O 79: Plasmonics and Nanooptics IV

Time: Thursday 16:00–18:30 Location: TRE Ma

O 79.1 Thu 16:00 TRE Ma

A Plasmon Autocorrelator — •Christoph Lemke[1], Till Leissner[1], Jörn Radke[1], Jacek Fiutowski[2], Jakob Kjelstrup-Hansen[2], Horst-Günter Rubahn[2], and Michael Bauer[1] — [1]University of Kiel, IEAP, Leibnizstraße 19, 24118 Kiel, Germany — [2]University of Southern Denmark, Mads Clausen Institute, NanoSYD, Alsion 2, DK-6400 Sønderborg, Denmark

Surface plasmon polaritons (SPP) are considered as a main component in future broadband and ultrafast nanophotonic devices. This perspective asks for methods that enable one to determine in-situ the temporal and spectral properties of ultrashort SPP pulses.

In this contribution we demonstrate the realization of a plasmonic autocorrelator [1] for the characterization of SPP pulse parameters. A wedge shaped structure is used to continuously increase the time delay between two interfering SPPs. The autocorrelation signal is monitored by non-linear two-photon photoemission electron microscopy. The presented approach is applicable to other SPP sensitive detection schemes that provide only moderate spatial resolution and may therefore be of general interest in the field of ultrafast plasmonics.

[1] Lemke, C. et al. Measurement of surface plasmon autocorrelation functions. Opt. Express 21, 4700-4705 (2013).

O 79.2 Thu 16:15 TRE Ma

Helical Plasmonic Nanostructures for Strong Chiral Near-Fields — •Martin Schäferling[1], Xinghui Yin[1], Nader Engheta[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Centers SCoPE and SimTech, University of Stuttgart, Germany — [2]Department of Electrical and Systems Engineering, University of Pennsylvania, Philadelphia, USA

Chiral electromagnetic fields are used to probe the handedness of natural chiral objects. The strength of the chiroptical interaction can be quantified by the so-called optical chirality [1]. Plasmonic nanostructures can tailor the optical chirality of their near-fields [2]. Even achiral structures can generate chiral near-fields. However, their properties strongly depend on the phase between incident and scattered fields [3].

We numerically demonstrate that the eigenmodes of helical nanostructures generate near-fields with strong optical chirality. Our design with multiple helices optimizes simultaneously the strength of the optical chirality and the coupling to the external field. This structure exhibits non-trivial dependencies on the pitch of the helices due to coupling effects. We show that the optimum design strategy depends strongly on the size of the whole structure. These nanostructures with chiral eigenmodes are model devices for enantiomer sensors with improved sensitivity. Our design theoretically enhances the interaction with chiral molecules by almost two orders of magnitude.

[1] Y. Tang and A. E. Cohen, Science **332**, 333 (2011).
[2] M. Schäferling et al., Phys. Rev. X **2**, 031010 (2012).
[3] M. Schäferling et al., Opt. Express **20**, 26326 (2012).

O 79.3 Thu 16:30 TRE Ma

Chiral Plasmonic Fano Resonance — •Xinghui Yin, Martin Schäferling, and Harald Giessen — 4. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

Chiral plasmonic structures are able to enhance the sensitivity in chiroptical spectroscopy methods. They provide superchiral fields that interact strongly with chiral molecular environments on the nanoscale. [1] At the same time, their inherent chiral spectral features are modified by such an interaction and thus serve as probes that can be readily accessed in far-field measurements. [2] From conventional refractive index based plasmonic sensors, it is known that their sensitivity is maximal for geometries that exhibit a Fano-dip. [3] Prominent examples are plasmonic oligomers with the pentamer as a special C4-symmetric case. Here, we show that stacking two Pentamers on top of each other with a relative rotation angle of 22.5° about the center particle, translates the sharp Fano feature into the circular dichroism spectrum of the thus created three-dimensional chiral plasmonic oligomer. Assessing the electromagnetic properties of the structure reveals that it additionally provides strong superchiral fields, rendering it the ideal candidate for highly-sensitive enhanced chiroptical spectroscopy.

[1] Y. Tang and A. E. Cohen, Science 332, 333 (2011).
[2] E. Hendry et al., Nature Nanotechnology 5 (11), 783 (2010).
[3] B. Gallinet et al., ACS Nano 7, 6978 (2013).

