O 63: Plasmonics and Nanooptics V

Time: Thursday 10:30–13:00 Location: H38

O 63.1 Thu 10:30 H38

Photothermal control of light propagation — •André Heber and Frank Cichos — Molecular Nanophotonics Group, University of Leipzig, Linnéstraße 5, D - 04103 Leipzig

Photons are an ideal choice when it comes to telecommunication. They can transfer information at high bandwidth over large distances with low losses. Therefore it is desirable to directly manipulate these signals by other photons which is a difficult task as photon photon interactions are intrinsically weak. Different schemes have been proposed to make beams of light interacting with each other. Some of these include nonlinear optical effects, optical resonators and single quantum systems such as single molecules. Our approach relies on the absorption of a single gold nano-particle which is exposed to an optical signal. It dissipates the excitation energy into the environment as heat creating a temperature profile. This particle is embedded into a nematic liquid crystal which changes its state of matter from the birefringent nematic to the isotropic phase at ambient temperature. The polarisation change by the liquid crystal depends on the thickness of the nematic layer. Therefore the transmission of a second laser beam through the nematic layer in polarisation contrast depends on the intensity of the signal beam. We demonstrate a 100% intensity modulation.

O 63.2 Thu 10:45 H38

Arrays of plasmonic particles for optical trapping — •Manuel Gonçalves[1], Fabian Enderle[2], Alfred Plettl[2], Paul Ziemann[2], and Othmar Marti[1] — [1]Ulm University - Institute of Experimental Physics, Ulm, Germany — [2]Ulm University - Institute of Solid State Physics, Ulm, Germany

Optical trapping based on plasmonic structures has been employed to exert electromagnetic forces on dielectric materials, as dielectric beads. The plasmonic structures have to be tailored in order to generate strong field gradients necessary to trap small objects. The spatial distribution of the plasmonic particles can be adjusted using lithography methods. Their size is selected to obtain surface plasmon resonances at the wavelength of the trapping beam.

We have fabricated arrays of gold nanoparticles on top of silicon and quartz pillars, using nanosphere lithography (NSL) and etching techniques. The techniques employed permit to obtain large scale of subwavelength gold nanoparticles arranged in hexagonal and triangular arrays. The materials used have good biocompatibility and can be applied in biological applications requiring optical trapping. On the other hand, due to the optical absorption at plasmon resonances or intrinsic absorption at wavelengths below 550 nm, gold particles can serve as local heating sources.

O 63.3 Thu 11:00 H38

Nonlinear Optical Properties of Gold Thin Films by Controlled Percolation — •Stefano De Zuani, Tobias Knoblauch, Audrey Berrier, Bruno Gompf, and Martin Dressel — 1.Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

When a metal is evaporated onto an insulating substrate and the metal filling factor is gradually increased, close to the percolation the almost touching metallic particles form an almost closed film and the insulator to metal transition occurs. The optical conductivity of such ultrathin metal films is dominated by a Drude component starting at the percolation threshold in the low-frequency range and by localized surface plasmons of the isolated particles. The interplay of both components leads to a dielectric anomaly in the infrared region with a divergence of the real dielectric constant at the insulator to metal transition. We present a systematic study of the nonlinear optical properties of ultrathin gold layers around the percolation threshold in order to correlate the dielectric anomaly in the real dielectric constant to the nonlinear signal of the films. We control the approach to percolation by using metallic seeds as templates for the formation of the islands, and by pre-heating the substrates. In this way the density of the metallic clusters is kept constant. We investigate the role of the capacitive coupling of the almost touching gold clusters on the nonlinear properties of the metallic film. This work brings fundamental understanding of the nonlinear properties of ultrathin metallic films and it opens the way to an active tailoring of the nonlinear signals.

O 63.4 Thu 11:15 H38

Simulation of Plasmonic Particles with MMP — •Ueli Koch, Jens Niegemann, and Christian Hafner — Institut für Feldtheorie und Höchstfrequenztechnik (IFH), ETH Zürich, Switzerland

The Multiple Multipole Program (MMP) is a Generalized Point Matching (GPM) method using analytical multipole expansions to solve Maxwell's equations in frequency domain. MMP is a well-established and highly flexible method for the simulation of photonic nanostructures. However, for three-dimensional systems it usually requires an experienced user to position the expansions and matching points in order to model the geometry accurately. Here, we present a novel mesh-based approach, which allows simulating a large variety of geometries without user interaction. Additionally, we adapted MMP for the calculation of electron-energy loss spectra (EELS). Our implementation has been validated against analytical solutions and by comparison with results from discontinuous Galerkin time-domain (DGTD) simulations. Finally, we discuss the possibility to employ layered Green's functions, which makes MMP a powerful tool for the accurate simulation of particles on layered substrates or membranes.

