O 74: Plasmonics and nanooptics IV

Time: Thursday 16:00–18:30 Location: MA 005

O 74.1 Thu 16:00 MA 005

The chirp of a surface plasmon polariton probed via plasmon-plasmon interference — •Christoph Lemke[1], Till Leissner[1], Stephan Jauernik[1], Alwin Klick[1], Jacek Fiutowski[2], Jakob Kjelstrup-Hansen[2], Horst-Günter Ruhbahn[2], and Michael Bauer[1] — [1]IEAP, Christian- Albrechts-Universität zu Kiel, 24098 Kiel, Germany — [2]2Mads Clausen Institute, NanoSYD, University of Southern Denmark, Alsion 2, DK-6400 Sønderborg, Denmark

In an interferometric time-resolved photoemission electron microscopy (ITR-PEEM) experiment, the near-field associated with propagating surface plasmon polaritons (SPP) can be locally sensed via interference with sub 20 fs ultrashort laser pulses [1].

Here, we present ITR-PEEM data of SPP propagation at a gold vacuum interface recorded in a counter-propagating pump-probe geometry. In comparison to former work this approach provides a considerably improved access to the SPP wavepacket dynamics. We exemplify the potential of the scheme by probing the chirp of phase modulated SPPs in a time resolved plasmon-plasmon-interference experiment. Wavepacket simulations quantitatively reproduce the experimental data and allow for a characterization of the phase modulated ultrashort plasmon pulses.

[1] A. Kubo et al., Nano Lett. 7, 470 (2007)

O 74.2 Thu 16:15 MA 005

Light trapping in thin-film solar cells characterized by fs-laser pulse backscattering — •Michael Birlo[1], Dominik Differt[1], Florian Lükermann[1], Christian Strüber[1], Helmut Stiebig[2], and Walter Pfeiffer[1] — [1]Universität Bielefeld, Universitätsstrasse. 25, 33615 Bielefeld, Germany — [2]Malibu GmbH & Co.KG, 33609 Bielefeld, Germany

Multiple light scattering at randomly nanostructured interfaces leads to light trapping and enhances the light absorption and efficiency of thin-film silicon solar cells. To increase the trapping efficiency the scattering mechanism has to be understood and selective characterization tools are needed. In this study we use dual-channel spectral interferometry in order to fully characterize the temporal properties of backscattered radiation from thin-film solar cells illuminated by ultra short laser pulses. The so obtained spectral phase, amplitude and polarization state of the scattered light reveals light localization in the few-micron thick randomly nanostructured thin-film solar cell. In comparison a reference cell with flat interfaces exhibits no light trapping. Spectral interference measurements of broadband coherent radiation represents a suitable tool for light trapping characterization.

O 74.3 Thu 16:30 MA 005

Normal Incidence Photoemission Electron Microscopy for the Observation of Surface Plasmon Polaritons — •P. Kahl[1], S. Wall[1], C. Witt[1], C. Schneider[2], D. Bayer[2], A. Fischer[2], P. Melchior[2], M. Horn-von Hoegen[1], M. Aeschlimann[2], and F.-J. Meyer zu Heringdorf[1] — [1]Faculty of Physics and CeNIDE, University of Duisburg-Essen — [2]Department of Physics and OPTIMAS, University of Kaiserslautern

Up to now the imaging of surface plasmon polaritons (SPPs) has been achieved in photoemission electron microscopy (PEEM) in a 2PPE process by illuminating a sample with fs laser pulses under grazing incidence. Under such conditions the experimentally observed Moiré-patterns can be explained by a time-integrated superposition of the light pulse and the SPP, resulting from the simultaneous propagation of the two pulses with different velocities, wavelengths and directions. This prevents a direct observation of SPPs, for example is the wavelength of the Moiré-pattern one order of magnitude larger than the SPP wavelength.

In normal incidence PEEM (NI-PEEM) the contrast mechanism is easier to interpret, because the propagation directions of the light and SPP pulse are perpendicular to each other. Experimentally, however, normal incidence is difficult to obtain. We will discuss two approaches to achieve NI-PEEM, based on different instrument designs. We demonstrate that the observed wavelength corresponds to the real SPP wavelength and that the location of excitation of the SPP on a silver island is adjustable by turning the polarization of the laser pulse.

