O 58: [DS] Plasmonics and Nanophotonics (jointly with HL and O)

Time: Wednesday 17:15–19:15 Location: GER 38

O 58.1 Wed 17:15 GER 38

Simulation of second harmonic generation from split ring resonators with the Discontinuous Galerkin Time Domain method — •Yevgen Grynko, Torsten Meier, and Jens Förstner — Universität Paderborn, Warburger Str. 100, 33098 Paderborn

We report our results of the application of the Discontinuous Galerkin Time Domain (DGTD) method [1] for the simulation of the linear and non-linear response of plasmonic nanostructures. We use DGTD as it has a number of attractive features including adaptive grid refinement and nonlinear stability. In this work, we consider an array of U-shaped split ring resonators. Metallic dispersion is described with a current density equation based on the representation of electron dynamics in terms of electron plasma. It includes linear Drude terms and non-linear terms for the Lorentz force and convective acceleration of the electron flow. The nonlinear part of the equation causes the doubling of the transmitted frequency leading to the the SH peak in the spectrum. Switching between the terms shows that the "convective" term plays the main role in the observed phenomena. The strength of the the SH peak is comparable to the values reported previously in the experiments [2] and FDTD simulations [3].

[1] J. S. Hesthaven, T. Warburton, 2002, J. Comp. Phys., 181, 186-221. [2] M. W. Klein, et al., 2007, Opt. Express, 15, 5238. [3] Y. Zeng, et al., 2009, Phys. Rev. B 79, 235109-1 - 235109-9.

O 58.2 Wed 17:30 GER 38

Analysis of optimization techniques for coherent optical control in nanostructures — •Tobias Fankhänel, Torsten Meier, and Jens Förstner — University of Paderborn, Department of Physics and CeOPP, Warburger Str. 100, D-33098 Paderborn, Germany

We compare the efficiency of optimization approaches for shaping coherent optical control in nanostructures. The optical response of various structures is calculated using the Finite-Difference Time-Domain (FDTD, [1]) method. Standard optimization algorithms (L-BFGS gradient method [2], genetic algorithm [3]) are used to maximize target function like the flux transmission or spatio-temporal response; the algorithms' convergence time and computational effort is analyzed.

[1] A. Taflove, S. C. Hagness. Computational electrodynamics: the finite-difference time-domain method, third edition (Artech House Inc., Norwood 2005)

[2] J. Nocedal. Updating Quasi-Newton Matrices with Limited Storage (1980), Mathematics of Computation 35, pp. 773-782.

[3] GALib, http://lancet.mit.edu/ga/

O 58.3 Wed 17:45 GER 38

Two state lasing from a quantum dot laser — •Diana Khabipova, Kathy Lüdge, Niels Majer, and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We investigate the emission properties of a quantum dot (QD) laser with two confined electron and two hole levels, respectively. Our microscopically based rate equation model for quantum dot lasers [1] is extended by including the first excited state of the QDs as a second lasing state besides the ground state. The model treats separately the dynamics of QD electrons and holes, photon densities of the ground and excited state lasing, respectively, and the electron and hole densities in the 2D wetting layer as carrier reservoir. The carrier-carrier scattering rates include the direct capture from the wetting layer into the ground and excited state as well as relaxation processes from excited to ground state. The influence of the energy differences between the excited state, ground state, and wetting layer on the turn-on dynamics is investigated. We analyse also the effect of the excited state upon the relaxation oscillations, their turn-on delay and damping rate. Furthermore we study the excited state dynamics under thermal heating conditions and for different device dimensions.

[1] K. Lüdge, R. Aust, G. Fiol, M. Stubenrauch, D. Arsenijevic, D. Bimberg, and E. Schöll, IEEE J.Quantum Electron. 46, 12, 1755 (2010).

O 58.4 Wed 18:00 GER 38

Analytical approach to modulation properties of quantum dot lasers — •Kathy Lüdge[1], Evgeny Viktorov[2], Thomas Erneux[2], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Universite Libre de Bruxelles, Optique Nonlineaire Theorique, Campus Plaine, C.P. 231, 1050 Bruxelles, Belgium

We analyze a microscopically based rate equation model for quantum dot lasers. The model separately treats the dynamics of electrons and holes, and the carrier-carrier scattering rates depend nonlinearly on the wetting layer carrier densities [1]. Our objective is to determine analytical expressions for the relaxation oscillation frequency and damping rate. To this end, we consider the Class B limit of the five rate equations and apply asymptotic techniques. We consider two cases corresponding to either equivalent or drastically different decay rates for the electrons and holes. We show how they contribute to increase the relaxation oscillation damping rate compared to the damping rate of the conventional laser and that there exist optimal conditions on the control parameters in order to observe maximum damping.

[1] K. Lüdge, E. Schöll, IEEE J.Quantum Electron. 45, 1396 (2009).

