O 31: Nano-optics of metallic and semiconducting nanostructures (theory)

Time: Wednesday 10:30–12:30 Location: SCH A216

O 31.1 Wed 10:30 SCH A216

Coherent control in hybrid metal-semiconductor nanostructures — Matthias Reichelt and •Torsten Meier — Department Physik, Fakultät für Naturwissenschaften, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

Recently it has been shown experimentally that it is possible to coherently control nano-optical excitations by using sophisticated shaped laser pulses. [1] In this work a similar technique is used to theoretically investigate a hybrid nanostructure which consists of a metal aperture and a quantum wire. It is shown that one can concentrate the optically excited electron density at an arbitray position due to wave packet dynamics [2] by chosing particular frequency components and phases of the chirped laser pulse. The optimization process is performed with a genetic algorithm [3] which is linked to a 3D-FDTD solver.

[1] M. Aeschlimann *et al.*, Nature **446**, 301 (2007)

[2] T. Meier, P. Thomas, and S.W. Koch *Coherent Semiconductor Optics*, Springer (2007)

[3] A.E. Eiben and J.E. Smith, *Introduction to Evolutionary Computing*, Springer (2003)

O 31.2 Wed 10:45 SCH A216

Impedance matching and emission properties of optical antennas in a nanophotonic circuit — Jer-Shing Huang, •Thorsten Feichtner, Paolo Biagioni, and Bert Hecht — Nano-Optics & Biophotonics group, Department of Experimental Physics 5, University of Würzburg, Germany

An experimentally realizable prototype nanophotonic circuit, consisting of a receiving and an emitting nano antenna connected by a two-wire optical transmission line is studied using finite-difference time- and frequency-domain simulations. It is pointed out, that nanoantennas can efficiently convert propagating photons into plasmonic excitations of a transmission line, whose effective wavelength is determined with both a mode solver and a reflection coefficient analysis. The coupling between the nanophotonic circuit elements is optimized applying impedance matching concepts in analogy to radio frequency technology. It will be shown that the degree of impedance matching, and in particular the impedance of the transmitting nano antenna, can be inferred from the standing wave pattern on the transmission line. We demonstrate the possibility of matching the nano antenna impedance to the transmission line characteristic impedance by variations of the antenna length and width realizable by modern microfabrication techniques. The radiation efficiency of the transmitting antenna also depends on its geometry but is independent of the degree of impedance matching. Our systems approach to nanophotonics provides the basis for realizing general nanophotonic circuits and a large variety of derived novel devices.

O 31.3 Wed 11:00 SCH A216

Plasmonic Optical Enhancement in an Au-Ag Hybrid Device for Bio Sensors — •Christin David[1], Inez Weidinger[2], Peter Hildebrandt[2], Marten Richter[1], and Andreas Knorr[1] — [1]Technische Universität Berlin, Institut für Theoretische Physik — [2]Technische Universität Berlin, Institut für Chemie

We present a model for plasmonic excitations in Au coated metal bio sensors. Our goal is to illustrate the interplay of surface plasmon polaritons (SPP) in metal layers with localized surface plasmon states (LSP) in the roughened electrode. We find a dielectric gap between electrode and metal layers to be crucial to produce a significant field enhancement.

O 31.4 Wed 11:15 SCH A216

From curved space to optical cloaking — •Tolga Ergin[1], Nicolas Stenger[1], Jonathan Mueller[1], Jad Halimeh[1], and Martin Wegener[1,2] — [1]Institut für Angewandte Physik, Universität Karlsruhe, 76131 Karlsruhe, Germany — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft, 76021 Karlsruhe, Germany

Transformation optics is a powerful approach to manipulate the propagation of electromagnetic waves [1]. Here, the curvature of space is mimicked by an anisotropic metamaterial, which is described by effective medium theory [2,3]. An interesting application of such composite metal-dielectric metamaterials is a non-resonant optical cloak. We present full-wave finite element simulations of feasible cloak designs in homogeneous medium approximation as well as in full geometry. Real world losses as well as microscopic phenomena are discussed and possible ways for the realization of such cloaking structures are shown.

[1] U. Leonhardt, Science 312, 1777 (2006)

[2] J.B. Pendry, et al., Science 312, 1780 (2006)

[3] W. Cai, et al., Nature Photonics 1, 224 (2007)

O 31.5 Wed 11:30 SCH A216

Poisson's Spot and Focusing of Surface Plasmon Polaritons — •Dominic Zerulla, Brian Ashall, and Brian Vohnsen — University College Dublin, School of Physics, Dublin 4, Ireland.

