O 34: Plasmonics and nanooptics: Light-matter interaction, spectroscopy III

Time: Tuesday 14:00–15:30 Location: MA 041

O 34.1 Tue 14:00 MA 041

Towards near-field coupling of surface plasmon polaritons across sub-micrometer gaps — •Vladimir Smirnov, Sven Stephan, Heiko Kollmann, Jue-Min Yi, Christoph Lienau, and Martin Silies — Institute of Physics and Center of Interface Science, Carl von Ossietzky Universität Oldenburg, Germany

Efficient nanofocusing of light is one of the major tasks for the realization of an ultrafast, all-optical switch. For this purpose, Surface Plasmon Polaritons (SPP) need to be confined in a conical metallic stripe-like antenna to nm-dimensions using a curved grating coupler with a second conical antenna at a nanometer distance acting as a receiver.

Here, we study the propagation of SPPs using far-field confocal microscopy in a 200 nm thin Au film in a tapered waveguide geometry across gaps of down to 15 nm that are fabricated using the Focused Ion Beam-based "Sketch and Peel" technique [1]. For gap sizes smaller than 30 nm, the transmitted intensity abruptly increases indicating an enhanced energy transport through near-field coupling [2], in accordance with finite difference time domain calculations. Results of the present work are of interest in the field of efficient strong coupling of plasmons and excitons towards ultrafast optical switching.

[1] Y. Chen, et al., ACS Nano 10(12), pp 11228-11236 (2016)
[2] H. Kollmann, et al., Nano Lett 14(2), pp 4778-4784 (2014)

O 34.2 Tue 14:15 MA 041

Electron dynamics in gold nanotips — •Andreas Wöste, Thomas Quenzel, Jan Vogelsang, Petra Gross, and Christoph Lienau — Institut für Physik, Carl von Ossietzky Universität, 26129 Oldenburg, Germany

Interaction between electrons and strong electromagnetic fields in solids plays a role in various physical phenomena, for example in optically induced emission of ultrashort electron pulses from metal nanotips. Besides the parameters of the incident laser pulses the electronic configuration of the emitter influences the emission process. On thin films, the electron dynamics are already intensely studied, mostly using two-photon emission pump-probe schemes. More recently, the electron dynamics in metal nanostructures come into focus, due to their potential as laser-triggered emitters in ultrafast electron microscopes. Unfortunately, the two-photon excitation schemes used typically cannot directly be transferred to nanostructures, because the need for wavelengths in the visible or UV regime often damages the samples. Therefore we show a measurement of electron relaxation times on chemicaly etched gold nanotips using multiphoton photoemission in a pump probe scheme with sub 20 fs laser pulses at center wavelengths of 600 nm and 1700 nm. We observe a four-fold increase of electron emission with respect to far delayed pulses, which indicates favored emission out of highly excited, non-thermal states which last for about 100 fs before they decay. The good agreement between our numerical model and the comparable timescale, in comparison with results from measurements on thin films, supports this suggestion.

O 34.3 Tue 14:30 MA 041

Vectorial near-field coupling — •Martin Esmann[1,2], Simon F. Becker[2], Julia Witt[2], Ralf Vogelgesang[2], Gunther Wittstock[2], and Christoph Lienau[2] — [1]CNRS Centre de Nanosciences et de Nanotechnologies (C2N), 91460 Marcoussis, France — [2]Carl von Ossietzky University, 26111 Oldenburg, Germany

The coherent exchange of optical near fields between two neighboring dipoles plays an essential role for the optical properties, quantum dynamics and thus for the function of many naturally occurring and artificial nanosystems[1,2]. These interactions are inherently short-ranged, extending over a few nanometers only, and depend sensitively on relative orientation, detuning and dephasing, i.e., on the vectorial properties of the coupled dipolar near fields. This makes it challenging to analyze them experimentally.

Here, we introduce plasmonic nanofocusing[3] spectroscopy to record coherent light scattering spectra with 5-nm spatial resolution from a small dipole antenna, excited solely by evanescent fields and coupled to plasmon resonances in a single gold nanorod. We resolve mode couplings, resonance energy shifts and Purcell effects as a function of dipole distance and relative orientation, and show how they arise from different vectorial components of the interacting optical near-fields. Our results pave the way for using dipolar alignment to control the optical properties and function of nanoscale systems.

