern)
Pages: 1305-1309
Publication date: 2013
Conference: 34th Progress In Electromagnetics Research Symposium, Stockholm, Sweden, 12/08/2013 - 12/08/2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Progress in Electromagnetics Research Symposium
ISSN (Print): 1559-9450
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
Electronic versions:
Willatzen_PIERS_2013.pdf
Links:
Source: dtu
Source-ID: u::8847
Publication: Research - peer-review › Conference article – Annual report year: 2013

General information
State: Published
Organisations: University of Southern Denmark
Authors: Barettin, D. (Ekstern), Madsen, S. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern)
Pages: 797-830
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Communications in Computational Physics
Volume: 11
Issue number: 3
ISSN (Print): 1815-2406
Ratings:
Web of Science (2017): Indexed Yes
Scopus rating (2016): SJR 0.97 SNIP 0.892 CiteScore 1.37
Scopus rating (2015): SJR 1.096 SNIP 1.18 CiteScore 1.4
Scopus rating (2014): SJR 1.299 SNIP 1.25 CiteScore 1.65
Scopus rating (2013): SJR 1.301 SNIP 1.09 CiteScore 1.49
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 1.25 SNIP 1.351 CiteScore 1.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 1.048 SNIP 1.376 CiteScore 1.67
Dynamic Electromechanical Modeling of Dielectric Elastomer Actuators With Metallic Electrodes

In this paper, a nonlinear electromechanical model for a PolyPower dielectric elastomer actuator is proposed based on an electric circuit model coupled with a viscoelastic mechanical model. The parameters of the model are found by fitting to an electrical step impulse for the mechanical part and by standard methods for the electric circuit. The resulting model is compared with experiments for a range of sinusoidal stimuli. The comparison shows good agreement between experiments and model results.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Sarban, R. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern)
Pages: 960-967
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE - ASME Transactions on Mechatronics
Volume: 17
Issue number: 5
ISSN (Print): 1083-4435
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.22 SJR 1.666 SNIP 2.519
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.053 SNIP 3.225 CiteScore 5.49
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.022 SNIP 3.388 CiteScore 4.94
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.609 SNIP 3.423 CiteScore 5.09
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.632 SNIP 3.184 CiteScore 4.44
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.436 SNIP 2.657 CiteScore 3.94
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.259 SNIP 2.644
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.121 SNIP 2.439
BFI (2008): BFI-level 2
Dynamic Modeling of Phase Crossings in Two-Phase Flow

Two-phase flow and heat transfer, such as boiling and condensing flows, are complicated physical phenomena that generally prohibit an exact solution and even pose severe challenges for numerical approaches. If numerical solution time is also an issue the challenge increases even further. We present here a numerical implementation and novel study of a fully distributed dynamic one-dimensional model of two-phase flow in a tube, including pressure drop, heat transfer, and variations in tube cross-section. The model is based on a homogeneous formulation of the governing equations, discretized by a high resolution finite difference scheme due to Kurganov and Tadmor. The homogeneous formulation requires a set of thermodynamic relations to cover the entire range from liquid to gas state. This leads a number of numerical challenges since these relations introduce discontinuities in the derivative of the variables and are usually very slow to evaluate. To overcome these challenges, we use an interpolation scheme with local refinement. The simulations show that the method handles crossing of the saturation lines for both liquid to two-phase and two-phase to gas regions. Furthermore, a novel result obtained in this work, the method is stable towards dynamic transitions of the inlet/outlet boundaries across the saturation lines. Results for these cases are presented along with a numerical demonstration of conservation of mass under dynamically varying boundary conditions. Finally we present results for the stability of the code in a case of a tube with a narrow section.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Madsen, S. (Ekstern), Veje, C. (Ekstern), Willatzen, M. (Intern)
Pages: 1129-1147
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Communications in Computational Physics
Volume: 12
Issue number: 4
ISSN (Print): 1815-2406
Ratings:
Web of Science (2017): Indexed Yes
Scopus rating (2016): SJR 0.97 SNIP 0.892 CiteScore 1.37
Scopus rating (2015): SJR 1.096 SNIP 1.18 CiteScore 1.4
Scopus rating (2014): SJR 1.299 SNIP 1.25 CiteScore 1.65
Scopus rating (2013): SJR 1.301 SNIP 1.09 CiteScore 1.49
ISI indexed (2013): ISI indexed yes
Scopus rating (2012): SJR 1.25 SNIP 1.351 CiteScore 1.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 1.048 SNIP 1.376 CiteScore 1.67
ISI indexed (2011): ISI indexed yes
Scopus rating (2010): SJR 1.272 SNIP 1.427
Flow-induced resonance shift in sonic slit array metamaterials
A modal analysis of flow-acoustic wave propagation through slit array metamaterials is presented. It is demonstrated that the transmission-coefficient change versus flow speed is a sensitive function of frequency. Our results further confirm that transmission resonance positions and resonance widths change significantly with the flow speed. As a reverse application, the present metamaterial slit structures allow for flow tuning of slit cavity modes, design of surface bound states such as superlens applications where a broad frequency operation interval is sought. Finally, it is shown rather surprisingly that the flow-acoustic coupling is almost independent of the angle of incidence.

General information
State: Published
Organisations: University of Southern Denmark, The Institute of Physical Chemistry "Rocasolano"
Authors: Christensen, J. (Intern), Willatzen, M. (Intern)
Number of pages: 6
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Volume: 85
Issue number: 9
Article number: 094304
ISSN (Print): 1098-0121
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.933 SNIP 0.94 CiteScore 2.8
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.667 SNIP 1.262 CiteScore 3.3
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.785 SNIP 1.339 CiteScore 3.55
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.206 SNIP 1.394 CiteScore 3.57
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.382 SNIP 1.438 CiteScore 3.61
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.417 SNIP 1.451
Gap-plasmon nanoantennas and bowtie resonators

Plasmonic bowtie resonators involving gap surface plasmons (GSPs) in metal-insulator-metal (MIM) structures, in which only the top metal layer is structured, are investigated using numerical simulations. We demonstrate that the considered configuration features two efficiently excitable GSP resonances associated with distinct charge distributions with the domination of the dipole and quadrupole moments resulting in low- and high-Q resonances, respectively. The typical Q factors for the high-Q resonances are shown to achieve ~25 in the near-infrared, thus potentially exceeding the quasistatic limit. Detailed physical interpretations of the obtained results and consistent dependencies of the resonance characteristics on the geometrical structural parameters are presented. Excellent resonant characteristics, the simplicity of fabrication, and tuning of the resonance wavelength by adjusting the size of the bowtie arms, separation between them, and/or thickness of the insulator (SiO2) layer in the MIM structure appear attractive for a wide variety of applications, ranging from surface sensing to photovoltaics.

General information

State: Published
Organisations: Nanophotonics Pty Ltd, University of Southern Denmark
Authors: Gramotnev, D. K. (Ekstern), Pors, A. (Ekstern), Willatzen, M. (Intern), Bozhevolnyi, S. I. (Ekstern)
Number of pages: 9
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Volume: 85
Issue number: 4
Article number: 045434
ISSN (Print): 1098-0121
Ratings:
BFI (2017): BFI-level 2
Laplace boundary-value problem in paraboloidal coordinates
This paper illustrates both a problem in mathematical physics, whereby the method of separation of variables, while applicable, leads to three ordinary differential equations that remain fully coupled via two separation constants and a five-term recurrence relation for series solutions, and an exactly solvable problem in electrostatics, as a boundary-value problem on a paraboloidal surface. In spite of the complex nature of the former, it is shown that the latter solution can be quite simple. Results are provided for the equipotential surfaces and electric field lines are given near a paraboloidal conductor.

General information
State: Published
Organisations: Wright State University, University of Southern Denmark
Authors: Duggen, L. (Ekstern), Willatzen, M. (Intern), Voon, L. C. L. Y. (Ekstern)
Pages: 689-696
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: European Journal of Physics
Volume: 33
Issue number: 3
ISSN (Print): 0143-0807
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.364 SNIP 0.784 CiteScore 0.54
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.472 SNIP 1.129 CiteScore 0.62
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.438 SNIP 1.009 CiteScore 0.58
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.504 SNIP 0.951 CiteScore 0.62
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.436 SNIP 0.838 CiteScore 0.63
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.505 SNIP 1.058 CiteScore 0.73
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.437 SNIP 1.017
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.377 SNIP 1.038
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.568 SNIP 0.779
Scopus rating (2007): SJR 0.469 SNIP 0.948
Scopus rating (2006): SJR 0.435 SNIP 0.886
Scopus rating (2005): SJR 0.434 SNIP 1.079
Scopus rating (2004): SJR 0.437 SNIP 0.882
Scopus rating (2003): SJR 0.36 SNIP 0.703
Scopus rating (2002): SJR 0.305 SNIP 0.452
Scopus rating (2001): SJR 0.331 SNIP 0.47
Scopus rating (2000): SJR 0.31 SNIP 0.575
Scopus rating (1999): SJR 0.232 SNIP 0.538
Learning peg-in-hole actions with flexible objects
This paper presents a method for learning Peg-In-Hole actions with flexible objects. To learn the actions we parametrize the entire trajectory by a single point and use Kernel Density Estimation to reflect the different variations of the action and the object characteristics. The object is characterized by its elastic behaviour rather than geometric properties. Thereby an action learned for one object can be transferred to a new object that behaves similarly although it might have different elastic properties, dimensions and geometries. To bootstrap the learning mechanism, the system performs simulated actions and utilizes the detailed information obtained from the simulation environment. Subsequently Peg-In-Hole actions are tested successfully on the real life setup.

Modeling Frequency Response of Photoacoustic Cells using FEM for Determination of N-heptane Contamination in Air: Experimental Validation
We briefly present the basic principle of the photoacoustic effect in gases. We present the equations and boundary conditions governing the acoustic field generated by the absorption of a modulated laser beam. We solve these equations using Finite Element Methods and compare the results with experiment. We find that apparently there are effects not taken into account in the classic acoustic theory as we find a larger damping than theory predicts. However, we see that these effects have significant negative influence on the quality factor of the cell and thereby the performance limit.
Modeling Heterostructures with Schrödinger–Poisson–Navier Iterative Schemes, Effect of Carrier Charge, and Influence of Electromechanical Coupling

This paper presents a detailed investigation of the effects of piezoelectricity, spontaneous polarization and charge density on the electronic states and the quasi-Fermi level energy in wurtzite-type semiconductor heterojunctions. This has required a full solution to the coupled Schrödinger-Poisson-Navier model, as a generalization of earlier work on the Schrödinger-Poisson problem. Finite-element-based simulations have been performed on an AlN/GaN quantum well by using both one-step calculation as well as the self-consistent iterative scheme. Results have been provided for field distributions corresponding to cases with zero-displacement boundary conditions and also stress-free boundary conditions. It has been further demonstrated by using four case study examples that a complete self-consistent coupling of electromechanical fields is essential to accurately capture the electromechanical fields and electronic wavefunctions. We have demonstrated that electronic energies can change up to approximately 0.5 eV when comparing partial and complete coupling of electromechanical fields. Similarly, wavefunctions are significantly altered when following a self-consistent procedure as opposed to the partial-coupling case usually considered in literature. Hence, a complete self-consistent procedure is necessary when addressing problems requiring more accurate results on optoelectronic properties of low-dimensional nanostructures compared to those obtainable with conventional methodologies.
Modelling of the Heating Process in a Thermal Screw

The procedure of separating efficiently dry-stuff (proteins), fat, and water is an important process in the handling of waste products from industrial and commercial meat manufactures. One of the sub-processes in a separation facility is a thermal screw where the raw material (after proper mincing) is heated in order to melt fat, coagulate protein, and free water. This process is very energy consuming and the efficiency of the product is highly dependent on accurate temperature control of the process. A key quality parameter is the time that the product is maintained at temperatures within a certain threshold. A detailed mathematical model for the heating process in the thermal screw is developed and analysed. The model is formulated as a set of partial differential equations including the latent heat for the melting process of the fat and the boiling of water, respectively. The product is modelled by three components; water, fat and dry-stuff (bones and proteins). The melting of the fat component is captured as a plateau in the product temperature. The model effectively captures the product outlet temperature and the energy consumed. Depending on raw material composition, "soft" or "dry", the model outlines the heat injection and screw speeds necessary to obtain optimal output quality.

General information

State: Published
Organisations: University of Southern Denmark
Authors: Zhang, X. (Ekstern), Veje, C. T. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern)
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Physics: Conference Series (Online)
Volume: 395
Issue number: 1
Article number: 012157
ISSN (Print): 1742-6596
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
Multilayer piezoelectric transducer models combined with Field II

One-dimensional and three-dimensional axisymmetric transducer model have been compared to determine their feasibility to predict the volt-to-surface impulse response of a circular Pz27 piezoceramic disc. The ceramic is assumed mounted with silver electrodes, bounded at the outer circular boundary with a polymer ring, and submerged into water. The transducer models are developed to account for any external electrical loading impedance in the driving circuit. The models are adapted to calculate the surface acceleration needed by the Field II software in predicting pressure pulses at any location in front of the transducer. Results show that both models predict the longitudinal resonances with consistency. The one-dimensional model is found to exhibit approximately 2.9 dB peak overshoot at the lowest longitudinal resonance frequencies prediction. These values are decreasing for higher longitudinal modes. If the three-dimensional model is restricted in its radial movement at the circular boundary both models exhibit identical results. The Field II predicted pressure pulses are found to have oscillating consistency with a 2.0 dB overshoot on the maximum amplitude using the one-dimensional compared to the three-dimensional model. This is with no electronic loading. With a 50 Ω loading an amplitude overshoot is found to be 1.5 dB.