Surface plasmon polaritons (SPPs) are surface waves bound to the interface between a metal and a dielectric. Their wave characteristics make them ideal candidates for the study of 2d-wave propagation on the nanoscale. This was recently demonstrated in a study of Young's classical interference experiment realized with SPPs. Here we examine another classic of wave optics, namely Poisson's bright spot that appears in the shadow region behind an obstacle. Constructive interference produced by SPPs from opposing sides of a linear obstacle is expected to be less apparent than in the optical case where the field across the entire rim of a circular obstacle contributes. The finite propagation length of the SPPs limits the total propagation length and the outcome will therefore be an elongated spot in the shadow region. This can be considered as a first step towards realizing Fresnel lenses for SPPs. Focusing is required to fully explore the potential of SPPs in integrated optical components and sensors. Typically, mirror-like arrangements have been used to accomplish this. An alternative option, however, is dielectric loading to modify the phase of the SPP. Ultimately, a high numerical aperture is required and in such a case their vectorial nature must be taken into account. Here we examine the potential use of Poisson's spot for SPP confinement and the focusing of SPPs in more general terms. Our numerical predictions are compared with the outcome of preliminary experimental studies.

O 31.6 Wed 11:45 SCH A216

Collective Surface Plasmons in Metallic Nanorod Arrays — •René Kullock[1], William R. Hendren[2], Andreas Hille[1], Stefan Grafström[1], Paul R. Evans[2], Robert J. Pollard[2], Ron Atkinson[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany — [2]Centre for Nanostructured Media, IRCEP, The Queens University of Belfast, Belfast BT7 1NN, UK

Metallic nanorod arrays exhibit several surface plasmon resonances: a short-axis resonance that occurs always [1], and several long-axis resonances appearing for p-polarized light under specific incident angles [2]. Until today, time-consuming numerical calculations were needed to fully describe these properties theoretically. Here we use propagating surface plasmons for an easier description.

Starting with single nanowires exhibiting surface plasmon polaritons (SPPs) we show how the SPPs on nanowires arranged in parallel couple to form collective surface plasmons (CSPs), which have a drastically changed dispersion. For nanorod arrays, such CSPs can be excited by illumination with p-polarized light. Since these arrays act as resonators, CSPs oscillate inside the structures and obey a standing wave condition [3]. Hence, with our model a fast prediction of the optical properties is possible which allows for an easy optimization of these structures for specific purposes and applications.

[1] R. Atkinson et al., *Phys. Rev. B 73, 235402 (2006)*

[2] P. Evans et al., *Adv. Func. Mater. 18, 1075 (2008)*

[3] R. Kullock et al., *Opt. Express (2008) submitted*

O 31.7 Wed 12:00 SCH A216

The Discontinuous Galerkin Time-Domain Method for Nanophotonics — Kai Stannigel[1], •Michael König[1,2], Jens Niegemann[1,2,3], and Kurt Busch[1,2,3] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe — [2]Karlsruhe School of Optics & Photonics (KSOP), Universität Karlsruhe — [3]DFG Centrum für Funktionelle Nanostrukturen (CFN), Universität Karlsruhe

Numerical methods have become invaluable tools for research in the field of photonics and plasmonics. The Discontinuous Galerkin Time-

Domain (DGTD) method, complemented by numerous extensions, allows us to solve Maxwell's equations on unstructured grids while maintaining an efficient, explicit time-stepping scheme. Using adaptive meshes we can accurately resolve complex geometric features without staircasing, thereby overcoming one of the key limitations of the widely used Finite-Difference Time-Domain algorithm.

As an example, we apply the DGTD method in three dimensions to the analysis of V-shaped silver nanostructures. In particular, we discuss local field enhancement effects, the onset of the quasi-static limit, and we investigate the possibility of coherent control.

O 31.8 Wed 12:15 SCH A216

Investigation of the dispersion relation of nanometer meander structures — •Heinz Schweizer, Liwei Fu, Thomas Weiss, and Harald Giessen — Universität Stuttgart, 4.Phys.Inst., Pfaffenwaldring 57

On the basis of a Fourier modal method we analyze the dispersion relation of nanometer meander structures. Meander structures are of special interest for designing metamaterials with respect to efficient coupling of the magnetic field into the meander loop at all angles of incidence [1] and for designing plasmonic lasers [2]. To understand in detail the behaviour of the meander structures we analyzed the dispersion relation of propagating electromagnetic fields with respect to the transversal component of the propagation vector. Varied coupling strength between the long range and short range plasmonic modes are observed. By tuning the local meander geometry and parameters such as width, depth, and metal layer thickness we are able to engineer the bandgap of the dispersion relation in a large range and in a simple way, which provides a large application potential for plasmonic lasers [2] and other plasmonic devices.

[1] H. Schweizer et al., phys. stat. sol. (a) 204, 3886 (2007). [2] T. Okamoto et al, Phys. Rev. B77, 115425 (2008).