O 79.4 Thu 16:45 TRE Ma

Simulations of plasmonic nano-structures using the hydrodynamic DGTD method — •Matthias Moeferdt[1], Christian Wolff[2], Christian Matyssek[1], Rogelio Rodriguez-Oliveros[1], and Kurt Busch[1,2] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik und Photonik, Newtonstr. 15, 12489 Berlin, Germany — [2]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

We present scattering simulations for plasmonic nano-structures, using the Discontinuous Galerkin Time Domain method (DGTD).

A classical nonlocal and nonlinear hydrodynamic material description is employed where the electron gas inside the metal is described by the hydrodynamic Euler equations and the pressure is implemented according to the Thomas-Fermi theory.

This constitutes a versatile computational framework that enables us to reliably obtain second harmonic spectra, to investigate the role of bulk plasmons, and to compute the field enhancement of nano-gap structures.

A comparison with corresponding simulations using a Drude material description allows us to discern nonlocal and nonlinear effects in the field enhancement.

O 79.5 Thu 17:00 TRE Ma

Angular resolved electron energy-loss spectroscopy on plasmonic nanostructures — •Felix von Cube[1,2,3], Jens Niegemann[4], Stephan Irsen[2], David C. Bell[3], and Stefan Linden[1] — [1]Physikalisches Institut, Universität Bonn, 53115 Bonn, Germany — [2]Electron Microscopy and Analytics (EMA), Center of Advanced European Studies and Research (caesar), 53175 Bonn, Germany — [3]School of Engineering and Applied Sciences, Harvard University, Cambridge MA 02138, USA — [4]Laboratory for Electromagnetic Fields (IFH), ETH Zurich, 8092 Zurich, Switzerland

We investigate the plasmonic near-field of a lithographically defined metallic nanostructure with angular resolved electron energy-loss spectroscopy in a scanning transmission electron microscope. By tilting the sample, different electric field components of the plasmonic modes can be probed with the electron beam. The electron energy-loss spectra recorded under oblique incidence can feature plasmonic resonances that are not observable under normal incidence. Our experimental findings are reproduced by full numerical calculations based on the discontinuous Galerkin time-domain method.

O 79.6 Thu 17:15 TRE Ma

Plasmon Dynamics in Noble Metal Nanorods with Femtosecond Pulse-Shaping — •Alberto Comin, Richard Ciesielski, Kevin Donkers, Giovanni Piredda, and Achim Hartschuh — Ludwig-Maximilians-Universitaet Muenchen

Plasmonic nanostructures exhibit localized surface plasmon resonances (LSPR) which greatly enhance optical absorption, scattering, and the near-field component of the electric field. LSPR are coherent, broadband and intrinsically ultrafast collective electronic excitations, with a lifetime of 5-15 fs. Here we present a time resolved study on the femtosecond plasmon dynamics of single metallic nano-particles using confocal microscopy. Broadband 10 fs laser pulses were controlled in amplitude and phase using a 4f shaper configuration. For pulse characterization in the focus of a high numerical aperture objective we developed an extension of the method of multiphoton intrapulse interference phase scans (MIIPS), which we called Gated-MIIPS. This technique allowed us to obtain an accurate characterization of the phase profile of the broadband pulses, which was valuable in achieving reliable characterization of plasmonic nanostructures in the femtosecond time range. In this contribution we will briefly discuss the newly developed Gated-MIIPS technique and the first results on the plasmon dynamics of metallic nanostructures.

O 79.7 Thu 17:30 TRE Ma

Plasmonically enhanced thin film Faraday effect with up to 4 degrees rotation — •Dominik Floess[1], Jessie Chin[1], Akihito Kawatani[1], Daniel Dregely[1], Hanns-Ulrich Habermeier[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center

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Light propagation is usually Lorentz-reciprocal. However, a static magnetic field along the propagation direction can break the Lorentz-reciprocity in the presence of magneto-optical (MO) materials. The Faraday effect in such materials rotates the polarization plane of light, and when light travels backward the polarization is further rotated. The enhancement of the Faraday rotation in MO thin films is of particular interest due to the demand of optical isolation devices in integrated optics. We hybridized MO materials with plasmonic structures and achieved 4 degrees of Faraday rotation for 200 nm thick structures. This large Faraday rotation is accompanied with a reasonably low relative insertion loss of 5.2 dB.