General information
State: Published
Organisations: Department of Electrical Engineering, Biomedical Engineering, Center for Fast Ultrasound Imaging
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Pages: 546-554
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Acustica United with Acta Acustica
Volume: 98
Issue number: 4
ISSN (Print): 1610-1928
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.451 SNIP 0.834 CiteScore 1.12
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.617 SNIP 1.093 CiteScore 1.11
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Simulation of flexible objects in robotics

In this paper, we present what appears to be the first simulation model for grasping of flexible bodies based on the three-dimensional elastic constitutive relations and Newton's Second Law for solids known as the Navier-Cauchy equations. We give an overview of the most important equations for strain, stress, and elasticity tensors based on which we outline the format of the Navier-Cauchy equations of motion in the general anisotropic case. We then specifically study the equations for homogeneous isotropic bodies. We formulate a numerical scheme based on finite differences for solving the equations. Finally, we present preliminary experimental work and outline future directions.

General information
State: Published
Organisations: University of Southern Denmark
Simultaneous estimation of material properties and pose for deformable objects from depth and color images

In this paper we consider the problem of estimating 6D pose, material properties and deformation of an object grasped by a robot gripper. To estimate the parameters we minimize an error function incorporating visual and physical correctness. Through simulated and real-world experiments we demonstrate that we are able to find realistic 6D poses and elasticity parameters like Young's modulus. This makes it possible to perform subsequent manipulation tasks, where accurate modelling of the elastic behaviour is important.

Spatial impulse response of a rectangular double curved transducer

Calculation of the pressure field from transducers having both a convex and a concave surface geometry is a complicated assignment that often is accomplished by subdividing the transducer surface into smaller flat elements of which the spatial impulse response is known. This method is often seen applied to curved transducers because an analytical solution is unknown. In this work a semi-analytical algorithm for the exact solution to a first order in diffraction effect of the spatial impulse response of rectangular shaped double curved transducers is presented. The algorithm and an approximation of it
The approximation reformulates the algorithm to an analytically integrable expression which is computationally efficient to solve. Simulation results are compared with the simulation software Field II. Calculating the response from 200 different points yields a mean error for the different approximations ranging from 0.03 % to 0.8 % relative to a numerical solution for the spatial impulse response. It is shown that the presented algorithm gives consistent results with Field II for a linear flat, a linear focused, and a convex non-focused element. Best solution was found to be 0.01 % with a three-point Taylor expansion.
Strain in inhomogeneous InAs/GaAs quantum dot structures

Most non-destructive experimental approaches for the determination of indium concentration profiles give information about average indium concentration profiles only. Due to this, there is a need to extrapolate the indium concentration profiles in a way that takes into account the geometry of the quantum dots. We here present two extrapolation approaches. In the first approach we assume that the indium concentration profile is constant in the direction perpendicular to the measurement plane, while in the second approach we take into account the symmetry of the structure. Both approaches are compared to a profile with a constant indium concentration inside the dot.

General information
State: Published
Organisations: University of Southern Denmark, University of Roma 'Tor Vergata'
Authors: Lassen, B. (Ekstern), Barettin, D. (Ekstern), Willatzen, M. (Intern)
Number of pages: 5
Publication date: 2012
Workshop: 3rd Workshop on Theory, Modelling and Computational Methods for Semiconductors (TMCSIII), Leeds, United Kingdom, 18/01/2012 - 18/01/2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 367
Issue number: 1
Article number: 012007
ISSN (Print): 1742-6596
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
Strong curvature effects in Neumann wave problems

Waveguide phenomena play a major role in basic sciences and engineering. The Helmholtz equation is the governing equation for the electric field in electromagnetic wave propagation and the acoustic pressure in the study of pressure dynamics. The Schrödinger equation simplifies to the Helmholtz equation for a quantum-mechanical particle confined by infinite barriers relevant in semiconductor physics. With this in mind and the interest to tailor waveguides towards a desired spectrum and modal pattern structure in classical structures and nanostructures, it becomes increasingly important to understand the influence of curvature effects in waveguides. In this work, we demonstrate analytically strong curvature effects for the eigenvalue spectrum of the Helmholtz equation with Neumann boundary conditions in cases where the waveguide cross section is a circular sector. It is found that the linear-in-curvature contribution originates from parity symmetry breaking of eigenstates in circular-sector tori and hence vanishes in a torus with a complete circular cross section. The same strong curvature effect is not present in waveguides subject to Dirichlet boundary conditions where curvature contributions contribute to second-order in the curvature only. We demonstrate this finding by considering wave propagation in a circular-sector torus corresponding to Neumann and Dirichlet boundary conditions, respectively. Results for relative eigenfrequency shifts and modes are determined and compared with three-dimensional finite element method results. Good agreement is found between the present analytical method using a combination of differential geometry with perturbation theory and finite element results for a large range of curvature ratios.

General information
State: Published
Organisations: Department of Mathematics, Geometry, University of Southern Denmark
Authors: Willatzen, M. (Intern), Pors, A. (Forskerdatabase), Gravesen, J. (Intern)
Number of pages: 16
Pages: 083507
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Mathematical Physics
Volume: 53
Issue number: 8
ISSN (Print): 0022-2488
Man-made composite materials called "metamaterials" allow for the creation of unusual wave propagation behavior. Acoustic and elastic metamaterials in particular, can pave the way for the full control of sound in realizing cloaks of invisibility, perfect lenses and much more. In this work we design acousto-elastic surface modes that are similar to surface plasmons in metals and on highly conducting surfaces perforated by holes. We combine a structure hosting these modes together with a gap material supporting negative modulus and collectively producing negative dispersion. By analytical techniques and full-wave simulations we attribute the observed behavior to the mass density and bulk modulus being simultaneously negative.
An outline for an intelligent system performing peg-in-hole actions with flexible objects

We describe the outline of an adaptable system which is able to perform grasping and peg-in-hole actions with flexible objects. The system makes use of visual tracking and shape reconstruction, physical modeling of flexible material and learning based on a kernel density approach. We show results for the different sub-modules in simulation as well as real world data. © 2011 Springer-Verlag.
Bending-induced strain and curvature effects on semiconductor nanowire electronic eigenstates

The combined influence of strain and geometry bending is analyzed quasi-analytically for nanostructures using differential geometry arguments. Appropriate general coordinates $u_1, u_2, u_3$ are chosen with $u_1$ along the nanowire centerline and $u_2, u_3$ locally spanning the nanowire cross section. This choice allows us to assume, for large aspect-ratio nanostructures, that terms proportional to $u_2, u_3$ or higher powers including combinations of $u_2, u_3$ are negligible. This assumption has been justified for nanostructures where the nanostructure radius is up to 10% of the local radius-of-curvature according to previous works. We show that the influence of bending-induced strains may lead to substantial electronic eigenstate and associated energy eigenvalue changes in the case of circular-bent nanowires (© 2011 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim)
Comparison of Atomic and Continuum Quantum-Dot Elastic Models and Implications for Optoelectronic Properties

A comparison between continuum and atomistic valence force field (VFF) strain models is presented for zincblende InGaAs/GaAs spherical quantum dots (QD), showing differences in the off-diagonal components of the strain tensor, relevant for optoelectronic properties. We also present a comparison with the continuum model between different homogeneous compositions and concentration profiles. It is shown that the biaxial strain component is different from zero inside the QD in the linear concentration case which is known to have an effect on the valence band electrons.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Barettin, D. (Ekstern), Madsen, S. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern)
Pages: 445-446
Publication date: 2011

Host publication information
Title of host publication: Physics of Semiconductors: 30th International Conference on the Physics of Semiconductors
Series: AIP Conference Proceedings
Volume: 1399
ISSN: 0094-243X
Main Research Area: Technical/natural sciences
Strain, Valence force fields, Continuum model, Optoelectronic properties
DOIs: 10.1063/1.3666445
Source: dtu
Source-ID: n::oai:DTIC-ART:isi/363206642::30707
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Comparison of continuum and atomistic methods for the analysis of InAs/GaAs quantum dots

We present a comparison of continuum k · p and atomistic empirical Tight Binding methods for the analysis of the optoelectronic properties of InAs/GaAs quantum dots.

General information
State: Published
Organisations: Department of Photonics Engineering, University of Roma ’Tor Vergata’, University of Southern Denmark
Authors: Barettin, D. (Ekstern), Pecchia, A. (Ekstern), Penazzi, G. (Ekstern), Auf der Maur, M. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern), di Carlo, A. (Ekstern)
Pages: 177-178
Publication date: 2011

Host publication information
Title of host publication: Proceedings of the 2011 11th International Conference on Numerical Simulation of Optoelectronic Devices
ISBN (Print): 978-1-61284-876-1
Control of the input efficiency of photons into solar cells with plasmonic nanoparticles

We study numerically the photon input efficiency of silicon solar cells due to gold plasmonic nanoparticles deposited on the cells. At low densities, when collective effects in light scattering by the nanoparticle ensemble are negligible, the absorption dependence increases linearly for a significant range of the solar spectrum. Collective effects lead to the input efficiency saturates, reaches its maximum and then decreases with nanoparticle density. The maximal input efficiency depends on the photon wavelength, nanoparticle shape and size, their distance to the cell, and the cell thickness, and can reach ~95% in thick solar cells. Finally, we show that aluminum nanoparticles improve the input efficiency in comparison with gold nanoparticles.
Detuned electrical dipoles metamaterial with bianisotropic response

The optical properties of a pair of gold nanorods with slightly different plasmon resonance frequencies, i.e., detuned electrical dipoles (DED), are studied in the near-infrared. Using a multipole expansion of the induced polarization current, we argue that the transmission enhancement (transparency) at the intermediate frequency is due to the suppression of the electric dipole moment in favor of a (weakly radiating) magnetic one. This suppression is found to be robust with respect to variations in geometrical parameters, but may depend on the direction of light incidence. Metamaterials consisting of DED unit cells are examined by making use of a new homogenization method based on the numerical calculation of dispersion curves of Bloch modes, an approach that we propose and exploit for retrieving the effective material parameters. We demonstrate that DED-based metamaterials feature magnetic and bianisotropic responses, implying the important property of optical activity without chirality and opening thereby a way to new promising applications.

General information

State: Published
Organisations: University of Southern Denmark
Authors: Pors, A. (Ekstern), Willatzen, M. (Intern), Albrektsen, O. (Ekstern), Bozhevolnyi, S. I. (Ekstern)
Number of pages: 8
Pages: 245409
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information

Journal: Physical Review B
Volume: 83
Issue number: 24
ISSN (Print): 1098-0121
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
Effect of strain on optical properties of bent nanowires

In this work we study the deformation of ZnO nanowires under the influence of an applied force at the top of the wire. We show that the Euler-Bernoulli beam equation can be used even for relatively high forces although a full non linear theory does show quantitative differences, however, not qualitative differences. We furthermore show that strain induces a confinement of the electrons which results in a significant increase in the conduction band energy spacing. It is known that piezoelectric effects are important in ZnO nanowire, however, these are disregarded in this work in order to wholly focus on the effect of strain.

