O 19: Plasmonics and Nanooptics II

Time: Monday 16:00–19:00 Location: H31

O 19.1 Mon 16:00 H31

Coherent/decoherent coupling of excitations in molecular-plasmonic heterostructures — •Stephanie Cheylan[1], Hongdan Yan[1], Peter Lemmens[1], Meinhard Schilling[2], Andrey Bakin[3], Johannes Ahrens[4], and Martin Bröring[4] — [1]IPKM, TU-BS, Braunschweig — [2]EMG, TU-BS, Braunschweig — [3]IHT, TU-BS, Braunschweig — [4]IAAC, TU-BS, Braunschweig

We study the coherent coupling between plasmons of Au nanowire arrays and excitons of moleculare components, given by BODIPY and its derivative aza-BODIPY. The exciton energy of these two classes of molecules is tuned to match with different plasmonic modes. Different interactions are investigated depending on the morphology of the nanowire array and the energy of molecular excitons. Work supported by DFG, B-IGSM and NTH School for Contacts in Nanosystems.

O 19.2 Mon 16:15 H31

Hybrid waveguide-particle-plasmon-polaritons enhance transverse magneto-optical Kerr effect — •Lars E. Kreilkamp[1], Vladimir I. Belotelov[2], Ilya A. Akimov[1], Manfred Bayer[1], Thomas Wehlus[3], Bernd Stritzker[3], Jessie Chin[4], Stefanie Neutzner[4], Daniel Dregely[4], and Harald Giessen[4] — [1]Experimental Physics 2, TU Dortmund University, D-44221 Dortmund, Germany — [2]A.M. Prokhorov General Physics Institute, Russian Academy of Sciences, 119992 Moscow, Russia — [3]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — [4]4th Physics Institute and Research Center SCoPE, University of Stuttgart, D-70569 Stuttgart, Germany

We demonstrate an enhanced transverse magneto-optical Kerr effect (TMOKE) at the optical resonance of a hybrid plasmonic structure. Polaritons are formed by the interaction of particle plasmons in gold nanowires in combination with a slab waveguide mode of the magneto-optical material bismuth iron garnet. A large TMOKE modulates the intensity of a transmitted beam by 1.5% upon switching the magnetization direction. This enhancement of TMOKE is explained by considering a waveguide-particle-plasmon resonance, which shifts and changes its shape upon magnetization flipping and hence leads to a large transmission contrast, in combination with a simultaneously high transmittance. The experimental results are compared to electromagnetic modelling of transmission and TMOKE spectra based on the Rigorous Coupled-Wave Analysis. The influence of surface roughness on the obtainable figure of merit is discussed.

O 19.3 Mon 16:30 H31

One-dimensional plasmons in arrays of monolayer silver wires on Si(557) — •Ulrich Krieg, Yu Zhang, Christian Brand, Herbert Pfnür, and Christoph Tegenkamp — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstrasse 2, D-30167 Hannover, Germany

An array of metallic stripes of monatomic height and up to 10 atoms wide was prepared on the (111)-oriented mini-terraces of vicinal Si (557) via self assembly. By characterization with spot profile analysis LEED (SPA-LEED), STM and electron energy loss spectroscopy (EELS) with both high energy and momentum resolution, we demonstrate that a quasi one-dimensional system was prepared after adsorption between 0.5 and 1 ML of Ag. Only stripes that show $\sqrt{3}\times\sqrt{3}R30°$ order turn out to be metallic with an almost linear dispersion of the plasmonic losses, in the direction parallel to the steps, while in perpendicular direction the plasmonic losses do not disperse at all. Therefore, the wires within the array seem to be electronically decoupled.

Due to the finite width, however, combined inter-subband-plasmon excitations become visible in the direction normal to the wires. The quantitative simulation is compatible with a wire width of 3.6 nm which agrees well with the width of the (111) terraces.

Interestingly, the electron concentration in the wires and thus the slope of the dispersion can be tuned in a wide range by doping these wires, making the Ag wires quite versatile for 1D conductance of plasmonic excitations.

