O 41: Plasmonics and Nanooptics IV

Time: Wednesday 11:15–13:00 Location: WIL A317

O 41.1 Wed 11:15 WIL A317

Steering and Negative Refraction of Surface Plasmon Beams

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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

O 41.2 Wed 11:30 WIL A317

Far-field optical characterization of ultrafast plasmon propagation in nanostructures

— •Christian Rewitz[1], Thomas Keitzl[1], Philip Tuchscherer[1], Jer-Shing Huang[2], Peter Geisler[3], Bert Hecht[3], and Tobias Brixner[1] — [1]Institut für Physikalische und Theoretische Chemie, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]Department of Chemistry, National Tsing Hua University, Hsinchu 30013, Taiwan — [3]Nano-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.

O 41.3 Wed 11:45 WIL A317

Ultrafast optical nonlinearities in hybrid metal-semiconductor nanostructures

— •Parinda Vasa[1], Robert Pomraenke[1], Giovanni Cirmi[2], Elenora De Re[2], Wei Wang[1], Stephan Schwieger[3], David Leipold[3], Erich Runge[3], Giulio Cerullo[2], and Christoph Lienau[1] — [1]Institut für Physik, Carl von Ossietzky Universität Oldenburg, Germany — [2]IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, Milano, Italy — [3]Institut 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.

O 41.4 Wed 12:00 WIL A317

Characteristics of the Electron Emission from Metal Nanotips due to Ultrashort Laser Pulses

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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).

O 41.5 Wed 12:15 WIL A317

Theory of ultrashort plasmon pulse generation by mode-locked surface plasmon polariton lasers

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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/cm^2 and shortest pulse duration of 280 fs.

O 41.6 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

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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 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.

O 41.7 Wed 12:45 WIL A317

Investigating Ag Nanostructures by TOF-PEEM using High Harmonic Radiation — •Soo Hoon Chew[1], Frederik Süssmann[2], Christian K. Späth[1], Alexander Guggenmos[2], Yingying Yang[2], Jürgen Schmidt[1], Adrian Wirth[2], Sergey Zherebtsov[2], Michael Hofstetter[2], Matthias F. Kling[2], Mark I. Stockman[3], Ferenc Krausz[2], and Ulf Kleineberg[1] — [1]Department of Physics, Ludwig Maximilian University of Munich, Garching, Germany — [2]Max Planck Institute of Quantum Optics, Garching, Germany — [3]Georgia State University, Altanta, USA

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.