Effects of hydrostatic strain on eigenstates of Möbius strips

In this paper we theoretically investigate the allowed energies and associate wave-functions for Möbius strips with varying thicknesses. We show that the induced strain in fabricating these Möbius strips will have an pronounced impact on the energies and wave-functions for thick strips, while for thin strips the impact of strain is negligible. We furthermore, show that a simpler strain free approximate theory base on differential geometry is in excellent agreement with detailed finite element calculations. © 2011 IEEE.
Electromechanical phenomena in semiconductor nanostructures

Electromechanical phenomena in semiconductors are still poorly studied from a fundamental and an applied science perspective, even though significant strides have been made in the last decade or so. Indeed, most current electromechanical devices are based on ferroelectric oxides. Yet, the importance of the effect in certain semiconductors is being increasingly recognized. For instance, the magnitude of the electric field in an AlN/GaN nanostructure can reach 1-10 MV/cm. In fact, the basic functioning of an (0001) AlGaN/GaN high electron mobility transistor is due to the two-dimensional electron gas formed at the material interface by the polarization fields. The goal of this review is to inform the reader of some of the recent developments in the field for nanostructures and to point out still open questions. Examples of recent work that involves the piezoelectric and pyroelectric effects in semiconductors include: the study of the optoelectronic properties of III-nitrides quantum wells and dots, the current controversy regarding the importance of the nonlinear piezoelectric effect, energy harvesting using ZnO nanowires as a piezoelectric nanogenerator, the use of piezoelectric materials in surface acoustic wave devices, and the appropriateness of various models for analyzing electromechanical effects. Piezoelectric materials such as GaN and ZnO are gaining more and more importance for energy-related applications; examples include high-brightness light-emitting diodes for white lighting, high-electron mobility transistors, and nanogenerators. Indeed, it remains to be demonstrated whether these materials could be the ideal multifunctional materials. The solutions to these and other related problems will not only lead to a better understanding of the basic physics of these materials, but will validate new characterization tools, and advance the development of new and better devices. We will restrict ourselves to nanostructures in the current article even though the measurements and calculations of the bulk electromechanical coefficients remain challenging. Much of the literature has focused on InGaN/GaN, AlGaN/GaN, ZnMgO/ZnO, and ZnCdO/ZnO quantum wells, and InAs/GaAs and AlGaN/AlN quantum dots for their optoelectronic properties; and work on the bending of nanowires have been mostly for GaN and ZnO nanowires. We hope the present review article will stimulate further research into the field of electromechanical phenomena and help in the development of applications. (C) 2011 American Institute of Physics. [doi:10.1063/1.3533402]
Experimental determination of the refractive index of metamaterials

We present a simple experimental technique based on diffraction for determining the complex refractive index of metamaterials, and demonstrate it with metamaterials that consist of detuned electrical dipoles (DEDs), mimicking the dressed-state picture of electromagnetically induced transparency (EIT). The metamaterials are realized by fabricating lithographically defined gold nanorods on a silica substrate, covered with a similar to 15 μm thick polymer layer, and feature EIT-like transmission spectra with transparency windows centered at wavelengths near similar to 800 nm. The refractive indices are determined for wavelengths where the DED metamaterials exhibit enhanced transmission. Thereby, we experimentally demonstrate normal dispersion in the transmission window and estimate the group refractive index to similar to 3.6. Furthermore, finite-element simulations are conducted on a monolayer of DED unit cells, which similarly exhibit the EIT-like behavior in terms of enhanced transmission revealed in the transmission spectra. Simulated transmission and reflection spectra are utilized for calculations of the real and imaginary parts of the metamaterial refractive index, showing consistent trends with those obtained experimentally.

General information

State: Published
Organisations: University of Southern Denmark
Authors: Nielsen, M. G. (Ekstern), Pors, A. (Ekstern), Albrektsen, O. (Ekstern), Willatzen, M. (Intern), Bozhevolnyi, S. I. (Ekstern)
Number of pages: 7
Finite Element Simulation of Photoacoustic Pressure in a Resonant Photoacoustic Cell Using Lossy Boundary Conditions

The finite-element method (FEM) is used to simulate the photoacoustic signal in a cylindrical resonant photoacoustic cell. Simulations include loss effects near the cell walls that appear in the boundary conditions for the inhomogeneous Helmholtz equation governing the acoustic pressure. Reasonably good agreement is obtained between theoretical results and experimental data. However, it was anticipated that loss mechanisms other than viscous and thermal boundary losses occur and should be included. Nevertheless, the feasibility to use FEM together with the derived boundary conditions to simulate the photoacoustic signal was demonstrated and good agreement with experiments for the actual resonance frequency and the quality factor of the cell was obtained despite its complicated geometry.

General information
State: Published
Organisations: University of Southern Denmark, PAJ Systemteknik
Authors: Duggen, L. (Ekstern), Lopes, N. (Ekstern), Willatzen, M. (Intern), Rubahn, H. (Ekstern)
Pages: 774-785
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Thermophysics
Volume: 32
Issue number: 4
ISSN (Print): 0195-928x
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.332 SNIP 0.65 CiteScore 0.83
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.39 SNIP 0.979 CiteScore 0.9
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.466 SNIP 1.104 CiteScore 1.02
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.401 SNIP 1.311 CiteScore 1.13
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.371 SNIP 0.752 CiteScore 0.77
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.532 SNIP 1.112 CiteScore 1.08
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.455 SNIP 0.798
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.459 SNIP 0.849
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.563 SNIP 0.92
Möbius semiconductor nanostructures and deformation potential strain effects
A discussion of Möbius nanostructures is presented with focus on (1) the accuracy of the approximate differential-geometry formalism by Gravesen and Willatzen and (2) to assess the influence of bending-induced strain on Schrödinger equation eigenstates in semiconductor Möbius structures. The differential-geometry model assumed complete confinement of a quantum-mechanical particle to a zero-thickness Möbius structure where the shape was computed based on minimization of elastic bending energy only and imposing the relevant boundary conditions. In the latter work, while bending was accounted for in finding the shape of the Möbius structure it was, for simplicity, neglected altogether in determining the direct strain influence on electronic eigenstates. However, as is well-known, deformation-potential strain effects in many semiconductor materials can lead to important changes in not only the energy levels but, perhaps more so, the symmetry of the associated eigenstates and, henceforth, optical and electronic properties. In this, work we investigate finite-thickness effects of different-sized Möbius structures as well as deformation-potential hydrostatic strain implications using the Finite Element Model commercial software COMSOL. The paper contains a detailed comparison of general Finite Element Model results with the differential-geometry method. Copyright © 2011 American Scientific Publishers All rights reserved.
Optical transparency by detuned electrical dipoles

We demonstrate that optical transparency can be realized with plasmonic metamaterials using unit cells consisting of detuned electrical dipoles (DED), thereby mimicking the dressed-state picture of the electromagnetically induced transparency (EIT) in atomic physics. Theoretically analyzing the DED cells with two and three different silver ellipsoids, we show the possibility of reaching a ≥10 times decrease in group velocity and a propagation loss of ≤1 dB per cell within the optical wavelength range of 625–640 nm. Similar configurations are realized with lithographically fabricated gold nanorods placed on a glass substrate and subsequently covered with a ~15-μm-thick polymer layer, featuring EIT-like transmission spectra with transparency windows at wavelengths of ~850 nm.
Plasmonic metamaterial wave retarders in reflection by orthogonally oriented detuned electrical dipoles

We demonstrate that a pair of perpendicular electrical dipolar scatterers resonating at different frequencies can be used as a metamaterial unit cell to construct a nanometer-thin retarder in reflection, designing nanocross and nanobrick plasmonic configurations to function as reflecting quarter-wave plates at $\sim$1520 and 770nm, respectively. The design is corroborated experimentally with a monolayer of gold nanobricks, transforming linearly polarized incident radiation into circularly polarized radiation at $\sim$780nm.

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General information
State: Published
Organisations: University of Southern Denmark, Politecnico di Milano
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Pages: 1626-1628
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Optics Letters
Volume: 36
Issue number: 9
ISSN (Print): 0146-9592
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.864 SNIP 1.658
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.142 SNIP 1.642 CiteScore 3.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.497 SNIP 2.056 CiteScore 3.86
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.458 SNIP 2.095 CiteScore 3.95
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.596 SNIP 1.95 CiteScore 3.52
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.518 SNIP 2.475 CiteScore 3.69
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.669 SNIP 2.293
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 3.167 SNIP 2.665
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 3.408 SNIP 2.378
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.489 SNIP 2.102
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.143 SNIP 2.334
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.251 SNIP 2.483
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.521 SNIP 2.718
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.708 SNIP 2.573
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 3.702 SNIP 2.39
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.62 SNIP 2.244
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 3.416 SNIP 1.705
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 4.044 SNIP 1.699
Original language: English
Metamaterials, Monolayers, Plasmons
DOIs:
10.1364/OL.36.001626
Scattering suppression and field enhancement of the fundamental plasmonic mode in bent nanorods

We study the absorption and scattering cross sections of three-dimensional retardation-based plasmonic resonators as straight gold nanorod antennas are transformed gradually to split-ring resonators. Using a multipole expansion of the scattered field, we show by bending the nanoantennas that it is possible at the fundamental resonance to suppress the scattering due to a decrease in the electric dipole response in favor of a magnetic dipole response. The decrease in scattering strength is accompanied by an increase in the Q-factor which in the split-ring resonator limit is improved by a factor of ~1.9 (equivalent to ~1.2 times larger than the quasi-static value). Additionally, the split-ring resonator shows promising prospects in surface enhanced sensing applications with local field enhancement of ≥50 in the split-ring gap.

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General information
State: Published
Organisations: University of Southern Denmark
Authors: Pors, A. (Ekstern), Willatzen, M. (Intern), Albrektsen, O. (Ekstern), Bozhevolnyi, S. I. (Ekstern)
Pages: 1619-1624
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Computational and Theoretical Nanoscience
Volume: 8
Issue number: 8
ISSN (Print): 1546-1955
Ratings:
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.23 SNIP 0.433 CiteScore 0.88
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.302 SNIP 1.048 CiteScore 1.72
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.324 SNIP 0.773 CiteScore 1.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.384 SNIP 0.606 CiteScore 0.96
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.359 SNIP 0.404 CiteScore 0.67
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.401 SNIP 0.482 CiteScore 0.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.417 SNIP 0.43
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.463 SNIP 0.497
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.484 SNIP 0.552
Scopus rating (2007): SJR 0.453 SNIP 0.472
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.398 SNIP 0.448
Scopus rating (2005): SJR 0.431 SNIP 0.502
Original language: English
Antennas, Bandpass filters, Nanorods, Plasmons, Quantum optics, Ring gages, Scattering
DOIs:
10.1166/jctn.2011.1856
**Strain and piezoelectric effects in quantum-dot structures**

A discussion of computational methods for calculating strain and piezoelectric fields in nanostructures is presented. Emphasis is on a comparison of continuum and valence force field atomistic models and the validity of the former in predicting, accurately, strain fields for nanostructures with dimensions down to a few nm. This is done on the experimentally relevant InAs/InGaAs quantum-dot wetting layer structures and on spherical quantum dot structures. We next address the influence of boundary conditions imposed at the computational domain for strain fields near and inside the quantum dot; a point largely missing in literature. Boundary conditions discussed include fixed, free, fixed-free, and periodic, and it is shown that the particular choice of boundary conditions is unimportant for the strain results; a conclusion that allows to choose the computationally most effective one being the fixed-free boundary conditions as it requires the smallest computational domain for obtaining convergent results. While this result is fortunate, it is not obvious from a mathematical point of view. A further important, and a priori not obvious conclusion, is that a continuum model captures well atomistic strain results; a fact that allows us to use a continuum formulation even in cases where structure dimensions are down to only a few lattice constants. In realistically grown structures, inhomogeneous concentration profiling exists. We present investigations for strain and piezoelectric results in the case where a spherical quantum dot region is gradually profiled from GaAs to InAs assuming the concentration is a function of the distance to the quantum dot sphere center. It is shown that quantum dot concentration profiling affects strain fields and biaxial strains in particular, electronic states and hence optical properties. We finally present some effective quasi-analytical studies of electronic states and strain fields in curved quantum dots based on applications of differential geometry and perturbation theory.

**Analysis of optical properties of strained semiconductor quantum dots for electromagnetically induced transparency**

Using multiband k*p theory we study the size and geometry dependence on the slow light properties of conical semiconductor quantum dots. We find the V-type scheme for electromagnetically induced transparency (EIT) to be most favorable, and identify an optimal height and size for efficient EIT operation. In case of the ladder scheme, the existence of additional dipole allowed intraband transitions along with an almost equidistant energy level spacing adds additional decay pathways, which significantly impairs the EIT effect. We further study the influence of strain and band mixing comparing four different k*p band structure models. In addition to the separation of the heavy and light holes due to the biaxial strain component, we observe a general reduction in the transition strengths due to energy crossings in the valence bands caused by strain and band mixing effects. We furthermore find a non-trivial quantum dot size dependence of the dipole moments directly related to the biaxial strain component. Due to the separation of the heavy and light holes the optical transition strengths between the lower conduction and upper most valence-band states computed using one-band model and eight-band model show general qualitative agreement, with exceptions relevant for EIT operation.
Analytic theory of curvature effects for wave problems with general boundary conditions

A formalism based on a combination of differential geometry and perturbation theory is used to obtain analytic expressions for confined eigenmode changes due to general curvature effects. In cases of circular-shaped and helix-shaped structures, where alternative analytic solutions can be found, the perturbative solution is shown to yield the same result. The present technique allows the generalization of earlier results to arbitrary boundary conditions. The power of the method is illustrated using examples based on Maxwell’s and Schrödinger’s equations for applications in photonics and nanoelectronics.
We analyze for the first time the coupled influence of band mixing, strain, and piezoelectricity on electronic structure, eigenstates, and optical transition strengths for InAs/GaAs quantum-ring structures. It is shown that band mixing and strain alter the level energies and optical absorption coefficients significantly.