O 63.5 Thu 11:30 H38

Surface Plasmons onordered and bi-continuous spongy nanoporous gold films — •Neha Sardana[1], Carsten Reinhardt[2], and Jörg Schilling[1] — [1]ZIK SiLi-nano, MLU, Halle, Germany — [2]Laser Zentrum Hannover, Hannover, Germany

In sub-wavelength optics of thin metal films (negative real dielectric constants), the dispersion relation of surface plasmons (SPs) on metal/dielectric surfaces is given as $k_x=(\omega/c)*\sqrt[2]{[\varepsilon_m*\varepsilon_d/(\varepsilon_m+\varepsilon_d)]}$, where k_x describes the wave vector of the SP and ε_m and ε_d are the dielectric constants of the metal and dielectric resp. We investigate tuning of dispersion of SPs by keeping ε_d fixed but changing ε_m via introducing a nanoporosity into the metal. We compare a bi-continuous nanoporosity fabricated by dealloying with a uniform hexagonal porosity formed by evaporating gold Au on self-ordered nanoporous templates. The porosity leads to increase in ε_m which causes red shift of the SP frequency at constant k_x. This is observed experimentally by applying angular resolved reflection measurements. A dip in reflectivity, which shifted to shorter wavelength with increasing angle of incidence, was identified. This shift is in good agreement with effective medium theory's. Determination of SP propagating losses, was performed by leakage radiation microscopy in both direct and Fourier space. It is observed that ordered nanoporous gold film exhibits lesser scattering and overall lower attenuation than the spongy nanopores. This metallic structure represents a bridge between designer plasmons at structured metal surfaces for microwave range and classic SP optics with plane metal layers in visible allows larger flexibility in SP devices.

O 63.6 Thu 11:45 H38

Ultrafast strong-field photoemission from plasmonic nanoparticles — •Péter Dombi[1,2], Anton Hörl[3], Péter Rácz[1], István Márton[1], Andreas Trügler[3], Joachim Krenn[3], and Ulrich Hohenester[3] — [1]Wigner Research Centre for Physics, Budapest, Hungary — [2]Max-Planck-Institut für Quantenoptik, Garching — [3]Institut für Physik, Karl-Franzens-Universität, Graz, Austria

We demonstrate strong-field electron emission from various plasmonic nanoparticles induced by ultrashort laser pulses. Significant electric field enhancement attributed to surface plasmons enable the experimental generation of up to 25-eV electrons in nano-localized fields around nanoparticles even at low exciting laser intensities. Clear correlation between the plasmonic resonance features of various nanoparticles and photoemission electron spectra are shown. The strong-field plasmonic photoemission and photoacceleration mechanisms involved are confirmed by numerical simulations.

O 63.7 Thu 12:00 H38

Tailoring the emission of electric and magnetic dipoles with plasmonic split-ring resonators — •Sven Moritz Hein and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, D-70569 Stuttgart, Germany

The radiative properties of photon emitters strongly depend on their photonic environment, i.e., on the local density of states (LDOS). Due to the high electric and magnetic fields around a resonantly excited

plasmonic nanostructure, the LDOS is strongly modified. This can enhance as well as suppress both radiative and non-radiative decay rates, dependent on the location and frequency of the emitter. Using a discrete dipole approximation (DDA) algorithm, we explore the emission behavior of electric as well as magnetic dipole emitters located next to resonant split ring resonators, which are well-known for their large magnetic moment at their fundamental resonance. We also show to what extend the widely used two-dipole model of an SRR is able to explain the resulting Fano-type features in the emission spectra.

O 63.8 Thu 12:15 H38

Strong-field photoemission from nanostructures at mid-infrared frequencies — •Georg Herink, Daniel R. Solli, Sergey V. Yalunin, Lara Wimmer, Katharina Echternkamp, Max Gulde, and Claus Ropers — Materials Physics Institute and Courant Research Centre, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

We investigate strong-field photoemission from plasmonic nanotips driven by ultrashort pulses at near-and mid-infrared wavelengths up to 12 μm. Kinetic energies of hundreds of electronvolts, corresponding to more than 1000 times the photon energy, are experimentally observed. The scaling of the cutoff energy with wavelength reveals electron dynamics that arise from acceleration within the enhanced optical near-field [1]. Electron dynamics and scalings exclusive to nanostructures are discussed, and their optical control is described using recent theoretical results.

[1] G. Herink, D. R. Solli, M. Gulde, C. Ropers, Nature 483,190 (2012)

O 63.9 Thu 12:30 H38

The Role of the Scattering Phase in Single Particle Spectroscopy — •Christian Dicken[1,2], Thorsten Schumacher[1,2], Daniela Ullrich[1,2], Klas Lindfors[1,2], Harald Giessen[2], and Markus Lippitz[1,2] — [1]Max Planck Institute for Solid State Research, Heisenberg Str. 1, 70560 Stuttgart, Germany — [2]4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

The continuously decreasing length scales in nanooptics and the trend towards single particle experiments requires powerful and highly sensitive measurement techniques. In many of these, such as homodyne amplification or when interferometers are used, the phase of light scattered by the nanostructure becomes important. In this talk we shed light on the properties of the scattering phase of metal nanoparticles in general and describe its strong influence on the optical response of the particle. We present an intuitive picture to understand the optical response of a metal nanoparticle as superposition of a dielectric and plasmonic contribution. Experimental data on interferometric detection of nickel nanoparticles is presented that clearly show the effects of the scattering phase and how it changes with particle size.

O 63.10 Thu 12:45 H38

Optical antennas for ultrafast spectroscopy of single CdSe nanoobjects — •Thorsten Schumacher[1,2], Daniela Ullrich[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

Ultrafast nonlinear spectroscopy investigates the deviations from linear light-matter interaction on very short timescales. The already weak nonlinear signals are reduced further when single nanoobjects such as quantum dots, molecules, or nanoparticles are the systems of interest. We present a method to resolve ultrafast carrier dynamics of excitonic states in an individual CdSe nanowire. We observe various fast and long living effects in the transient absorption spectra that we attribute to a highly excited electron-hole plasma and excitonic state bleaching. To enhance this nonlinear response we developed a method to place gold nanoantennas in close vicinity to the nanowires. Here we present first experimental results of these hybrid systems.