O 19.4 Mon 16:45 H31

In-situ mode selectivity and control in top-down fabricated optical nano-circuits — •Peter Geisler[1], Gary Razinskas[1], Enno Krauss[1], Xiao-Fei Wu[1], Christian Rewitz[2], Phillip Tuchscherer[2], Sebastian Götz[2], Tobias Brixner[2], and Bert Hecht[1] — [1]Experimentelle Physik 5, Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Plasmonic modes supported by noble-metal nanostructures offer strong sub-wavelength confinement and therefore promise the realization of nanometer-scale integrated optical circuits with well-defined functionality. The implementation of optical nanocircuitry requires the possibilities to fabricate arbitrary circuit designs as well as to selectively excite, propagate and re-emit specific eigenmodes within a circuit.

In our work we investigate the fundamental properties of microfabricated optical two-wire transmission lines. These structures possess two fundamental propagating modes: one that can be identified as an anti-symmetric mode with a field concentration in the gap and an symmetric mode with a mode pattern similar to the mode of a single wire. By carefully optimizing an incoupling antenna and by using well defined illumination conditions it is possible to selectively excite either of both modes. The selective detection of either mode can be achieved by spatially separating the emission spots within a unique mode-detector structure.

O 19.5 Mon 17:00 H31

Coherent control of plasmon propagation in top-down fabricated optical nano-circuits — •Monika Pawłowska[1], Christian Rewitz[1], Sebastian Goetz[1], Peter Geisler[2], Gary Razinskas[2], Enno Krauss[2], Bert Hecht[2,3], and Tobias Brixner[1,3] — [1]Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Nano-Optics and Biophotonics Group, Experimentelle Physik 5, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [3]Röntgen Center for Complex Material Systems (RCCM), Am Hubland, 97074 Würzburg, Germany

Plasmonic modes supported by noble-metal nanostructures offer strong subwavelength confinement and promise the realization of nanometer-scale integrated optical circuits with well-defined functionality. The coherent control of spatial and temporal energy distribution within a nanostructure is also of high interest. Here, we present the experimental realization of such a coherent control scheme exploiting the interaction of two plasmonic modes propagating on a single gold nanostructure. The structure consists of an input antenna attached to a two-wire transmission line that splits into two branches. It was optimized by finite-difference frequency-domain (FDFD) simulations and fabricated by focused ion-beam milling (FIB). Upon illumination of the antenna with two perpendicularly polarized ultrashort laser pulses two modes can be launched. Since the interference of both modes determines the near-field intensity distribution, the plasmonic energy can be guided towards either arm by controlling the relative phase between the two laser pulses.

O 19.6 Mon 17:15 H31

Large-area 3D chiral plasmonic nanostructures fabricated by colloidal hole mask nanolithography — •Bettina Frank, Jun Zhao, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We fabricate large-area (square centimeter size) 3D chiral plasmonic nanostructures using colloidal hole mask lithography [1]. We rotate the sample in a polar direction and change the speed of the rotation. Hence, the evaporated amount of metal through the gold holes changes as a function of polar angle. This leads to ramp-like structures and yields true 3D chirality. Additionally, we fabricate a 3D chiral ramp of MgF2 and evaporate a flat strip of gold on top of it. By changing the polar rotation direction, left- as well as right-handed enantiomers can be manufactured. Measuring the transmittance upon circularly polarized light and applying the rules of Hentschel et al. to determine circular dichroism if the sample does not exhibit C3 or C4 symmetry [2], we find a strong chiral optical response with several resonances in the near-infrared between 1 and 3 micrometer wavelength. We are able to interpret this response with the aid of the fundamental modes of the split-ring resonators. Our structures will be very useful for large-area thin-film chiroptical elements and for plasmonic chiral enantiomer sensors.

[1] S. Cataldo et al., ACS Nano 6, 979 (2012).
[2] M. Hentschel et al., Nano Lett 12, 2542 (2012), supplement.