Band-mixing and strain effects in InAs/GaAs quantum rings
We analyze for the first time the coupled influence of band mixing, strain, and piezoelectricity on electronic structure, eigenstates, and optical transition strengths for InAs/GaAs quantum-ring structures. It is shown that band mixing and strain alter the level energies and optical absorption coefficients significantly.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Lassen, B. (Ekstern), Willatzen, M. (Intern), Barettin, D. (Ekstern)
Pages: 103-107
Publication date: 2010
Conference: 9th International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN 2009), Lecce, Italy, 01/01/2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Superlattices and Microstructures
Volume: 47
Issue number: 1
ISSN (Print): 0749-6036
Calibration of Field II using a Convex Ultrasound Transducer

Field II is an ultrasound simulation program capable of simulating the pressure scattering from inhomogeneous tissue. The simulations are based on a convolution between spatial impulse responses from the field in front of the transducer and the volt-to-surface acceleration impulse response of the transducer. For such simulations to reflect actual measured intensities and pressure levels, the transducer impulse response is to be known. This work presents the results of combining a modified form of a 1D linear transducer model originally suggested by Willatzen with the Field II program to calibrate the pressure simulations of a 128 element convex medical transducer with elevation focus at 70mm. The simulations are compared to pressure measurements from an automatic water bath needle hydrophone setup. The transducer was driven at 4.0 MHz using a research scanner with a commercial transducer amplifier from BK-Medical (Herlev, Denmark). As input waveform for the Field model we measured the output voltage of the research amplifier, which peak voltage was limited to 31 V to avoid too high non linear effects. We measured the hydrophone output from three transducer front elements by
averaging 40 shoot sequences on each element using a remotely controlled Agilent MSO6014A oscilloscope. The pressure along the elevation line in 32 mm, 70 mm (elevation focus) and 112 mm for each element are measured.

**Comparison of wurtzite atomistic and piezoelectric continuum strain models: Implications for the electronic band structure**

We compare continuum and atomistic models for the electromechanical fields in wurtzite GaN/AlN quantum dots and their relative impact on the electronic band structure. Qualitative agreement between atomistic strain calculations and continuum elastic models for a wurtzite hexagonal quantum-dot structure is demonstrated; however, significant quantitative discrepancies of up to 100 meV are observed. A smaller difference of approximately 15 meV is found between fully coupled and semi-coupled continuum models.
Crystal orientation effects on wurtzite quantum well electromechanical fields

A one-dimensional continuum model for calculating strain and electric field in wurtzite semiconductor heterostructures with arbitrary crystal orientation is presented and applied to GaN/AlGaN and ZnO/MgZnO heterostructure combinations. The model is self-consistent involving feedback couplings of spontaneous polarization, strain, and electric field. Significant differences between fully coupled and semicoupled models are found for the longitudinal and shear-strain components as a function of the crystal-growth direction. In particular, we find that the semicoupled model, typically used in the literature for semiconductors, is inaccurate for ZnO/MgZnO heterostructures where shear-strain components play an important role. An interesting observation is that a growth direction apart from [1210] exists for which the electric field in the quantum well region becomes zero. This is important for, e.g., optimization of light-emitting-diode quantum efficiency.
Cylindrical symmetry and spurious solutions in eight band k·p theory

Spurious solutions in eight band k·p theory for low-dimensional semiconductor heterostructures is a well-known problem. In this paper we study two approaches for the removal of spurious solutions, the plane wave cutoff approach [1] and the approach suggested by Foreman [2] where the Kane parameter is changed. We show that in order to use the plane wave
cutoff approach for a cylindrical symmetric system Bessel functions has to be used as the expansion basis in the radial direction. Furthermore we compare the two approaches for a InAs/GaAs conical quantum dot.

Detuned Electrical Dipoles for Plasmonic Sensing
We demonstrate that a pair of electrical dipolar scatterers resonating at different frequencies, i.e., detuned electrical dipoles, can be advantageously employed for plasmonic sensing of the environment, both as an individual subwavelength-sized sensor and as a unit cell of a periodic array. It is shown that the usage of the ratio between the powers of light scattered into opposite directions (or into different diffraction orders), which peaks at the intermediate frequency, allows one to reach a sensitivity of ≈400 nm/RIU with record high levels of figure of merit exceeding 200. Qualitative considerations are supported with detailed simulations and proof-of-principle experiments using lithographically fabricated gold nanorods with resonances at ∼800 nm.
Dynamic Electro-Mechanical Modelling of Dielectric EAP

In this paper a nonlinear electromechanical model for a dielectric electro-active polymer (DEAP) actuator is proposed based on an electric-circuit model coupled with a viscoelastic mechanical model. The parameters of the model are found by fitting to a creep test for the mechanical part and by standard methods for the electric circuit. The resulting model is compared with experiments for a sinusoidal and a sweep stimulus. The comparison shows a good agreement between experiments and model results.

General information

State: Published
Organisations: Danfoss PolyPower A/S, University of Southern Denmark
Authors: Sarban, R. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern), Jones, R. W. (Ekstern)
Pages: 465-468
Publication date: 2010
Electron conductance in curved quantum structures

A differential-geometry analysis is employed to investigate the transmission of electrons through a curved quantum-wire structure. Although the problem is a three-dimensional spatial problem, the Schrodinger equation can be separated into three general coordinates. Hence, the proposed method is computationally fast and provides direct (geometrical) parameter insight as regards the determination of the electron transmission coefficient. We present, as a case study, calculations of the electron conductivity of a helically shaped quantum-wire structure and discuss the influence of the quantum-wire centerline radius of curvature and pitch length for the conductivity versus the chemical potential.

General information
State: Published
Organisations: Geometry, Department of Mathematics
Authors: Willatzen, M. (Intern), Gravesen, J. (Intern)
Pages: 202-206
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Superlattices and Microstructures
Volume: 47
Issue number: 1
ISSN (Print): 0749-6036
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.583 SNIP 0.994 CiteScore 2.09
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.583 SNIP 1.007 CiteScore 2.21
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.62 SNIP 1.032 CiteScore 2.18
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.66 SNIP 1.006 CiteScore 2.19
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.59 SNIP 0.833 CiteScore 1.59
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.707 SNIP 0.836 CiteScore 1.47
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.717 SNIP 0.642
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.665 SNIP 0.67
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.926 SNIP 0.852
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.983 SNIP 0.865
Scopus rating (2006): SJR 0.869 SNIP 0.736
Scopus rating (2005): SJR 0.581 SNIP 0.455
Scopus rating (2004): SJR 0.473 SNIP 0.304
Scopus rating (2003): SJR 0.743 SNIP 0.521
Scopus rating (2002): SJR 0.698 SNIP 0.501
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.603 SNIP 0.374
Scopus rating (2000): SJR 0.498 SNIP 0.273
Electrostriction Coefficients of GaN, AlN, MgO and ZnO in the Wurtzite Structure from First-Principles

First-principles calculations have been performed on wurtzite AlN, GaN, MgO and ZnO, with a view to obtaining electrostriction coefficients.

Extension of the Landau theory for hysteretic electric dynamics in ferroelectric ceramics

In this paper, a macroscopic differential model for the nonlinear dynamics of the electric field in ferroelectric ceramics is developed on the basis of polarization switching theory. In a one-dimensional description, dynamics with hysteresis caused by polarization switching is modelled by using the Landau theory of phase transitions for single-crystal cases. For ferroelectric ceramics, the orientation of the principal axis of grains is assumed to have a certain distribution. The overall dynamics is determined by making a weighted combination of the dynamics of each grain. The weight function for the combination is taken phenomenologically based on experimental observations. It is shown that experimental hysteresis can be reproduced by the macroscopic differential model precisely.
FEM analysis of cylindrical resonant photoacoustic cells

Using a mathematical model on photoacoustics that includes both temperature and pressure effects explicitly, we analyze the behaviour of resonances of a cylindrical photoacoustic cell consisting of two buffer volumes and a resonator. We excite the cell at a certain frequency and find the ratio of resonator versus buffer diameter needed to obtain resonance. The results show that the resonance ratio depends on the absolute cell size. Also the amplitude of the acoustic signal measured in the middle of the resonator does not necessarily decrease when the total cell volume is increased. If the resonator diameter is sufficiently small, decreasing its diameter will increase the acoustic signal, although the total cell volume has to be increased to obtain resonance. This gives the advantage of being able to obtain a comparably large signal and at the same time use large buffer diameters to suppress window absorption signals. Finally we also compare the quality of the above-mentioned model and the lossy Helmholtz equation. We find that there is a shift in resonance ratio and the signal damping differs slightly. Albeit these differences are not large, and in many cases negligible, the model can be easily coupled with a solid absorption model in order to investigate the importance of thermal and pressure coupling between two acoustic media subject to heat absorption.
From plasmonic nanoantennas to split-ring resonators: Tuning scattering strength
Evolution of the absorption and scattering cross sections, quality-factor (Q-factor), and field enhancement of three-dimensional retardation-based plasmonic resonators being transformed from straight gold nanorod antennas to split-ring resonators by bending is considered. The optical resonances are confirmed to be of plasmonic origin and are specifically shown to be related to the formation of standing waves of short-range surface plasmon polaritons supported by straight and bent nanorods. We verify that by bending nanoantennas it is possible to reduce and ultimately, in the split-ring resonator limit, practically eliminate their scattering at the fundamental resonance, resulting in a substantial increase in the corresponding Q-factors. The decrease in scattering by bending is connected with the attenuation of the electric-dipole response in favor of a magnetic-dipole one, leading to Q-factors exceeding the quasi-static limit by a factor of ~1.7. Simultaneously, the structures exhibit local field enhancements of >50.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Pors, A. (Ekstern), Willatzen, M. (Intern), Albrektsen, O. (Ekstern), Bozhevolnyi, S. I. (Ekstern)
Pages: 1680-1687
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of the Optical Society of America B (Optical Physics)
Volume: 27
Issue number: 8
ISSN (Print): 0740-3224
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.894 SNIP 1.015
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.023 SNIP 1.002 CiteScore 1.78
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.188 SNIP 1.156 CiteScore 2.09
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.354 SNIP 1.281 CiteScore 2.33
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.517 SNIP 1.273 CiteScore 2.2
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.527 SNIP 1.495 CiteScore 2.33
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.47 SNIP 1.356
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.763 SNIP 1.59
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.645 SNIP 1.33
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.737 SNIP 1.29
Web of Science (2007): Indexed yes
Investigating the effect of magnetic pipes connected to electromagnetic flowmeters using experimentally validated finite element models

This paper describes a finite element model for computing the magnetic field distribution in commercial electromagnetic flowmeter designs. The model is validated through an experimental setup, measuring the magnetic flux density in the radial direction at the inner perimeter of the flowmeter wall. The predicted flux densities are in overall good agreement with experimental obtained data. The model is used to evaluate the effect of having magnetic pipes connected to flowmeters of two different designs. Using analytic models, the flowmeter sensitivity is computed both with magnetic and non-magnetic pipes connected.

General information
State: Published
Organisations: Siemens Flow Instruments, University of Southern Denmark
Authors: Christensen, T. A. (Ekstern), Willatzen, M. (Intern)
Pages: 62-69
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Flow Measurement and Instrumentation
Volume: 21
Issue number: 1
ISSN (Print): 0955-5986
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.45 SJR 0.53 SNIP 1.355
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.533 SNIP 1.642 CiteScore 1.67
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.51 SNIP 1.647 CiteScore 1.52
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.567 SNIP 1.927 CiteScore 1.6
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.491 SNIP 1.697 CiteScore 1.35
Investigations of scattering and field enhancement effects in retardation-based plasmonic nanoantennas

Modifications in scattering strength of and local field enhancement by retardation-based plasmonic nanoantennas when being transformed from straight nanorods to split-rings are investigated. The scattering properties are monitored by linear reflection and extinction spectroscopy whereas local field enhancement is estimated from measurements on individual nanoantennas by nonlinear scanning optical microscopy in which two-photon-excited photoluminescence (TPL) is detected. The linear and nonlinear optical characterizations reveal, that the optical response of nanoantennas is dominated by constructively interfering short-range surface plasmon polaritons (SR-SPP) and that the transformation of straight nanorods into split-rings by bending significantly influences the scattering strength. Importantly, strong suppression of scattering for the fundamental SR-SPP mode is observed when the bend radius is decreased, a feature that we attribute to the decrease in the nanoantenna electric-dipole response in tact with its bending. The experimental observations are corroborated with numerical simulations using the finite-element method.
Modeling transducer impulse responses for predicting calibrated pressure pulses with the ultrasound simulation program FIELD II

FIELD II is a simulation software capable of predicting the field pressure in front of transducers having any complicated geometry. A calibrated prediction with this program is, however, dependent on an exact voltage-to-surface acceleration impulse response of the transducer. Such impulse response is not calculated by FIELD II. This work investigates the usability of combining a one-dimensional multilayer transducer modeling principle with the FIELD II software. Multilayer here refers to a transducer composed of several material layers. Measurements of pressure and current from Pz27 piezoceramic disks as well as pressure and intensity measurements in front of a 128 element commercial convex medical transducer are compared to the simulations. Results show that the models can predict the pressure from the piezoceramic disks with a root mean square (rms) error of 11.2% to 36.2% with a 2 dB amplitude decrease. The current through the external driving circuits are predicted within 8.6% to 36% rms error. Prediction errors of 30% and in the range of 5.8%-19.9% for the pressure and the intensity, respectively, are found when simulating the commercial transducer. It is concluded that the multilayer transducer model and the FIELD II software in combination give good agreement with measurements.

