DS 38: Plasmonics and Nanophotonics O-V (jointly with HL and O)

Time: Wednesday 15:00–17:00 Location: WIL A317

DS 38.1 Wed 15:00 WIL A317

Optical Nanoantennas for Ultrafast Spectroscopy of Single Nanoparticles — •Thorsten Schumacher[1,2], Daniela Ullrich[1,2], Kai Kratzer[1,2], Mario Hentschel[1,2], Harald Giessen[2], and Markus Lippitz[1,2] — [1]Max Planck Institute for Solid State Research, Stuttgart — [2]4th Physics Institute, University of Stuttgart

Nonlinear spectroscopy investigates the deviations from linear light-matter interaction. The already weak signals are reduced further when single nanoobjects such as quantum dots, molecules, or nanoparticles are investigated. Here, we demonstrate how such an extremely weak nonlinear signal can be enhanced by an optical nanoantenna. For this purpose we use the transient optical response of a mechanically oscillating single gold nanodisc. Our antenna is another gold nanostructure which is placed closely next to the small disc. In this configuration we find a strong plasmonic coupling what can be described by a plasmon hybridization model and numerical simulations. Our calculations show how this plasmonic interaction cause a transfer of the weak nonlinear response of the nanoparticle to the much stronger antenna signal. With ultrafast pump-probe spectroscopy we verify the theoretical predictions and show a measured signal enhancement by a factor of 10, what is in good agreement with our simulations. Finally we can give an outlook for more advanced antenna structures to further increase the enhancement factor.

DS 38.2 Wed 15:15 WIL A317

Connecting antennas, waveguides and couplers in nanoplasmonics — •Arian Kriesch[1,2,3], Jing Wen[1,2], Daniel Ploss[1,2,3], Peter Banzer[1,2], and Ulf Peschel[1,2] — [1]MPI für die Physik des Lichts, Erlangen, Germany — [2]Friedrich-Alexander-Universtität Erlangen-Nürnberg, Erlangen, Germany — [3]Erlangen Graduate School in Advanced Optical Technologies (SAOT)

Subwavelength, plasmonic waveguides open the way to the manipulation of light in photonic circuits at the nanoscale. However, they demand new techniques to efficiently transfer light from the far-field into these highly confined waveguide modes. Recent technological progress has enabled the fabrication of plasmonic metal gap waveguides on dielectric substrates with a width in the range of a few tens of nanometers as well as connected optical nanoantennas by Focussed Ion Beam (FIB) and e-beam lithography. We present experimental measurements of the properties of such waveguides, namely transmission and bend losses, which are compared to Finite Element Method (FEM) calculations. Our optimized optical antennas (coupling efficiency from the far-field to waveguide $\approx$ 15%) allow for efficient, selective coupling to single waveguides. Utilizing these antennas together with a setup for high-numerical-aperture focal scanning, we have demonstrated and quantitatively analyzed the coupling between closely adjacent waveguides, thus realizing discrete diffraction and coupling effects in nanoplasmonic waveguide arrays. Efficient optical antennas, low loss bent waveguides and interwaveguide couplers are each a building block in future highly confined plasmonic nanocircuitry.

DS 38.3 Wed 15:30 WIL A317

Spiral Optical Nanoantenna — •Daniel Dregely, Martin Schäferling, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, D-70569 Stuttgart, Germany

Advances in nanofabrication in the past years allowed for adaption of concepts of the radiofrequency and microwave regime to optical wavelengths [1]. Recently, the road has been opened towards more complex antenna geometries suitable for tailoring light emission on the nanoscale [2,3]. Self-complementary structures are commonly used in the high frequency regime to transmit and receive signals over a broad frequency range.

We investigate a self-complementary spiral nanoantenna for the optical wavelength range. The structure has different handedness for opposite incident directions of light. Albeit being planar, its emission cone is normal to the surface. We study experimentally the optical properties in transmission and reflection for circularly polarized light. Numerical simulations confirm our measurements and give insight to the near-field response of our structure.

References:

[1]P. Mühlschlegel et al., Science 308, 1607 (2005)

[2]T. Kosako, Y. Kadoya, and H. F. Hofmann, Nature Photonics 4, 312-315 (2010)

[3]A. G. Curto et al., Science 329, 930-933 (2010)

DS 38.4 Wed 15:45 WIL A317

Plasmonic sensing using multipolar infrared antenna resonances — •Frank Neubrech[1], Daniel Weber[1], Jörg Bochterle[1], Gui Han[2], Tadaaki Nagao[2], and Annemarie Pucci[1] — [1]Kirchhoff-Institute for Physics, Heidelberg University, Germany — [2]National Institute for Materials Science, Tsukuba, Japan

Excited resonantly, antenna-like nanostructures confine the electromagnetic radiation on the nanoscale and therefore enhance the electromagnetic field in their vicinity, which can be exploited for surface enhanced infrared spectroscopy. The only precondition is a good match between the fundamental resonant excitation of the nanoantenna and the vibrational signal of the adsorbate of interest. But not only the near field of the fundamental mode can be used to enhance vibrational signals, but also multipolar modes (l=3, 5, 7) as we will show in this contribution. We performed infrared spectroscopic measurements of nanoantennas supported by a silicon wafer with a natural SiO_2 layer. For parallel polarized light and at a good match of the fundamental resonance mode of the antenna with the SiO_2 phonon, the SiO_2 surface phonon-polariton signal is enhanced. Its line shape reveals a Fano-type interaction with the antenna resonance. Detuning the nanoantenna by increasing its length leads to a decrease of the SiO_2 signal due to the frequency dependence of the antenna resonance. For even longer antennas the SiO_2 signal increases again and reaches a second maximum if the multipolar l=3 excitation of the nanoantenna matches the excitation frequency of the SiO_2 phonon-polariton.