[1] Zhang, Y. et al., Nature 531, 623 (2016).
[2] Scholes, G.D., et al., Nature Chemistry 3, 763 (2011).
[3] Stockman, M.I., PRL 93, 137404 (2004).

O 34.4 Tue 14:45 MA 041

Phase-resolved mapping of local optical near-fields around a single plasmonic nanoresonator — Martin Esmann, •Abbas Chimeh, Simon F. Becker, and Christoph Lienau — Institüt für Physik, Unversität Oldenburg

Plasmonic nanoantennas confine electromagnetic fields into nanoscale volumes. To fully understand and exploit this field localization, e.g., for nanoscale energy transport or for enhancing local nonlinear optical properties, a knowledge of their local optical response function, characterizing the electromagnetic fields emitted by the antenna in response to a point-like excitation in space and time, is highly desirable. Here, we show how to measure this local response function with ultrahigh, 5-nm spatial resolution by means of an isolated light spot, created by plasmonic nanofocusing [1]. Spectrally broadband surface plasmon polariton (SPP) waves are grating-coupled onto the shaft of conical gold taper and propagated towards the taper apex. The nanolocalized field at the apex locally excites a small gold rod acting as nanoantenna. The electric fields emitted by the rod are collected by the taper and emitted into the far field at a point scatterer at few microns distance from the apex. Its interference with a fraction of the incident light results in a spectral interferogram which carries full information on the local response of the antenna. By scanning the rod relative to the taper apex, we achieve fully spatially imaging of the local response function, directly mapping the dynamics of the locally emitted optical near field. [1] S. Schmidt et al., ACS Nano 6, 6040 (2012).

O 34.5 Tue 15:00 MA 041

Spectral shift and spectral broadening of broadband surface plasmon polaritons monitored in real-time during propagation — •Malte Grossmann[1], Paul Bittorf[1], Alwin Klick[1], Arkadiusz J. Goszczak[2], Jacek Fiutowski[2], Horst-Günter Rubahn[2], and Michael Bauer[1] — [1]Institute for Experimental and Applied Physics, University of Kiel, Kiel, Germany — [2]Mads Clausen Institute, NanoSYD, University of Southern Denmark, Sonderborg, Denmark

Interferometric time-resolved two-photon photoemission electron microscopy in a normal incidence configuration is used to monitor changes in the spectral distribution of a near-infrared broadband surface plasmon polariton (SPP) pulse as it propagates within 120 fs along a gold-vacuum interface. Next to a red-shift in the central frequency of the SPP pulse clear indications of spectral broadening are observed. The data are interpreted in terms of dispersive plasmon damping as qualitatively confirmed by numerical modeling of SPP propagation along a rough gold surface under consideration of ohmic losses and radiation damping.

O 34.6 Tue 15:15 MA 041

Exciton interaction with surface plasmon polaritons in hybrid metal-semiconductor nanostructures — •Felix Spitzer[1], Alexander N. Poddubny[2,3], Ilya A. Akimov[1,2], Victor F. Sapega[2], Lars Klompmaker[1], Lars E. Kreilkamp[1], Leonid V. Litvin[4], Ralf Jede[4], Grzegorz Karczewski[5], Maciej Wiater[5], Tomasz Wojtowicz[5,6], Dmitri R. Yakovlev[1,2], and Manfred Bayer[1,2] — [1]Experimentelle Physik 2, Technische Universität Dortmund, 44221 Dortmund, Germany — [2]Ioffe Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]ITMO University, 197101 St. Petersburg, Russia — [4]Raith GmbH, Konrad-Adenauer-Allee 8, 44263 Dortmund, Germany — [5]Institute of Physics, Polish Academy of Sciences, PL-02668 Warsaw, Poland — [6]International Research Centre MagTop, PL-02668 Warsaw, Poland

We study the photoluminescence of diluted magnetic semiconductor CdMnTe/CdMgTe quantum well (QW) structures at low temperatures of 10 K using a Fourier imaging spectroscopy setup. It allows to observe the emitted lights intensity both angular and energy resolved. We demonstrate the coupling of QW exciton emission to surface plasmon polaritons close to the interface by observing a magnetic field induced change in emitted intensity. The effect decreases with increasing QW to surface distance.