General information
State: Published
Organisations: Biomedical Engineering, Department of Electrical Engineering, Center for Fast Ultrasound Imaging
Authors: Bæk, D. (Intern), Jensen, J. A. (Intern), Willatzen, M. (Intern)
Pages: 2825-2835
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Volume: 127
Issue number: 5
ISSN (Print): 0001-4966
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.83 SJR 0.749 SNIP 1.27
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.802 SNIP 1.437 CiteScore 1.77
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 0.788 SNIP 1.423 CiteScore 1.8
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.705 SNIP 1.966 CiteScore 2
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 0.763 SNIP 1.622 CiteScore 1.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 0.695 SNIP 1.642 CiteScore 1.68
ISI indexed (2011): ISI indexed yes
Photoacoustics in a Cylindrical Resonator Containing a Flowing Gas

A detailed study of photoacoustics in circular resonators and waveguides in the presence of a gas flow is presented based on the Green's function method. In the first part of the paper, a wave equation is derived describing sound propagation in a flowing (perfect) gas due to a localized heating source. Analytical results are obtained for the acoustic pressure in the case of a constant gas flow subject to different boundary conditions. In the second part of the paper, the derived wave equation is solved for a parabolic flow profile using the finite-element method and results are compared with the constant-flow case. It is demonstrated that the gas-flow profile does not change the pattern of acoustic resonance frequencies significantly. In particular, it is noted that the presence of flow gives rise to new peaks, and we show that non-linearities with respect to the mean flow velocity appear already at 1% of the speed of sound at certain frequencies.
Simulating Capacitive Micromachined Ultrasonic Transducers (CMUTs) using Field II

Field II has been a recognized simulation tool for piezoceramic medical transducer arrays for more than a decade. The program has its strength in doing fast computations of the spatial impulse response (SIR) from array elements by dividing the elements into smaller mathematical elements (MEs) from which it calculates the SIR responses. The program features predefined models for classical transducer geometries, but currently none for the fast advancing CMUTs. This work addresses the assumptions required for modeling CMUTs with Field II. It is shown that rectangular array elements, populated with cells, can be well approximated by neglecting the cells. Further, it is demonstrated that scaling of the SIR translates into better computational efficiency.

Testing of a spatial impulse response algorithm for double curved transducers

The spatial impulse response (SIR) method for solving the Rayleigh integral is a well known method for fast time response simulation of acoustic waves. Several analytical expressions have been found for simple transducer geometries such as rectangles and discs. However, no analytical solution is known for double curved transducers (DCT), i.e. transducers with both concave and convex radius. To calculate the SIR from such transducers Field II uses a far-field approximation by dividing the surface into smaller flat elements and then performs a summation of the response from all the elements using Huygen’s principle. This calculation method involves several summations, and it relies on exact phase calculation to avoid numerical noise in the response. A stable analytical expression for the SIR would thus be beneficial to the Field II software as an alternative solver. A semi-analytic algorithm (SAA) has been developed, and it is the objective of this work to validate an analytical approximation of the algorithm as an alternative solver for Field II. Two approximations of a SAA that efficiently finds the SIR for DCT have been implemented into a MATLAB and a C-code environment. The root mean square (RMS) error of calculating the SIR using Field II and the C-implemented approximation are calculated relative to a high resolution solution obtained with MATLAB on a DCT, a linear concave, and a flat transducer. The computation time for solving a point 400 times is also found. Calculations are performed at sampling frequencies ranging from 100 MHz to 15 GHz in steps of 100 MHz. The transducer width is 250 μm and the height is 10 mm. The C-implementation exhibits errors ranging from 4.9 – 10^-4 % to 0.91 % and Field II 0.0117 % to 0.94 %. A slight trade off between accuracy and computation time is found. Field II outperforms the SAA in computation time if high accuracy is not needed. However, if a higher accuracy is required, the SAA is the best model choice. © 2010 IEEE.
Curved nanowire structures and exciton binding energies

Growth of quantum-confined semiconductor structures is a complicated process that may lead to imperfect and complex shapes as well as geometrical nonuniformities when comparing a large number of intended identical structures. On the other hand, the possibility of tuning the shape and size of nanostructures allows for extra optimization degrees when considering electronic and optical properties in various applications. This calls for a better understanding of size and shape effects. In the present work, we express the one-band Schrödinger equation in curved coordinates convenient for determining eigenstates of curved quantum-wire and quantum-dash structures with large aspect ratios. Firstly, we use this formulation to solve the problem of single-electron and single-hole states in curved nanowires. Secondly, exciton states for the curved quantum-wire Hamiltonian problem are found by expanding exciton eigenstates on a product of single-particle eigenstates. A simple result is found for the Coulomb matrix elements of an arbitrarily curved structure as long as the radius-of-curvature is much larger than the cross-sectional dimensions. We use this general result to compute the groundstate exciton binding energy of a bent nanowire as a function of the bending radius-of-curvature. It is demonstrated that the groundstate exciton binding energy increases by 40 meV as the radius-of-curvature changes from 20 to 2 nm while keeping the total length (and volume) of the nanowire constant.
Effective computation of complex-shaped quantum-dot structures

The possibility of growing complex-shaped nanodot structures of various material composition allows optimization of certain physical parameters. In the present work, we present effective analytical methods for computing conduction-band eigenstates in quantum-dot structures of complex shape. Comparison with detailed finite-element computations is made. The electronic bandstructure model used is a one-band $\vec{k}\cdot\vec{p}$ model assuming infinite barriers. Results based on two semi-analytical models are presented. The first model employs geometrical perturbation theory to obtain the quantitative effect of quantum-dot surface perturbations on electron energy levels. Furthermore, the method output includes the level of degeneracy and variations with geometry to be assessed. The second model allows both energy levels and eigenstates to be easily determined for three-dimensional axisymmetrical GaAs structures of varying radius embedded in an AlGaAs matrix by extending a method originally due to Stevenson on electromagnetic waveguide structures (Stevenson in J. Appl. Phys. 22:1447, 1951) to account for electron states. The latter model simplifies the description of a three-dimensional partial-differential equation problem into a small set of ordinary differential equations.
For structures with a large aspect ratio, the small set reduces to a single ordinary differential equation yet maintaining high accuracy. A case study is presented to exemplify the models shown.

**General information**

State: Published  
Organisations: University of Southern Denmark  
Authors: Lassen, B. (Ekstern), Willatzen, M. (Intern)  
Pages: 609-613  
Publication date: 2009  
Main Research Area: Technical/natural sciences

**Publication information**

Volume: 96  
Issue number: 3  
ISSN (Print): 0947-8396  
Ratings:  
BFI (2017): BFI-level 1  
Web of Science (2017): Indexed Yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): SJR 0.101 SNIP 0.12 CiteScore 1.52  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 0.1 SNIP 0 CiteScore 1.38  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 0.113 SNIP 0.002 CiteScore 1.74  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.1 SNIP 0 CiteScore 1.75  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 0.1 SNIP 0 CiteScore 1.71  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): SJR 0.866 SNIP 1.129 CiteScore 1.77  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 1.064 SNIP 1.029  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 1.016 SNIP 0.996  
Web of Science (2009): Indexed yes  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 1.204 SNIP 1.065  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.223 SNIP 1.08  
Web of Science (2007): Indexed yes  
Scopus rating (2006): SJR 1.286 SNIP 1.065  
Web of Science (2006): Indexed yes  
Scopus rating (2005): SJR 1.102 SNIP 0.934  
Web of Science (2005): Indexed yes  
Scopus rating (2004): SJR 1.101 SNIP 1.111
Electromagnetic-wave propagation along curved surfaces

We show that Maxwell's equations for a nonmagnetic, isotropic, but electrically inhomogeneous medium in the absence of charges or current sources lead to a wave equation governing surface electromagnetic wave propagation along a general curved, smooth surface which, when recasted using an appropriate choice of curvilinear coordinates $u_1, u_2, u_3$, can be fully separated in the spatial dimensions. It is shown that surface electromagnetic wave solutions decay exponentially away from the surface (along the $u_3$ coordinate) with the same decay rate independent of the shape of the surface. Transmission and reflection coefficients governing scattering of electromagnetic waves on a varying surface shape are derived. Two test cases of a Gaussian-shaped and a sinusoidal-shaped surface are solved in details and discussed numerically in terms of transmission and reflection coefficients including dependencies on surface-shape parameters in the wavelength range 250-750 nm. The present method for determining surface electromagnetic wave propagation along complex-shaped metal-dielectric surfaces allows better insight into the importance of surface geometry as well as considerably faster computational speeds than those provided by standard numerical methods.
Exciton states in three-dimensional ring structures: A differential-geometric analysis
An effective method for computing excitonic shifts in curved quantum-wire geometries is presented. As a case example, we consider a GaAs quantum ring with infinite barriers along the cross-sectional dimensions assumed to be of square shape albeit this assumption can be easily avoided. A simple analytic expression for excitonic shifts is found using first-order perturbation theory.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Willatzen, M. (Intern), Lassen, B. (Ekstern)
Pages: 315-316
Publication date: 2009

Host publication information
Title of host publication: Physics of Semiconductors
ISBN (Print): 978-0-7354-0736-7

Series: AIP Conference Proceedings
Modelling of nonlinear dynamics for reciprocal multi-layer piezoceramic transducer systems

The dynamics of multi-layer transducer systems are modelled and simulated by use of a multi-domain spectral method. The model accounts for a nonlinear constitutive relation between the electric displacement and the electric field. Simulation of resonance and wave propagation in the transducer is implemented using a domain-decomposition method and governing equations in each layer are discretized using a Chebyshev collocation method. The model is applied to a reciprocal transducer system, as used in many engineering applications including ultrasonic flowmeter applications and blood-velocity measurement setups, where the transducer consists of a PZT5 piezoceramic layer and a matching layer.

General information
State: Published
Organisations: Hangzhou Dianzi University, University of Southern Denmark
Authors: Wang, L. (Ekstern), Willatzen, M. (Intern)
Pages: 2263-2273
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Applied Mathematical Modelling
Volume: 33
Issue number: 5
ISSN (Print): 0307-904X
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.03 SJR 1.145 SNIP 1.748
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.212 SNIP 1.697 CiteScore 2.67
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.179 SNIP 1.923 CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.096 SNIP 1.985 CiteScore 2.73
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.919 SNIP 1.856 CiteScore 2.22
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.871 SNIP 1.549 CiteScore 2.06
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.741 SNIP 1.51
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.622 SNIP 1.498
Web of Science (2009): Indexed yes
Using multiband k center dot p theory we study the size and geometry dependence on the slow light properties of conical semiconductor quantum dots. We find the V-type scheme for electromagnetically induced transparency (EIT) to be most favorable and identify an optimal height and size for efficient EIT operation. In case of the ladder scheme, the existence of additional dipole allowed intraband transitions along with an almost equidistant energy-level spacing adds additional decay pathways, which significantly impairs the EIT effect. We further study the influence of strain and band mixing comparing four different k center dot p band-structure models. In addition to the separation of the heavy and light holes due to the biaxial-strain component, we observe a general reduction in the transition strengths due to energy crossings in the valence bands caused by strain and band-mixing effects. We furthermore find a nontrivial quantum dot size dependence of the dipole moments directly related to the biaxial-strain component. Due to the separation of the heavy and light holes the optical transition strengths between the lower conduction and upper most valence-band states computed using one-band model and eight-band model show general qualitative agreement, with exceptions relevant for EIT operation.
Gallium arsenide, III-V semiconductors, Indium compounds, k, p calculations, Optimisation, Semiconductor quantum dots, Transparency, Valence bands

Electronic versions:
Houmark.pdf

DOIs:
10.1103/PhysRevB.80.235304

Links:

Bibliographical note
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Parameter sensitivity study of a Field II multilayer transducer model on a convex transducer

A multilayer transducer model for predicting a transducer impulse response has in earlier works been developed and combined with the Field II software. This development was tested on current, voltage, and intensity measurements on piezoceramics discs (Bæk et al. IUS 2008) and a convex 128 element ultrasound imaging transducer (Bæk et al. ICU 2009). The model benefits from its 1D simplicity and has shown to give an amplitude error around 1.7-2 dB. However, any prediction of amplitude, phase, and attenuation of pulses relies on the accuracy of manufacturer supplied material characteristics, which may be inaccurate estimates. The previous test cases have assumed the simulation parameters to be exact as received from the manufacturer. In this paper the influence of a deviation in the accuracy of the different parameters is studied by comparing simulation and measurement. The long term objective is a quantitative calibrated model for a complete ultrasound system. This includes a sensitivity study as presented here.

Statement of Contribution/Methods

The study alters 35 different model parameters which describe a 128 element convex transducer from BK Medical Aps. The changes are within ±20 % of the values supplied by the manufacturer, which are considered the zero reference (ZR). Simulations of a system consisting of a transmit unit, a five material layer transducer, and the FIELD II predicted pressure are performed by altering in turn the value of a single parameter in steps of 2 %. The remaining simulation parameters are held fixed at the ZR. The influence of the parameter change is determined by calculating the pressure and the intensity at a distance of 112 mm on an element’s center axis and comparing it with hydrophone measurements. These are performed with a water bath hydrophone setup using an Agilent MSO6014A oscilloscope that is set to average consecutive pulses 48 times for noise reduction of the hydrophone output. A commercial transmitter unit is used to drive the transducer with a 10 cycle tone burst at a frequency of 4.0 MHz and a maximum excitation amplitude of 31 volt.