DS 38.5 Wed 16:00 WIL A317

Dispersion engineering in a plasmonic microcavity through mode interaction — •Liwei Fu[1], Heinz Schweizer[1], Thomas Weiss[1,3], Philipp Schau[2], Karsten Frenner[2], Wolfgang Osten[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Institut für Technische Optik and Research Center SCoPE, University of Stuttgart, Germany — [3]LASMEA, Université Blaise Pascal, F-63177 Aubière Cedex, France

Microcavities provide the possibility to control and enhance light-matter interaction, which is indispensable for future quantum optical communication [1]. Microcavities with two identical periodically corrugated metallic mirrors supporting surface plasmon polaritons can further confine optical fields into a subwavelength regime. In this report, we demonstrate that mode interactions between surface plasmons and a microcavity mode can be used to tune mode dispersion, which is essential for light matter interaction. We study here numerically how the surface plasmons interact with the cavity modes in both near and far field regimes in a metallic meander cavity via tuning the excitation strength of the surface plasmons [2].

[1] K. J. Vahala, "Optical microcavities," Nature 424, 839 (2003).

[2] L. Fu, H. Schweizer, T. Weiss, and H. Giessen, "Optical properties of metallic meanders," J. Opt. Soc. Am. B 26, B111 (2009).

DS 38.6 Wed 16:15 WIL A317

Cavity-enhanced localized plasmonic resonance sensing — •Ralf Ameling, Lutz Langguth, Mario Hentschel, Martin Mesch, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We present a method to enhance the sensing properties of a localized plasmon resonance sensor. The concept is based on the combination of localized plasmons in nanostructures and a photonic microcavity. Metal nanorods that are placed at Bragg distance above a metal mirror form a Fabry-Pérot microcavity and constitute a coupled photonic-plasmonic system. The localized plasmon resonances of the nanorods and the phase shifts upon plasmon excitation are extremely sensitive to changes of the refractive index of the material surrounding the nanorods. Compared to the plasmonic nanorods alone, the coupled photonic-plasmonic system allows for a much more sensitive detection of small refractive index changes. We experimentally demonstrate our method with water and glucose solution. Our concept can be applied

to many localized plasmonic sensor structures (e.g., colloidal systems such as nanostars) and will considerably increase their sensing properties. Potential applications in the fields of biotechnology, medical diagnostics, or pharmacology including biomolecule detection as well as real-time monitoring of chemical reactions or molecular kinetics might benefit from this concept.

DS 38.7 Wed 16:30 WIL A317

Simulating EELS Spectra using the Discontinuous Galerkin Time Domain Method — •Christian Matyssek[1,2], Jens Niegemann[3], Wolfram Hergert[2], and Kurt Busch[3] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle, Germany — [2]Institute of Physics, von-Seckendorff-Platz 1, 06120 Halle, Germany — [3]Institut für Theoretische Festkörperphysik and DFG-Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), D-76128 Karlsruhe, Germany

Electron Energy Loss Spectroscopy (EELS) was recently used to examine single metal nano particles[1] and also systems of particles[2,3]. Frequently, the calculation of these spectra is done in frequency domain, e.g. using the Boundary Element Method[1]. We present the calculation of EEL spectra using the Discontinuous Galerkin Time Domain (DGTD) method, which is well approved in photonics calculations[4]. The numerical results are compared to analytical results that are available for spheres. The influence of substrates on the surface-plasmon excitation is studied. Application of nonlinear material models will be discussed.

[1] Nelayah et al., Nat. Phys. 3, 348 (2007)
[2] Chu et al., Nanotech. 20, 235705 (2009)
[3] Sigle et al., Opt. Lett. 34, 2150 (2009)
[4] Niegemann et al., Phot. and Nanostr. 7, 2 (2009)

DS 38.8 Wed 16:45 WIL A317

Release of the fluorescent dye DAPI via photothermal dissociation of programmable DNA-gold-nanoparticle networks — •Malte Linn[1], Anne Buchkremer[2], Maximilian Reismann[1], Ulrich Simon[2], and Gero von Plessen[1] — [1]Inst. of Physics (IA), RWTH Aachen University, Germany — [2]Institute of Inorganic Chemistry, RWTH Aachen University, Germany

The optical excitation of particle plasmons in gold nanospheres by means of laser light enables a highly localised and contact free heating of the nanoparticles and their immediate surroundings. This effect can be exploited to control temperature-sensitive biochemical reactions. In this work, it is used for the selective release of the DNA-intercalating fluorescent dye 4',6-diamidino-2-phenylindole (DAPI). Here, the release is realized via the photothermal dissociation of networks consisting of DNA-linked gold nanoparticles using focused cw-laser light (532 nm wavelength). Since the DAPI molecules only intercalate into DNA double strands, these molecules are released from the networks due to the photothermal controlled dehybridisation of the DNA into single strands. This process can be spectroscopically observed by measuring the fluorescence intensity, since the fluorescence of DAPI stored in the networks is suppressed by the nearby nanoparticles (fluorescence quenching). By using layer-by-layer networks, consisting of nanoparticles linked by different types of DNA, both a well-defined network structure and a step-by-step release of molecules can be realized. The principle shown here might be the basis for a remote release process of medical agents of future medicines.