O 19.7 Mon 17:30 H31

Chiral Plasmonic Realization of the Born-Kuhn Model — •Xinghui Yin, Martin Schäferling, and Harald Giessen — 4th Physics Institut, Research Center SCoPE, and Research Center SimTech, University of Stuttgart, Stuttgart, Germany

In recent years, chiral assemblies of plasmonic nanostructures and their associated optical spectra have gained considerable interest [1]. This is due to their ability to generate optical rotatory dispersion (ORD) and circular dichroism (CD) that is orders of magnitude larger than for any naturally occurring substance. Drawing inspiration from the classical theories of optical activity, we investigate a plasmonic version of the most basic system exhibiting chiroptical responses: two coupled anisotropic oscillators that are vertically displaced with respect to each other, known as the Born-Kuhn model [2,3]. It was originally developed to describe two-chromophore coupling in optically active molecules, where each chromophore by itself is achiral. We experimentally realize the Born-Kuhn model of chiral media in a plasmonic system of corner-stacked nanorods and discuss the arising spectra in terms of hybridized modes and retardation effects.

[1] A. Kuzyk et al., Nature **483**, 311 (2012).
[2] M. Born, Z. Phys. A - Hadron Nucl. **16**, 251 (1922).
[3] W. Kuhn, T. Faraday Soc. **26**, 293 (1930).

O 19.8 Mon 17:45 H31

Chiral Fields in Achiral Systems — •Martin Schäferling, Xinghui Yin, and Harald Giessen — 4th Physics Institut, Research Center SCoPE, and Research Center SimTech, University of Stuttgart, Stuttgart, Germany

Chirality – the absence of mirror symmetry – is an integral component of our world. The so-called optical chirality quantifies the chirality of electromagnetic fields [1]. It has been shown that fields with high optical chirality can arise near plasmonic nanostructures with strong planar or three-dimensional geometrical chirality [2].

We demonstrate numerically that geometrical chirality is not a necessary prerequisite for obtaining chiral near-fields: Even a higly symmetric linear plasmonic rod antenna illuminated with linearly polarized light under normal incidence generates chiral electromagnetic fields [3]. We explain this behavior qualitatively by analyzing a Hertzian dipole driven at resonance. This simple model is further utilized to analyze and compare different incident polarizations. We show that the chiral near-field patterns generated by circularly polarized light are still dominated by the distribution found for the linear polarization.

The handedness of the chiral fields near a square structure can be flipped locally by changing the polarization angle of the incident light. Based on these findings, we propose a novel method for enantiomer sensing using linearly polarized light.

[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. Expr. **20**, 26326 (2012).

O 19.9 Mon 18:00 H31

Adiabatic Nanofocusing on Ultrasmooth Single-Crystalline Gold Tapers Creates a 10-nm-Sized Light Source with Few-Cycle Time Resolution — •Slawa Schmidt[1], Björn Piglosiewicz[1], Diyar Sadiq[1], Javid Shirdel[1], Jae Sung Lee[2], Parinda Vasa[1], Namkyoo Park[2], Dai-Sik Kim[3], and Christoph Lienau[1] — [1]Institut für Physik, Carl von Ossietzky Universität, Oldenburg — [2]Photonic Systems Laboratory, School of EECS, Seoul National University, Korea — [3]Department of Physics and Astronomy, Seoul National University, Seoul, Korea

We demonstrate adiabatic nanofocusing of few-cycle light pulses using ultrasharp and ultrasmooth single-crystalline gold tapers. We show that the grating-induced launching of spectrally broad-band surface plasmon polariton wavepackets onto the shaft of such a taper generates isolated, point-like light spots with 10 fs duration and 10 nm diameter spatial extent at its very apex. This nanofocusing is so efficient that nanolocalized electric fields inducing strong optical nonlinearities at the tip end are reached with conventional high repetition rate laser oscillators. We use here the resulting second harmonic to fully characterize the time structure of the localized electric field in frequency-resolved interferometric autocorrelation measurements. Our results strongly suggest that these nanometer-sized ultrafast light spots will enable new experiments probing the dynamics of optical excitations of individual metallic, semiconducting, and magnetic nanostructures.