Results

Predictions using the ZR give a pressure pulse error (PPE) and an intensity error (IE) of 32 % and 23 %, respectively, relative to the measured. Altering the piezoelectric permittivity +12 % from ZR decreases the PPE to 30 % and the IE to 2 % relative to the measured. Changing the stiffness constant of the lens -4 % from ZR increases the PPE and the IE with 6 % and 1 %, respectively. Performing the same with the ceramic stiffness the PPE is lowered 1.5 % and the IE is lowered 12 %. Discussion and Conclusions

PPEs are found mainly to be sensitive to lens properties and piezoceramic properties, but minor sensitive to changes in matching layers. IEs are mainly sensitive to the piezoceramic properties. The study shows that minor changes can improve predictions significantly.

General information

State: Published
Organisations: Biomedical Engineering, Department of Electrical Engineering, Center for Fast Ultrasound Imaging
Authors: Bæk, D. (Intern), Jensen, J. A. (Intern), Willatzen, M. (Intern)
Number of pages: 4
Publication date: 2009

Host publication information

Title of host publication: 2009 IEEE International Ultrasonics Symposium (IUS)
Publisher: IEEE
ISBN (Electronic): 978-1-4244-4390-1
Main Research Area: Technical/natural sciences
Transducer modeling, Field II, Sensitivity study, piezo

Electronic versions:
Baek 2009.pdf

DOI:
10.1109/ULTSYM.2009.5441669

Links:
http://ewh.ieee.org/conf/ius_2009/

Bibliographical note

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Source: orbit
Source-ID: 247993
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Spurious Solutions in the Multiband Effective Mass Theory Applied to Low Dimensional Nanostructures

In this paper we analyze a long standing problem of the appearance of spurious, non-physical solutions arising in the application of the effective mass theory to low dimensional nanostructures. The theory results in a system of coupled eigenvalue PDEs that is usually supplemented by interface boundary conditions that can be derived from a variational
formulation of the problem. We analyze such a system for the envelope functions and show that a failure to restrict their Fourier expansion coefficients to small k components would lead to the appearance of non-physical solutions. We survey the existing methodologies to eliminate this difficulty and propose a simple and effective solution. This solution is demonstrated on an example of a two-band model for both bulk materials and low-dimensional nanostructures. Finally, based on the above requirement of small k, we derive a model for nanostructures with cylindrical symmetry and apply the developed model to the analysis of quantum dots using an eight-band model.

Crystal orientation effects on the piezoelectric field of strained zinc-blende quantum-well structures

A three-layered zinc-blende quantum-well structure is analyzed subject to both static and dynamic conditions for different crystal growth directions taking into account piezoelectric effects and lattice mismatch. It is found that the strain component S_zz in the quantum-well region strongly depends on the crystal growth direction and that a piezoelectric strain contribution exists in zinc blende as in wurtzite, albeit smaller. It is also found in the absence of loss effects that resonance frequencies, giving large strains in the structure, depend strongly on the crystal growth direction. Due to the higher symmetry of the zinc-blende structure, we find in a one-dimensional model that piezoelectric effects do not affect strain values for zinc-blende structures grown along the [001] direction in contrast to the corresponding wurtzite result. However, zinc-blende structures grown along a general crystal direction show important changes in strain and the electric distribution due to piezoelectric effects. The findings indicate the quantitative importance of a fully coupled model even for zinc blende, in particular when discussing electronic band structure and optoelectronic properties.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Lassen, B. (Ekstern), Melnik, R. V. N. (Ekstern), Willatzen, M. (Intern)
Pages: 699-729
Publication date: 2009
Main Research Area: Technical/natural sciences
Electromechanical effects in electron structure for GaN/AlN quantum dots

We study the impact of using the fully coupled electromechanical equations including piezoelectric effect and spontaneous polarization as compared to the semi-coupled approach, where the strain is solved first without piezoelectric coupling and then inserted into the equation for the electric potential. We show that for circular GaN/AlN quantum dots the fully coupled approach is needed for dots with a radius comparable to or larger than the height, however, when the radius is smaller than the height the semi-coupled approach is sufficient. We highlight this by studying the effect on the electronic structure using an effective mass approximation.
We show that the governing equations for the electromechanical fields of wurtzite structures are axisymmetric, hence all electric- and mechanical-field solutions are axisymmetric as well and the original three-dimensional problem can be solved as a two-dimensional mathematical-model problem [1]. We present results of the combined influence of lattice mismatch, piezoelectric effects, and spontaneous polarization for wurtzite (WZ) structures consisting of a GaN quantum dot embedded in a AlN matrix.

**General information**

State: Published  
Organisations: University of Southern Denmark  
Authors: Barettin, D. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern)  
Number of pages: 9  
Publication date: 2008  
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Physics: Conference Series (Online)  
Volume: 107  
Issue number: 1  
ISSN (Print): 1742-6596  
Ratings:  
BFI (2017): BFI-level 1  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
Electronic properties of nanowire superlattices in the presence of strain and magnetic-field effects

A calculation of the effective electron barrier potential in quantum-wire superlattices subject to magnetic-field and strain effects is presented. It is shown that, besides the lateral-confinement contributions to the barrier potential emphasized by the authors in earlier work (Lew Yan Voon and Willatzen 2003 J. Appl. Phys. 93 9997; Lew Yan Voon et al 2004 J. Appl. Phys. 96 4660), strong contributions from strain (lattice mismatch) may be present as well. This is due to the fact that strain values can be several percent in heterostructures while electron deformation potentials are of the order of 10 eV. It is also shown that Landau and Landé magnetic-field contributions become important at magnetic fields of 10 T or higher. The driving force behind the lateral-confinement and the Landau magnetic-field contributions is the same, namely, the electron effective-mass difference in the two material constituents forming the superlattice structure; however, the dependences of the two contributions on lateral dimensions are inverse squared and squared, respectively. Similarly, the driving force behind the Landé magnetic-field contribution, being independent of lateral dimensions, is the difference in electron g factors between the two material constituents. We note that, for InAs/GaAs nanowire superlattices, it is possible to tune the effective barrier potential around 0 for cross-sectional dimensions of 5–6 nm by use of a magnetic field. Further, since the effective barrier potential is different for spin-up and spin-down polarized electrons, magnetic-field tuning can be used to separate spin-up and spin-down electrons in quantum-wire superlattices.
Electronic Properties of Semiconductor Nanowires
This paper provides a review of the state-of-the-art electronic-structure calculations of semiconductor nanowires. Results obtained using empirical k . rho, empirical tight-binding, semi-empirical pseudopotential, and with ab initio, methods are compared. For conciseness, we will restrict our detailed discussions to free-standing plain and modulated nanowires. Connections to relevant experimental data, particularly band gaps and polarization anisotropy, will be made since these results depend crucially on the electronic properties. For completeness, a brief review on the synthesis of nanowires is included.

General information
State: Published
Organisations: Wright State University, National Renewable Energy Laboratory, University of Southern Denmark, Pennsylvania State University
Authors: Lew Yan Voon, L. (Ekstern), Zhang, Y. (Ekstern), Lassen, B. (Ekstern), Willatzen, M. (Intern), Xiong, Q. (Ekstern), Eklund, P. (Ekstern)
Pages: 1-26
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Nanoscience and Nanotechnology
Volume: 8
Issue number: 1
ISSN (Print): 1533-4880
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.321 SNIP 0.49 CiteScore 1.34
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.338 SNIP 0.488 CiteScore 1.23
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.328 SNIP 0.523 CiteScore 1.36
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.339 SNIP 0.546 CiteScore 1.26
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.422 SNIP 0.501 CiteScore 1.21
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.553 SNIP 0.697 CiteScore 1.47
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.571 SNIP 0.524
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.675 SNIP 0.589
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.835 SNIP 0.653
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.843 SNIP 0.69
Scopus rating (2006): SJR 0.996 SNIP 0.731
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.073 SNIP 0.774
Electron states in curved quantum structures with varying radius
The influence of size and shape is investigated for quantum-dot electronic states and intra-band oscillator strengths adapting a method originally due to Stevenson. The present work solves the one-band envelope-function problem for conduction-band eigenstates in the framework of k\cdot p theory using general curved coordinates. The eigenstates found are subsequently employed to express intra-band oscillator strengths and emphasis is given to the dependence of oscillator strengths on quantum-dot size and shape. We finally provide four simple examples.
**Electrostriction in GaN/AlN heterostructures**

A one-dimensional model accounting for electrostriction, lattice mismatch, piezoelectricity, and strain is presented with special emphasis on GaN/AlN heterostructures recently examined extensively in the literature. It is shown that electrostriction, being a second-order effect in the strain–electric field relation, plays a significant, sometimes dominant contribution subject to DC voltage conditions and externally imposed hydrostatic pressure. Model results are based on experimentally reported values for electrostriction coefficients in GaN.

**General information**

**State:** Published  
**Organisations:** University of Southern Denmark, Wright State University  
**Authors:** Willatzen, M. (Intern), Wang, L. (Ekstern), Lew Yan Voon, L. (Ekstern)  
**Pages:** 436-440  
**Publication date:** 2008  
**Conference:** 7th International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN7), Havana, Cuba, 12/04/2007 - 12/04/2007  
**Main Research Area:** Technical/natural sciences

**Publication information**

**Journal:** Superlattices and Microstructures  
**Volume:** 43  
**Issue number:** 5-6  
**ISSN (Print):** 0749-6036  
**Ratings:**  
BFI (2017): BFI-level 1  
Web of Science (2017): Indexed Yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): SJR 0.583 SNIP 0.994 CiteScore 2.09  
BFI (2015): BFI-level 1  
Scopus rating (2015): SJR 0.583 SNIP 1.007 CiteScore 2.21  
BFI (2014): BFI-level 1  
Scopus rating (2014): SJR 0.62 SNIP 1.032 CiteScore 2.18  
BFI (2013): BFI-level 1  
Scopus rating (2013): SJR 0.66 SNIP 1.006 CiteScore 2.19  
ISI indexed (2013): ISI indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): SJR 0.59 SNIP 0.833 CiteScore 1.59  
ISI indexed (2012): ISI indexed yes  
BFI (2011): BFI-level 1
Flow acoustics in solid-fluid structures.

The governing two-dimensional equations of a heterogeneous material composed of a fluid (allowed to flow in the absence of acoustic excitations) and a crystalline piezoelectric cubic solid stacked one-dimensionally (along the z direction) are derived and special emphasis is given to the discussion of acoustic group velocity for the structure as a function of the wavenumber component perpendicular to the stacking direction (being the x axis). Variations in physical parameters with y are neglected assuming infinite material homogeneity along the y direction and the flow velocity is assumed to be directed along the x direction. In the first part of the paper, the governing set of differential equations are derived as well as the imposed boundary conditions. Solutions are provided using Hamilton's equations for the wavenumber vs. frequency as a function of the number and thickness of solid layers and fluid layers in cases with and without flow (also the case of a position-dependent flow in the fluid layer is considered). In the first part of the paper, emphasis is given to the small-frequency case. Boundary conditions at the bottom and top parts of the full structure are left unspecified in the general solution but examples are provided for the case where these are subject to rigid-wall conditions (Neumann boundary conditions in the acoustic pressure). In the second part of the paper, emphasis is given to the general case of larger frequencies and wavenumber-frequency bandstructure formation. A wavenumber condition for an arbitrary set of consecutive solid and fluid layers, involving four propagating waves in each solid region, is obtained again using the monodromy matrix method. Case examples are finally discussed.
Modelling Acoustic Wave Propagation in Axisymmetric Varying-Radius Waveguides

A computationally fast and accurate model (a set of coupled ordinary differential equations) for fluid sound-wave propagation in infinite axisymmetric waveguides of varying radius is proposed. The model accounts for fluid heat conduction and fluid irrotational viscosity. The model problem is solved by expanding solutions in terms of cross-sectional eigenfunctions following Stevenson’s method. A transfer matrix can be easily constructed from simple model responses of a given waveguide and later used in computing the response to any complex wave input. Energy losses due to heat conduction and viscous effects are also assessed.
Modelling nonlinear electro-mechanical effects in nano-heterostructures using domain-decomposition methods

In this work, a continuum three-dimensional axi-symmetrical model for a nonlinear coupled multiphysics system is constructed accounting for self-consistency in electromechanical fields. A cylindrical GaN/AIN wurtzite nano-heterostructure is considered so as to simplify the mathematical problem to a two-dimensional model. To cope with the inherent discontinuity of the physical parameters and lattice mismatch across the interface, the domain-decomposition strategy is combined together with the Chebyshev spectral methods for the numerical analysis of the nonlinear problem. We report numerical results in the current presentation. We provide details on continuous mechanical and electric displacements and quantify jumps of discontinuities in the electric fields and strain distributions occurring across the interface between the two material. The importance of using a nonlinear model (with electrostriction) is investigated by comparison with a linear model (without electrostriction). We also point out significant differences qualitatively in the self-consistent electric fields and strains found using a two-dimensional and a one-dimensional model analysis. © 2008 Civil-Comp Press.
Nonlinearities in ultrasonic flow measurement
The governing equations of flow acoustics including nonlinearities are solved and analyzed in terms of ultrasonic flow-measurement properties. The effect of nonlinearities for sound propagation is expected to be most significant for gas-flow measurement applications as gas-sound speeds are much smaller while fluid flows generally are much higher in the corresponding case of liquid-flow measurement applications. The equation framework is applied to the case of a sinusoidal ultrasound transducer speed excitation at one location and detected by a receiver at another location. Flowmeter errors due to nonlinearities are highlighted in this work based on the well-known transit-time reciprocal transducer system setup. It is found that accounting for nonlinear effects leads to, for a given flowmeter configuration and in a large flow range, an almost constant error which can be calibrated out in applications.

