

DS 37: Plasmonics and Nanophotonics O-IV (jointly with HL and O)

Time: Wednesday 11:15–13:00

Location: WIL A317

DS 37.1 Wed 11:15 WIL A317

Steering and Negative Refraction of Surface Plasmon Beams

— ●BENEDIKT STEIN, JEAN-YVES LALUET, ELOÏSE DEVAUX, CYRI-AQUE GENET, and THOMAS W. EBBESEN — ISIS, Université de Strasbourg & CNRS, 8 allée Gaspard Monge, 67000 Strasbourg, France

Surface plasmon polaritons have raised renewed interest over the past decade for their potential in optical devices and circuits [1]. Inspired by the design principles of photonic bandgap materials [2,3], we have studied the propagation of surface plasmon beams through singly and doubly periodic metallic gratings. Large beam steering effects are experimentally revealed by probing the isofrequency surfaces related to propagating Bloch waves inside the gratings. In particular, negative refraction is demonstrated close to the Bragg condition. We also analyze how the local structure of the isofrequency surface can amplify the sensitivity of surface plasmon based refractive-index sensors [4].

- [1] Barnes, W. L.; Dereux, A.; Ebbesen, T. W. *Nature* 2003, 424, 824
 [2] Zengerle, R. *Journal of Modern Optics* 1987, 34, 1589
 [3] Russell, P.S.J. *Phys. Rev. A* 1986, 33, 3232
 [4] Stein, B.; Laluet, J.-Y.; Devaux, E.; Genet, C.; Ebbesen, T. W. *Phys. Rev. Lett.*, in press

DS 37.2 Wed 11:30 WIL A317

Far-field optical characterization of ultrafast plasmon propagation in nanostructures— ●CHRISTIAN REWITZ¹, THOMAS KEITZL¹, PHILIP TUCHSCHERER¹, JER-SHING HUANG², PETER GEISLER³, BERT HECHT³, and TOBIAS BRIKNER¹ — ¹Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg — ²Department of Chemistry, National Tsing Hua University, Hsinchu 30013, Taiwan — ³Nano-Optics and Biophotonics Group, Department of Experimental Physics 5, University of Würzburg, Am Hubland, 97074 Würzburg

Our goal is to characterize and control the propagation of ultrafast excitations in optical nanocircuits. For this purpose, the technique of spectral interferometry (SI) is combined with a microscope setup. This allows for a full characterization (amplitude and phase) of an ultrafast pulse emitted at the output of a nanocircuit. The input and output of the nanostructure can be addressed with a diffraction-limited resolution. As a first experiment, we investigate the propagation of plasmons in silver wires with nanometer radial and micrometer longitudinal dimensions. Once the excitation pulse is focused on one end of a wire, part of the energy is converted into a propagating plasmon mode. Upon propagation the plasmon is modified by dispersion and attenuation that is specific to the nanostructure. After the plasmon is converted into a radiative far-field mode at the other end of the wire the field is collected by the microscope objective and can be fully characterized via SI. Thus, specific plasmonic properties of the nanostructure can be determined. One of them is the propagation speed of the plasmon.

DS 37.3 Wed 11:45 WIL A317

Ultrafast optical nonlinearities in hybrid metal-semiconductor nanostructures— ●PARINDA VASA¹, ROBERT POMRAENKE¹, GIOVANNI CIRMI², ELENORA DE RE², WEI WANG¹, STEPHAN SCHWIEGER³, DAVID LEIPOLD³, ERICH RUNGE³, GIULIO CERULLO², and CHRISTOPH LIENAU¹ — ¹Institut für Physik, Carl von Ossietzky Universität Oldenburg, Germany — ²IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, Milano, Italy — ³Institut für Physik and Institut für Mikro- und Nanotechnologien, Technische Universität Ilmenau, Germany

Understanding and manipulating the interactions between quantum emitters and surface plasmon polaritons (SPPs) is the key to designing and implementing novel nano-optical devices. We report the measurements of ultrafast optical nonlinearity resulting from the strong interaction between SPPs on a gold grating and excitons in either a semiconductor QW or a J-aggregated cyanine dye. The hybrid structures are characterized by linear reflectivity measurements and exhibit enhanced SPP-exciton coupling. The nonlinearity is investigated by low-temperature, angle-resolved, ultrafast pump-probe spectroscopy under different excitation schemes. Strong optical excitation drastically alters the hybrid nanostructure response by transiently changing the exciton density. A significant shift in the polariton resonance wavelength and changes in the response time are observed. The results are

explained within a semi-classical density matrix formalism. Such a strong ultrafast nonlinear interaction between SPPs and excitons will be of key importance in adding active functionality to plasmonic devices.

DS 37.4 Wed 12:00 WIL A317

Characteristics of the Electron Emission from Metal Nanotips due to Ultrashort Laser Pulses — ●STEVE LENK and ERICH RUNGE — Institut für Physik und Institut für Mikro- und Nanotechnologien, Technische Universität Ilmenau, 98693 Ilmenau, Germany

We investigate the electron emission process from sharp gold nanotips illuminated by ultrashort femtosecond laser pulses theoretically. The emission processes under discussion for few-femtosecond laser pulses are multiphoton emission [1] and optical field emission [2]. We calculate the probability current from a numerical solution in two spatial dimensions of an initial-value problem [3] via an exponential split-operator method and a real-space product-formula algorithm [4]. The time-dependent electromagnetic potentials used for the study of the electron emission are derived from a finite-difference time-domain method calculation. We observe spatial emission spot changes dependent on the bias voltage as well as different time characteristics due to different laser pulse powers. The electric field and the photoelectron current are compared to experimental results.