O 19.10 Mon 18:15 H31

Adiabatic nanofocusing of few-cycle laser pulses with wave-front shaping using a deformable mirror — •Pascal Engelke, Slawa Schmidt, Petra Gross, and Christoph Lienau — Institut für Physik, Carl von Ossietzky Universität, Oldenburg, Germany

Adiabatic nanofocusing of ultrashort laser pulses can be used to generate a highly confined light source with few nanometer spatial and few femtoseconds time resolution [1,2]. By grating-coupling a spectrally broad-band light source onto ultra smooth single-crystalline gold tapers, typically coupling efficiencies below 1% are reached. We have identified a wave-front mismatch between the illuminating laser pulses and the conical surface of the tip as a possible cause for the restricted coupling efficiency. Here we demonstrate shaping of the wave front to match the surface radius of curvature using a deformable mirror. The wave front curvature was adapted to the tip surface using an evolutionary algorithm. We found that the coupling efficiency of the light to surface plasmon polariton (SPP) wavepackets was improved considerably, resulting in an enhancement by a factor 8 of the light scattered from the tip apex. Interferometric frequency resolved autocorrelation techniques confirmed that the time structure of the 6-fs pulses was preserved. We anticipate that the demonstrated technique offers considerable improvement for scanning near field optical microscopy techniques.

[1] Berweger, S. et al. Nano Lett. 2011, 11, 4309*4313.
[2] Schmidt, S. et al. ACS Nano 2012, 6, 6040*6048

O 19.11 Mon 18:30 H31

Plasmonic Diastereomers: Adding Up Chiral Centers — •Mario Hentschel[1,2], Martin Schäferling[1], Bernd Metzger[1], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart — [2]Max Planck Institite for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart

We construct chiral plasmonic molecules by assembling two individual chiral centers. Interestingly, depending on the exact arrangement of the centers, all combinations result in a chiral compound with a strong chiral optical response. Furthermore, we demonstrate that the overall circular dichrosim (CD) is determined by the response of the individual chiral centers. We find that the CD spectra of the composite molecules are then simply given as the sum of the CD spectra of the constituting building blocks. Interestingly, as soon as strong near-field coupling takes place between chiral centers, we find strong deviation from the simple additive chiral behavior. Most importantly, we demonstrate that the optical response of complex chiral plasmonic systems [1] can be decomposed and understood in terms of fundamental building blocks, offering simple and straightforward design rules for future applications such as chiral optical elements and enantiomer sensors.

[1] M. Hentschel et al., Nano Lett. 12, 2542 (2012)

O 19.12 Mon 18:45 H31

Nonreciprocal Plasmonics: Thin Film Faraday Rotator — •Jessie Chin[1], Tobias Steinle[1], Thomas Wehlus[2], Thomas Weiss[1], Daniel Dregely[1], Vladimir Belotelov[3], Bernd Stritzker[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCOPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany — [3]Lomonosov Moscow State University, Faculty of Physics, 119991 Moscow, Russia

Light propagation is usually reciprocal. However, a static magnetic field along the propagation direction can break the time-reversal symmetry in the presence of magneto-optical (MO) materials. The Faraday effect in this material rotates the polarization plane of light, and when light travels backward the polarization is further rotated. It is an important MO effect due to its crucial application in optical isolation. Thin film optical isolators and the enhancement of the MO Faraday effect are of particular interest due to the demand in integrated optics. We report large enhancement of thin film Faraday rotation by a sophisticated plasmonic system hybridized with nonreciprocal MO materials. We present experimental enhancement of Faraday rotation up to one order of magnitude by plasmonics. The enhanced Faraday rotation is accompanied by high transparency, which is favorable for potential applications. Numerical simulations agree very well with the measurement results and explain the mechanism of the enhancement. Our magneto-plasmonic system can be further engineered and may lead to ultracompact device applications in optical systems.