O 79.8 Thu 17:45 TRE Ma

Plasmoelectrons: Electron emission by decay of confined bulk plasmons in epitaxial ultrathin Mg films — •Ulrich Hagemann and Hermann Nienhaus — Faculty of Physics and Center for Nanointegration (CeNIDE), University of Duisburg-Essen, D-47048 Duisburg, Germany

A novel electron emission process is observed for epitaxially grown Mg layers on Si(111)-7x7 surfaces. The metal film thickness ranges between 5 and 50 monolayers and the surface (SS) as well as quantum well states (QWS) are well resolved by ultraviolet photoelectron spectroscopy (UPS). Intensive replica peaks of the SS and QWS structures are detected in the UPS spectra on the secondary electron background at a constant kinetic energy independent of the energy of the incident photons (HeI, NeI, ArI, ArII). The emission structures are up to two orders of magnitude more intense than the photoelectron peaks. Since they appear for an excitation energy of 10.3 eV, i.e., the Mg bulk plasmon energy, the emission is explained by the decay of optically excited bulk plasmon modes confined in the ultrathin metal film. Such modes couple effectively to the QWS and SS of the Mg film. This plasmoelectron emission is only present for well-ordered and ultrathin Mg films. At 300 ML Mg films, the effect vanishes. A threshold photon energy for the plasmoelectron excitation is found between 12 and 13eV. First experiments with Mg and Al thin films demonstrate that a similar but weaker effect is found for surface plasmons as well.

O 79.9 Thu 18:00 TRE Ma

Coupled photon-exciton modes in CHPI-based devices — •David Leipold[1], Wendy Niu[2], Lindsey Ibbotson[2], Vijaya Prakash[3], Jeremy Baumberg[2], and Erich Runge[1] — [1]Institut für Physik, Technische Universität Ilmenau, Germany — [2]Cavendish Laboratory, University of Cambridge, UK — [3]Nanophotonics Research Group, Indian Institute of Technology Delhi, India

Almost all designs proposed for future active all-optical data processing devices with subwavelength dimensions involve the coupling of electromagnetic excitations in or on metal (mostly plasmons) with nonlinear optics in dielectric materials (mostly due to excitons).

Candidates for the nonlinear materials are low-dimensional semiconductor heterostructures and organic dyes. While the former are hard to build close enough to the metal, the latter are generally chemically unstable at room temperature and high optical intensities.

Recently, CHPI ($(C_6H_9C_2H_4NH_3)_2PbI_4$), a lead iodide based inorganic-organic hybrid material gained a lot of interest because it promises to combine the best of both worlds: like many organic dyes, CHPI can be spin-coated from a solution directly onto the metal interface. After drying, it forms self-assembled 2D semiconductor sheets. Thus, the CHPI combines the stability of an inorganic semiconductor nano-structure and the simple processing of an organic dye layer.

In this talk, we will present experiments and calculations with CHPI-covered metal gratings. Several optical modes can be identified which are predominantly localized in the slits of the grating. These show strong coupling with CHPI exciton resonances.

O 79.10 Thu 18:15 TRE Ma

Multi-photon photoelectron microscopy of porphyrin thin films in contact with plasmonic silver structures — •Klaus Stallberg and Winfried Daum — Intstitute of Energy Research and Physical Technologies, TU Clausthal, Leibnizstraße 4, 38678 Clausthal-Zellerfeld

Porphyrins represent a prominent class of molecules with extended π-electron system extensively studied for light harvesting and solar energy conversion. Recent studies showed strong coupling of molecular excitations in J-aggregates of porphyrins with surface plasmons of metallic films and plasmonic nanostructures. We study the interaction of magnesium-tetraphenylporphyrin (Mg:TPP) excited states (S_2 level, Soret band) with localized surface plasmons (LSPs) in silver nanostructures by energy-resolved photoemission electron microscopy (PEEM) and by photoelectron excitation with short laser pulses for time-resolved single particle spectroscopy. As a first step in this direction we fabricated silver nanoparticles with a broad distribution of sizes and LSP resonances by evaporation of silver through a mask of polysterene spheres onto a natively oxidized silicon substrate. By variation of the photon excitation wavelength we identify LSP resonances that match the Mg:TPP Soret band. We also report on wavelength-dependent PEEM experiments with Mg:TPP films deposited on substrates with more homogeneous Ag nanoparticles prepared from solutions. First results from time-resolved 2- and 3-photon photoemission pump-probe experiments on Mg:TPP films are presented.