O 58.5 Wed 18:15 GER 38

Periodic Nanostructures: Spatial dispersion mimics chirality — •Bruno Gompf[1], Julia Braun[1], Thomas Weiss[1], Harald Giessen[1], Martin Dressel[1], and Uwe Hübner[2] — [1]Physikalisches Institut and Research Center SCOPE, Universität Stuttgart — [2]Institut für Photonische Technologien, Jena

The underlying idea of metamaterials is that it should be possible to construct artificial materials with completely new effective dielectric properties from nanometer-sized photonic atoms. One of these new fascinating properties is, for example, the recently achieved optical activity in photonic metamaterials. In our work we demonstrate that even a simple isotropic metal-dielectric nanostructure, i.e., a subwavelength hole array on a square lattice in a semitransparent Au film, rotates the polarization state at oblique incidence, but this behaviour cannot be explained by effective optical parameters. The structure was characterized by Mueller matrix spectroscopic ellipsometry at various angles of incidence and azimuthal orientations in the energy range of 0.73 to 4.6 eV. For the additional theoretical simulations, we employed a Fourier modal approach. To visualize the theoretical and experimental results, we plot the matrix elements in polar coordinates. Already from a brief look at the off-diagonal elements, it becomes obvious that the hole array mixes different incoming polarization states upon reflection in a complex way, which can not be explained by purely dielectric optical constants. It can be shown that for our square array even a bi-anisotropic model must fail. Rather spatial dispersion has to be taken into account.

O 58.6 Wed 18:30 GER 38

New transparent conductive metal based on polymer composite — •mehdi keshavarz hedayati[1], mohammad jamali[1], thomas strunkus[2], vladimir zaporochentko[2], franz faupel[2], and mady elbahri[1,3] — [1]Nanochemistry and Nanoengineering, Institute for Materials Science, Faculty of engineering, Christian-Albrechts-University of Kiel — [2]Multicomponent Materials, Institute for Materials Science, Faculty of engineering, Christian-Albrechts-University of Kiel — [3]Helmholtz-Zentrum Geesthacht GmbH, Institute of Polymer Research, Nanochemistry and Nanoengineering

Currently great efforts are made to develop new kind of transparent conductors (TCs) to replace ITO. In this regard different materials and composites have been proposed and studied including conductive polymers, carbon nanotubes (CNTs), metal grids, and random networks of metallic nanowires. But so far none of them could be used as a replacing material, since either they are either fragile and brittle or their electrical conductivity is below the typical ITO. Thin metallic films due to their high electrical conductivity could be one of the best replacing materials for ITO, however their poor transparency makes their application as TCs limited. Here we design and fabricate a new polymeric composite coating which enhances the transparency of the thin metal film up to 100% relative to the initial value while having a high electrical conductivity of typical metals. Therefore our proposed device has a great potential to be used as new transparent conductor.

O 58.7 Wed 18:45 GER 38

A self-assembly route to mesoporous Bragg reflectors —

•Stefan Guldin[1], Matthias Kolle[1], Morgan Stefik[3], Richard Langford[1], Dominik Eder[2], Ulrich Wiesner[3], and Ullrich Steiner[1] — [1]Physics Department, Cavendish Laboratory, University of Cambridge, UK — [2]Materials Science Department, University of Cambridge, UK — [3]Materials Science Department, Cornell University, Ithaca, NY, USA

Mesoporous distributed Bragg reflectors (MDBRs) consist of a periodic lattice of alternating high and low refractive index, while exhibiting porosity on the sub-optical length scale. MDBRs have great potential as sensing materials in biology and chemistry, as adsorption and desorption of gas phase molecules lead to reversible changes in the refractive index of the stack. Optoelectronics is another promising field of applications. MDBRs can be used as light harvesting element in excitonic solar cells. When infiltrated with light emitting polymers, MDBRs have exhibited distributed feedback lasing.

We present a new route for the fabrication of MDBRs which relies on the self-assembling properties of the block copolymer PI-*b*-PEO in combination with sol-gel chemistry to finely tune porosity and pore size in the resulting inorganic material. Stacking-up multiple layers of alternating refractive index results in a fast and reliable assembly of a continuous network with well defined interfaces. The outcome are MDBRs of high quality optical properties even when built from a single material, in our case TiO_2.

O 58.8 Wed 19:00 GER 38

Launching Surface Plasmons by Carbon Nanotube Photoluminescence — •Nicolai Hartmann[1], Johann Berthelot[2], Alexandre Bouhelier[2], and Achim Hartschuh[1] — [1]Department Chemie and CeNS, Ludwig-Maximilians-Universität München, Germany — [2]Département Nanosciences, Laboratoire Interdisciplinaire Carnot Bourgogne, Université de Bourgogne, Dijon, France

We report on the excitation of propagating surface plasmons in metal films and waveguides via photoluminescence emission from semiconducting single-walled carbon nanotubes. Upon excitation in the visible regime a single carbon nanotube acts as a directive near-infrared point dipole source for surface plasmons propagating along the direction of the nanotube axis. To investigate this behaviour we used leakage radiation microscopy [1,2]. The excitation of propagating surface plasmons manifests itself by a narrow emission of leakage radiation in Fourier space appearing at angles according to the surface plasmon resonance. In real space we observe the exponential decay of the intensity along the propagation direction of the plasmon. Propagation lengths between 11 and 13 μm could be extracted and supported by calculations, depending on the thickness of the dielectric spacer layer separating carbon nanotubes and metal film. Combining surface plasmon coupling with electroluminescence from carbon nanotubes [3] opens up the possibility to create an electrically driven plasmon source.

[1] B. Hecht, et.al., Phys. rev. Lett. 77, 1889 (1996) [2] M. Böhmler, et.al., Opt. Express 18, 16443 (2010) [3] P. Avouris, et.al., Nat. Photonics 2, 341 (2008)