- [1] C. Ropers, D. Solli, C. Schulz, C. Lienau, and T. Elsaesser, *Phys. Rev. Lett.* **98**, 043907 (2007).
 [2] P. Hommelhoff, C. Kealhofer, and M. Kasevich, *Phys. Rev. Lett.* **97**, 247402 (2006).
 [3] S. Glutsch, *Excitons in Low-Dimensional Semiconductors*, Springer Heidelberg (2004).
 [4] H. De Raedt, *Comp. Phys. Rep.* **7**, 1 (1987).

DS 37.5 Wed 12:15 WIL A317

Theory of ultrashort plasmon pulse generation by mode-locked surface plasmon polariton lasers — ●KWANG-HYON KIM, ANTON HUSAKOU, and JOACHIM HERRMANN — Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max-Born-Str. 2a, 12489 Berlin

Amplification of surface plasmon polaritons (SPP) by embedding a dielectric with a gain medium is of great importance for a variety of applications including surface spectroscopy, imaging and information processing. By adding a feedback and a fast modulator, mode-locked lasing of SPPs becomes possible. In this contribution, we extend a semiclassical theory of surface plasmon polariton lasers to the case of mode-locked SPP lasers. In the considered scheme feedback is provided by a Bragg reflector of SPPs, and the SPP laser is composed of a metal film deposited on a polymer host as well as a saturable absorber layer and a gain layer. We investigate mode-locking characteristics, such as pulse duration and peak intensity, in dependence on the layer thickness of the metal film and the absorber layer, the pump intensity, and densities of gain and absorber molecules. We consider the dyes R6G as gain and DQOCI as saturable absorber and predict the possibility of SPP pulse generation with maximum peak intensity of more than 500 GW/cm² and shortest pulse duration of 280 fs.

DS 37.6 Wed 12:30 WIL A317

Spatiotemporal nanofocusing in random nanostructures achieved by time-reversal, adaptive optimization, and optimal open-loop control of ultrashort laser pulses — ●DOMINIK DIFFERT¹, JAVIER GARCIA DE ABAJO², CHRISTIAN STRÜBER¹, DMITRI VORONINE^{1,3}, and WALTER PFEIFFER¹ — ¹Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, 33615 Bielefeld, Germany — ²Instituto de Optica, CSIC, Serrano 121, 28006 Madrid, Spain — ³Department of Physics, Texas A&M University, 4242 TAMU, College Station, USA

Because of the reciprocity of electromagnetic wave propagation the time-reversal of a wave emitted from a nanoemitter embedded in a random scattering environment should refocus in space and time at the emitter site. If only partial waves, e.g. one particular planar wave component, of the outgoing wave are time-reversed this nanolocalization of the back-propagated wave is not perfect. Here we investigate the degree of spatiotemporal nanolocalization of time-reversed partial planar

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waves. The chosen nanostructure consists of two nanoemitter particles embedded in a random assembly of metallic nanospheres acting as scattering environment. A multiple elastic scattering of multipole expansion (MESME) code is used for solving Maxwell's equations in frequency domain. The degree of nanolocalization varies significantly and depends critically on which partial planar wave is time-reversed. In addition, direct adaptive optimization or optimal open-loop control of the spatiotemporal nanofocusing of planar waves at the emitter position exhibits a much higher degree of nanolocalization.

DS 37.7 Wed 12:45 WIL A317

Investigating Ag Nanostructures by TOF-PEEM using High Harmonic Radiation — •SOO HOON CHEW¹, FREDERIK SÜSSMANN², CHRISTIAN K. SPÄTH¹, ALEXANDER GUGGENMOS², YINGYING YANG², JÜRGEN SCHMIDT¹, ADRIAN WIRTH², SERGEY ZHEREBTSOV², MICHAEL HOFSTETTER², MATTHIAS F. KLING², MARK I. STOCKMAN³, FERENC KRAUSZ², and ULF KLEINEBERG¹ —
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We demonstrate first experimental results on imaging plasmonic nanostructures by Time-of Flight-Photoelectron Emission Microscope (TOF-PEEM) in combination with Extreme Ultraviolet (XUV) attosecond pulses from a High Harmonic Generation source. The 1 kHz coherent attosecond XUV radiation is produced by ionizing neon atoms with waveform-controlled near-infrared (0.6 mJ, 5 fs) laser pulses and spectrally filtered at 93 eV by means of a multilayer mirror. We have characterized various polycrystalline Cu microstructures and Ag nanostructures using these ultrashort XUV pulses by TOF-PEEM with a spatial resolution approaching 100 nm. The electron energy spectrum have been investigated at different sample positions and energy filtering has been applied to improve image resolution. The experiments demonstrate first steps towards the temporal characterization of nanoscaled localized surface plasmon fields in a femtosecond optical-pump/attosecond XUV-probe experiments.