General information
State: Published
Organisations: University of Southern Denmark
Authors: Willatzen, M. (Intern), Kamath, H. (Ekstern)
Pages: 79-84
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Flow Measurement and Instrumentation
Volume: 19
Issue number: 2
ISSN (Print): 0955-5986
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.45 SJR 0.53 SNIP 1.355
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.533 SNIP 1.642 CiteScore 1.67
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.51 SNIP 1.647 CiteScore 1.52
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.567 SNIP 1.927 CiteScore 1.6
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.491 SNIP 1.697 CiteScore 1.35
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.602 SNIP 1.641 CiteScore 1.38
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.591 SNIP 1.511
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.466 SNIP 1.538
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.616 SNIP 1.821
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.391 SNIP 1.363
Scopus rating (2006): SJR 0.349 SNIP 1.288
Scopus rating (2005): SJR 0.419 SNIP 1.134
Scopus rating (2004): SJR 0.332 SNIP 1.142
Scopus rating (2003): SJR 0.332 SNIP 0.864
Scopus rating (2002): SJR 0.477 SNIP 1.057
In November 2007, some of the world’s best nanoscientists and nanoengineers met at the Banff Centre, where the Banff International Research Station hosted a workshop on recent developments in the mathematical study of the physics of nanomaterials and nanostructures. The Banff International Research Station for Mathematical Innovation and Discovery (BIRS) is a collaborative Canada–US–Mexico venture that provides an environment for creative interaction as well as the exchange of ideas, knowledge, and methods within the Mathematical Sciences, with related disciplines and with industry. The research station is located in a scenic part of Alberta, Canada and is supported by Canada’s Natural Science and Engineering Research Council (NSERC), the US National Science Foundation (NSF), Alberta’s Advanced Education and Technology, and Mexico’s Consejo Nacional de Ciencia y Tecnología (CONACYT). We would like to thank the BIRS and its sponsors for the given opportunity and the BIRS staff for their excellent support during the workshop. Nanotechnology is the study and application of phenomena at or below the dimensions of 100 nm and has received a lot of public attention following popular accounts such as in the bestselling book by Michael Crichton, Prey. It is an area where fundamental questions of applied mathematics and mathematical physics, design of computational methodologies, physical insight, engineering and experimental techniques are meeting together in a quest for an adequate description of nanomaterials and nanostructures for applications in optoelectronics, medicine, energy-saving, bio- and other key technologies which will profoundly influence our life in the 21st century and beyond. There are already hundreds of applications in daily life such as in cosmetics and the hard drives in MP3 players (the 2007 Nobel prize in physics was recently awarded for the science that allowed the miniaturization of the drives), delivering drugs, high-definition DVD players and stain-resistant clothing, but with thousands more anticipated. The focus of this interdisciplinary workshop was on determining what kind of new theoretical and computational tools will be needed to advance the science and engineering of nanomaterials and nanostructures. Thanks to the stimulating environment of the BIRS, participants of the workshop had plenty of opportunity to exchange new ideas on one of the main topics of this workshop—physics-based mathematical models for the description of low-dimensional semiconductor nanostructures (LDSNs) that are becoming increasingly important in technological innovations. The main objective of the workshop was to bring together some of the world leading experts in the field from each of the key research communities working on different aspects of LDSNs in order to (a) summarize the state-of-the-art models and computational techniques for modeling LDSNs, (b) identify critical problems of major importance that require solution and prioritize them, (c) analyze feasibility of existing mathematical and computational methodologies for the solution of some such problems, and (d) use some of the workshop working sessions to explore promising approaches in addressing identified challenges. With the possibility of growing practically any shape and size of heterostructures, it becomes essential to understand the mathematical properties of quantum-confined structures including properties of bulk states, interface states, and surface states as a function of shape, size, and internal strain. This workshop put strong emphasis on discussions of the new mathematics needed in nanotechnology especially in relation to geometry and material-combination optimization of device properties such as electronic, optical, and magnetic properties. The problems that were addressed at this meeting are of immense importance in determining such quantum-mechanical properties and the group of invited participants covered very well all the relevant disciplines in the cross-disciplinary research area: low-dimensional semiconductor nanostructures. Since the main properties of two-dimensional heterostructures (such as quantum wells) are now quite well understood, there has been a consistently growing interest in the mathematical physics community to further dimensionality reduction of semiconductor structures. Experimental achievements in realizing one-dimensional and quasi-zero-dimensional heterostructures have opened new opportunities for theory and applications of such low-dimensional semiconductor nanostructures. One of the most important implications of this process has been a critical re-examining of assumptions under which traditional quantum mechanical models have been derived in this field. Indeed, the formation of LDSNs, in particular quantum dots, is a competition between the surface energy in the structure and strain energy. However, current models for bandstructure calculations use quite a simplified analysis of strain relaxation effects, although such effects are in the heart of nanostructure formation. By now, it has been understood that traditional models in this field may not be adequate for modeling realistic objects based on LDSNs due to neglecting many effects that may profoundly influence optoelectronic properties of the nanostructures. Among such effects are electromechanical effects, including strain relaxation, piezoelectric effect, spontaneous polarization, and higher order nonlinear effects. Up to date, major efforts have been concentrated on the analysis of idealized, isolated quantum dots, while a typical self-assembled semiconductor quantum dot nanostructure is an array (or a molecule) of many individual quantum dots sitting on the same ‘substrate’ known as the wetting layer. Each such dot contains several hundred thousand atoms. In order to account for quantum effects accurately in a situation like that, attempts can be made to apply ab initio or atomistic methodologies, but then one would face a task of enormous computational complexity in solving a large-scale many-body problem. On the other hand, taking each quantum dot in...
General information
State: Published
Organisations: University of Southern Denmark
Authors: Voon, L. C. L. Y. (Ekstern), Melnik, R. (Ekstern), Willatzen, M. (Intern)
Pages: 011001
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 107
Issue number: 1
ISSN (Print): 1742-6596
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1

We had four main plenary talks of one hour duration that gave state-of-the-art overviews of the subject from perspectives of applied mathematics (Professor Russel Caflisch of the University of California at Los Angeles), physics (Professor Antti-Pekka Jauho of the Danish Technical University), and computational science and engineering communities (Professor Gerhard Klimeck of Purdue University), as well as from a point of view of experimentalists (Dr Gail Brown of the Materials Lab/Air Force Research Lab at Wright-Patterson AFB). These talks helped identify the areas where joint efforts needed to be directed to, and they set up the scene for further work during the workshop, including discussions at the workshop open problem sessions. All participants had time to present their research and a specific time was allocated for on-site demonstrations of software and explanations of tools applied in the LDSN analysis. This special issue provides a flavor of the problems discussed at the workshop. It contains 12 refereed papers. Additional information, including the abstracts of all presented talks, can be found at http://www.m2netlab.wlu.ca/ldsn-banff/. Using this opportunity, we would like to thank the referees of this volume for their time and efforts. Without their timely professional comments this volume would not have been made possible. In conclusion, we note that advances in mathematics, physics and computation of LDSNs, impact such seemingly distant applications as biotechnology and medicine, quantum information processing and optoelectronics. The research into LDSNs offered exciting new challenges that are intrinsically interdisciplinary in nature and should be addressed by a multidisciplinary team of applied mathematicians, theoretical and experimental physicists, engineers and computational scientists. We hope that we are able to pass this idea to the reader. Lok C Lew Yan Voon(Wright State University, OH, USA) Roderick Melnik(M2NeT Lab, Wilfrid Laurier University, ON, Canada) Morten Willatzen(MCI, University of Southern Denmark, Denmark)
Piezoelectric models for semiconductor quantum dots
The importance of fully coupled and semi-coupled piezoelectric models for quantum dots are compared. Differences in the strain of around 30% and in the electron energies of up to 30meV were found possible for GaN/AlN dots.

**General information**

State: Published
Organisations: University of Southern Denmark, Wright State University
Authors: Lassen, B. (Ekstern), Barettin, D. (Ekstern), Willatzen, M. (Intern), Lew Yan Voon, L. (Ekstern)
Pages: 1226-1228
Publication date: 2008
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Microelectronics Journal
Volume: 39
Issue number: 11
ISSN (Print): 0959-8324
Ratings:
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.38 SJR 0.301 SNIP 0.901
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.327 SNIP 0.88 CiteScore 1.27
Plasmonic effects in dynamic tunable metal-dielectric composites

Sub-wavelength metal-dielectric-metal (MDM) composites support localized electromagnetic modes that are strongly confined in periodic structures. These modes can be controlled by tuning the shape of the composites as we demonstrated in previous works. Moreover, the Localized Surface Plasmon Resonance (LSPR) can be applied in new sensor applications. In this paper, we use the Finite-Difference Time-Domain (FDTD) method to study double-periodic metal-dielectric-metal composites and put emphasis to interactions with the dielectric cover layer. The numerical results demonstrate that variation of the refractive index (RI) of the cover layer as well as the layer thickness affect the LSPR response of the proposed MDM composite. The resonance-curve min/max groove period, the resonance-curve width, and the resonance-curve amplitudes from the MDM sensor output indicate that the proposed composite may find use as an effective sub-wavelength dielectric sensing optical component for photonic applications.
Testing of a one dimensional model for Field II calibration

Field II is a program for simulating ultrasound transducer fields. It is capable of calculating the emitted and pulse-echoed fields for both pulsed and continuous wave transducers. To make it fully calibrated a model of the transducer’s electromechanical impulse response must be included. We examine an adapted one dimensional transducer model originally proposed by Willatzen [9] to calibrate Field II. This model is modified to calculate the required impulse responses needed by Field II for a calibrated field pressure and external circuit current calculation. The testing has been performed with Pz27 piezoceramic discs from Ferroperm Piezoceramics A/S, Kvistgaard, Denmark. The transmitted acoustic pressures from two sets of five disc samples with 10.08 mm diameters were measured in an automatic water bath needle hydrophone setup together with the current flow through the driving circuit. Resonance frequencies at 2.1 MHz and 4 MHz were applied. Two types of circuits were considered, one circuit with a simple resistance load of 47.5 Ohm and one with an example of a LR tuning circuit typically found in commercial transducers. The measurements were averaged 128 times and afterwards compared to the calibrated Field II program for 1, 4, and 10 cycle excitations. Two parameter sets were applied for modeling, one real valued Pz27 parameter set, manufacturer supplied, and one complex valued parameter set found in literature, Algueró et al. [11]. The latter implicitly accounts for attenuation. Results show that the combination of the model and Field II can calculate the pressure within −15 % to 5 % RMS error for long excitation bursts and 7 % to 23 % for short excitation bursts. Furthermore it is shown that current simulations can be done within 1 % to maximum 33 % RMS error, where best current simulations are found for 4 MHz long burst simulations and worst case is found for 2.1 MHz short bursts. Finally it is shown that maximum pressure deviation for the real parameter set and the complex parameter simulation is 3 % for pressure and 5.3 % for current.

General information
State: Published
Organisations: Biomedical Engineering, Department of Electrical Engineering, Center for Fast Ultrasound Imaging
Authors: Bæk, D. (Intern), Jensen, J. A. (Intern), Willatzen, M. (Intern)
Pages: 1417-1420
Publication date: 2008

Nonlinear gain suppression in semiconductor lasers due to carrier heating

We present a simple model for carrier heating in semiconductor lasers from which the temperature dynamics of the electron and hole distributions can be calculated. Analytical expressions for two new contributions to the nonlinear gain coefficient epsilon are derived, which reflect carrier heating due to stimulated emission and free carrier absorption. In typical cases, carrier heating and spectral holeburning are found to give comparable contributions to nonlinear gain suppression. The results are in good agreement with recent measurements on InGaAsP laser diodes.

General information
State: Published
Organisations: Teleteknisk Forskningslaboratorium, University of Copenhagen
Authors: Willatzen, M. (Intern), Uskov, A. (Ekstern), Merk, J. (Ekstern), Olesen, H. (Ekstern), Tromborg, B. (Ekstern), Jauho, A. (Ekstern)
Pages: 606-609
Publication date: 1991
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Photonics Technology Letters
Projects:

**Photonic quantum technologies in structured environments**
Department of Photonics Engineering  
Period: 01/02/2017 → 31/01/2020  
Number of participants: 4  
PhD Student:  
Denning, Emil Vosmar (Intern)  
Supervisor:  
Iles-Smith, Jake (Intern)  
Willatzen, Morten (Intern)  
Main Supervisor:  
Mørk, Jesper (Intern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Grundforskningsfonden  
Project: PhD

**k.p Theory of Two-Dimensional Materials**
Department of Photonics Engineering  
Period: 01/07/2016 → 29/11/2019  
Number of participants: 3  
PhD Student:  
Jensen, Mathias Rosdahl (Intern)  
Supervisor:  
Mørk, Jesper (Intern)  
Main Supervisor:  
Willatzen, Morten (Intern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Grundforskningsfonden  
Project: PhD

**Dark-field hyperlens: high-contrast subwavelength imaging in optics and acoustics**
Department of Photonics Engineering  
Period: 01/09/2015 → 31/08/2018  
Number of participants: 3  
PhD Student:  
Repän, Taavi (Intern)  
Supervisor:  
Willatzen, Morten (Intern)  
Main Supervisor:  
Lavrinenko, Andrei (Intern)

**Financing sources**
Source: Internal funding (public)  
Name of research programme: Privatist  
Project: PhD
Quantum Hall effects in nanostructured graphene

Department of Micro- and Nanotechnology
Period: 01/04/2014 → 14/06/2017
Number of participants: 6
Phd Student:
Gregersen, Søren Schou (Intern)
Supervisor:
Power, Stephen (Intern)
Main Supervisor:
Jauho, Antti-Pekka (Intern)
Examiner:
Willatzen, Morten (Intern)
Ferreira, Mauro (Ekstern)
Harju, Ari (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet

Relations
Publications:
Magnetic Properties of Large-Scale Nanostructured Graphene Systems
Project: PhD

Extreme nonlinear THz optics of metals

Department of Photonics Engineering
Period: 15/03/2014 → 23/08/2017
Number of participants: 6
Phd Student:
Tarekegne, Abebe Tilahun (Intern)
Supervisor:
Iwaszczuk, Krzysztof (Intern)
Main Supervisor:
Jepsen, Peter Uhd (Intern)
Examiner:
Willatzen, Morten (Intern)
Johnston, Michael Benjamin (Ekstern)
Kampfrath, Tobias (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Quantum dot Energy level Engineering for laser applicationS on InP and Si platforms

This project is dedicated to the research of quantum dot (QD) epitaxial growth on both indium phosphide (InP) and silicon (Si) based platforms with the aim of creating superior gain material emitting in the 1.5-1.6 μm wavelength range. The majority of the proposed research is quite fundamental but will have noticeable impact to device applications for our everyday life in the near future. Diverse areas like telecommunication, optical coherence tomography including medical applications, sensing, computer and network clock-distribution, THz generation, and metrology can benefit from the materials investigated.

The projected research covers two directions. The first is the development of QDs which possess desired electronic and optical properties in the InP based material system, i.e. tailoring the energy level structure and wave functions in the dots. Manipulating the shape, chemical composition and surroundings of the nanostructures is the key to achieving the set goals. In the frame of the project I will implement two different approaches to design and grow high optical quality arrays of QDs. Those approaches are self-assembled quantum dot growth and selective area growth using block copolymer lithography. The second direction of the research is the deployment of the highly efficient QD gain material to a silicon platform. The development of epitaxial growth technology of III-V materials on Si combines the benefits of high optical quality III-V QD gain material with low cost silicon photonics, which is a key platform to push towards increased integration, higher speed and lower energy consumption.
Department of Photonics Engineering
Nanophotonic Devices
Center for Nanostructured Graphene
Department of Micro- and Nanotechnology
Amphiphilic Polymers in Biological Sensing
Center for Electron Nanoscopy

DTU Danchip
Period: 01/06/2013 → 31/08/2017
Number of participants: 9
Acronym: QUEENs
Number of related Ph.D. students: 2
Project participant:
Yvind, Kresten (Intern)
Almdal, Kristoffer (Intern)
Kadkhodazadeh, Shima (Intern)
Ottaviano, Luisa (Intern)
Willatzen, Morten (Intern)
Barettin, Daniele (Ekstern)
Phd Student:
Viazmitinov, Dmitrii (Intern)
Shikin, Artem (Intern)
Project Manager, academic:
Semenova, Elizaveta (Intern)

Development of nondestructive inspection tools for cultural heritage artefacts with 3D THz imaging

Department of Photonics Engineering
Period: 01/09/2012 → 17/02/2016
Number of participants: 6
Phd Student:
Dandolo, Corinna Ludovica Koch (Intern)
Supervisor:
Christensen, Mads Christian (Ekstern)
Main Supervisor:
Jepsen, Peter Uhd (Intern)
Examiner:
Willatzen, Morten (Intern)
Abraham, Emmanuel (Ekstern)
Gallerano, Gian Piero (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)

Relations
Publications:
Development of nondestructive inspection tools for cultural heritage artefacts with 3D THz imaging
Project: PhD

Optical Signal Processing using Four Wave Mixing

Department of Photonics Engineering
Period: 01/10/2011 → 26/01/2015
Number of participants: 5
Phd Student:
Andersen, Lasse Mejling (Intern)
Main Supervisor:
Rottwitt, Karsten (Intern)
Examiner:
Willatzen, Morten (Intern)
Karlsson, Magnus (Ekstern)
Qian, Li (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Metal-dielectric-metal waveguides as ultrafast CMOS compatible modulators
Department of Photonics Engineering
Period: 15/10/2010 → 11/12/2013
Number of participants: 6
Phd Student:
Babicheva, Viktoria (Intern)
Supervisor:
Boltasseva, Alexandra (Intern)
Main Supervisor:
Lavrinenko, Andrei (Intern)
Examiner:
Willatzen, Morten (Intern)
Bozhevolnyi, Sergey I. (Intern)
Zayats, Anatoly V. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

All-optical transistor / Optisk transistor
Department of Photonics Engineering
Period: 01/01/2010 → 15/08/2013
Number of participants: 6
Phd Student:
Heuck, Mikkel (Intern)
Supervisor:
Kristensen, Philip Trøst (Intern)
Main Supervisor:
Mørk, Jesper (Intern)
Examiner:
Willatzen, Morten (Intern)
Manning, Robert John (Ekstern)
Santagiustina, Marco (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Slow light enhancement and limitations in periodic media
Department of Photonics Engineering
Period: 01/01/2009 → 19/04/2012
Number of participants: 7
Phd Student:
Grgic, Jure (Intern)
Supervisor:
Jauho, Antti-Pekka (Intern)
Mørk, Jesper (Intern)
Main Supervisor:
Mortensen, N. Asger (Intern)
Examiner:
Lavrinenko, Andrei (Intern)
De Rossi, Alfredo (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Modeling of Coupled Nano-Cavity Lasers
Department of Photonics Engineering
Period: 01/10/2008 → 19/04/2012
Number of participants: 5
Phd Student:
Skovgård, Troels Suhr (Intern)
Supervisor:
Gregersen, Niels (Intern)
Main Supervisor:
Mørk, Jesper (Intern)
Examiner:
Abram, Izo (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Negative Index Materials and Plasmonic Antennas Based Nanocoupler
Department of Photonics Engineering
Period: 01/06/2008 → 23/11/2011
Number of participants: 6
Phd Student:
Andryieuski, Andrei (Intern)
Supervisor:
Malureanu, Radu (Intern)
Main Supervisor:
Lavrinenko, Andrei (Intern)
Examiner:
Breinbjerg, Olav (Intern)
Martin, Olivier J.F. (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Non-linear ultrasound imaging
Department of Electrical Engineering
Period: 01/06/2008 → 28/09/2011
Number of participants: 6
Phd Student:
Du, Yigang (Intern)
Supervisor:
Jensen, Henrik (Ekstern)
Main Supervisor:
Jensen, Jørgen Arendt (Intern)
Examiner:
Ferkinghoff-Borg, Jesper (Intern)
Torp, Hans (Ekstern)
Willatzen, Morten (Intern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU

**Relations**
Publications:
Non-linear Ultrasound Imaging
Project: PhD

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**Calibrated modelling of ultrasonic fields using Field II**
Department of Electrical Engineering
Period: 01/08/2007 → 24/11/2010
Number of participants: 6
Phd Student:
Bæk, David (Intern)
Supervisor:
Willatzen, Morten (Intern)
Main Supervisor:
Jensen, Jørgen Arendt (Intern)
Examiner:
Sams, Thomas (Intern)
Persson, Hans W. (Ekstern)
Stepinski, Tadeusz (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie

**Relations**
Publications:
Modeling of ultrasound transducers
Project: PhD

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**Semiconductor Quantum Dot Devices for Optical Signal Processing**
Department of Photonics Engineering
Period: 01/05/2007 → 29/09/2010
Number of participants: 7
Phd Student:
Chen, Yaohui (Intern)
Supervisor:
Poel, Mike van der (Intern)
Öhman, Filip (Intern)
Main Supervisor:
Mørk, Jesper (Intern)
Examiner:
Jeppesen, Palle (Intern)
Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Silicon-based Nanophotonic Structures for Controlling Light

Department of Photonics Engineering
Period: 01/11/2006 → 20/04/2011
Number of participants: 6
Phd Student:
Yang, Lirong (Intern)
Supervisor:
Lavrinenko, Andrei (Intern)
Sigmund, Ole (Intern)
Main Supervisor:
Hvam, Jørn Marcher (Intern)
Examiner:
Melloni, Andrea (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Light-matter Interaction in Nano-structured Materials

Department of Photonics Engineering
Period: 15/10/2006 → 21/04/2010
Number of participants: 6
Phd Student:
Kristensen, Philip Trøst (Intern)
Supervisor:
Lodahl, Peter (Intern)
Main Supervisor:
Mørk, Jesper (Intern)
Examiner:
Breinbjerg, Olav (Intern)
Busch, Kurt (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Quantum Kinetics of charge carriers in quantum dots: applications to slow light and light amplification

Department of Micro- and Nanotechnology
Period: 15/05/2006 → 20/01/2010
Number of participants: 8
Phd Student:
Houmark-Nielsen, Jakob (Intern)
Supervisor:
Mørk, Jesper (Intern)
Nielsen, Torben Roland (Intern)
Willatzen, Morten (Intern)
Main Supervisor:
Jauho, Antti-Pekka (Intern)
Examiner:
Mortensen, N. Asger (Intern)
Kuhn, Tilmann (Ekstern)
Pedersen, Thomas Garm (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Topology Optimization of Surface Acoustic Wave Devises
Department of Mechanical Engineering
Period: 01/02/2006 → 21/10/2009
Number of participants: 6
Phd Student:
Dühring, Maria Bayard (Intern)
Supervisor:
Jensen, Jakob Søndergaard (Intern)
Main Supervisor:
Sigmund, Ole (Intern)
Examiner:
Hansen, Ole (Intern)
Maute, Kurt (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Modelling of Ultrafast Semiconductor Components
Department of Photonics Engineering
Period: 01/01/2003 → 29/10/2007
Number of participants: 6
Phd Student:
Nielsen, Jens Adler (Intern)
Supervisor:
Yvind, Kresten (Intern)
Main Supervisor:
Mørk, Jesper (Internal)
Examiner:
Hvam, Jørn Marcher (Intern)
Lenstra, Daan (Ekstern)
Willatzen, Morten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Ulineær Dynamik i Halvlederlasere
Department of Photonics Engineering
Period: 01/11/2002 → 30/01/2007
Number of participants: 7
Phd Student:
**Opto-elektroniske komponenter baseret på kvante-strukturer**

Department of Photonics Engineering  
Period: 15/10/2000 → 06/09/2004  
Number of participants: 6  
Phd Student:  
    Berg, Tommy Winther (Intern)  
Supervisor:  
    Birkedal, Dan (Intern)  
Tromborg, Bjarne (Intern)  
Main Supervisor:  
    Mørk, Jesper (Intern)  
Examiner:  
    Jauho, Antti-Pekka (Intern)  
Willatzen, Morten (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Risø (Løn)  
Project: PhD

**Gain dynamics in quantum dot structures**

Department of Photonics Engineering  
Period: 01/09/1999 → 28/05/2003  
Number of participants: 7  
Phd Student:  
    Magnúsdóttir, Ingibjörg (Intern)  
Supervisor:  
    Bischoff, Svend (Intern)  
Hvam, Jørn Marcher (Intern)  
Main Supervisor:  
    Mørk, Jesper (Intern)  
Examiner:  
    Bjarklev, Anders Overgaard (Intern)  
Vinter, Børge (Ekstern)  
Willatzen, Morten (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: DTU-lønnet stipendie  
Project: PhD
Activities:

Presentation title: "A valence force field-Monte Carlo algorithm for quantum dot growth modeling".
Period: 24 Jul 2017 → 28 Jul 2017
Shima Kadkhodazadeh (Other)
Elizaveta Semenova (Other)
Morten Willatzen (Other)
Alessandro Pecchia (Other)
Matthias Auf de Maur (Other)
Daniele Barettin (Speaker)
Center for Electron Nanoscopy
DTU Danchip
Department of Photonics Engineering
Nanophotonic Devices
Centre of Excellence for Silicon Photonics for Optical Communications
Degree of recognition: International
Documents:
nusod17paper59
Links:

Related event

17th International Conference on Numerical Simulation of Optoelectronic Devices (NUSOD17)
24/07/2017 → 28/07/2017
Kgs. Lyngby, Denmark
Activity: Talks and presentations › Conference presentations