O 74.4 Thu 16:45 MA 005

Coupling of Excitons in Carbon Nanotubes to Propagating Surface Plasmons — •Nicolai Hartmann[1], Johann Berthelot[2], Padmnabh Rai[2], Francesco Tantussi[3], Francesco Fuso[3], Maria Allegrini[3], Alexandre Bouhelier[2], and Achim Hartschuh[1] — [1]Department Chemie and CeNS, Ludwig-Maximilians-Universität, München, Germany — [2]Département Nanosciences, Université de Bourgogne, Dijon, France — [3]Dipartimento di Fisica E. Fermi, Università di Pisa, Italy

We report on the coupling between excitonic states in semiconducting single-walled carbon nanotubes and propagating surface plasmons in thin metal films.

First we show that upon optical excitation in the visible regime a single carbon nanotube acts as a directive near-infrared dipolar source for surface plasmons propagating mainly along the direction of the nanotube axis. Plasmon excitation and propagation is monitored in Fourier and real space by leakage radiation microscopy [1, 2] and is modelled by rigorous theoretical calculations. Coupling to plasmons almost completely reshapes the emission of nanotubes both spatially and with respect to polarization as compared to photoluminescence on a dielectric substrate. Second we visualize the remote excitation of single nanotubes via propagating surface plasmons.

Our results demonstrate the potential of carbon nanotubes as active elements in plasmonic circuits.

[1] B. Hecht, et.al., Phys. rev. Lett. 77, 1889 (1996) [2] M. Böhmler, et.al., Opt. Express 18, 16443 (2010)

O 74.5 Thu 17:00 MA 005

Organic nanofibers as waveguides and emitters of surface plasmon polaritons — •Till Leissner[1], Jacek Fiutowski[2], Christoph Lemke[1], Kasper Thilsing-Hansen[2], Stephan Jauernik[1], Alwin Klick[1], Jakob Kjelstrup-Hansen[2], Michael Bauer[1], and Horst-Günter Rubahn[2] — [1]IEAP, Christian-Albrechts-Universität zu Kiel, 24098 Kiel, Germany — [2]Mads Clausen Institute, NanoSYD, University of Southern Denmark, Alsion 2, DK-6400 Sønderborg, Denmark

Surface plasmon polariton (SPP) excitation and propagation at gold films as governed by the presence of organic nanofibers composed of self-assembled para-Hexaphenylene (p6P) molecules is studied using interferometric time-resolved photoemission electron microscopy (ITR-PEEM). Two different SPP modes are identified in the experiment: a) the nanofibers act as superior sources for the emission of SPPs at the gold-vacuum interface [1]; b) along the interface between nanofiber and goldfilm we observe 1-d SPP waveguiding as recently also reported by Radko et al. [2]. A quantitative analysis of the data enables us to determine critical SPP propagation parameters such as damping length and group velocity. The results are compared with model simulations based on Hugyens principle and the effective index method [3].

[1] T. Leißner et al., Plasmonics, accepted, [2] Radko et al., Opt. Ex. 19, 16 (2011), [3] Holmgaard and Bozhevolnyi, Phys. Rev. B 75, 245405 (2007)

O 74.6 Thu 17:15 MA 005

Surface plasmon near-field intensity switching using spectral intensity variation combined with photoemission electron microscopy — •Christian Schneider[1], Martin Piecuch[1], Daniela Bayer[1], Alexander Fischer[1], Pascal Melchior[1], Christoph Lemke[2], Michael Bauer[2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern — [2]Institut für Experimentelle und Angewandte Physik, Universität Kiel, 24118 Kiel

The physical effects at interfaces between metallic and dielectric media attract more and more attention due to the possibility to generate collective electron density oscillations. These propagating surface plasmon polaritons (SPPs) open the opportunity to guide the electrical field energy. By tailoring a gold microstructure in an appropriate manner, we are able to focus the electrical field energy at a given point of the structure. In addition, based on the coherence between the SPP and the light pulse the field concentration can be switched on and off by alternating the laser pulse spectrum. Applying photoemission electron microscopy (PEEM) as a near field probe and our fast and effective algorithm based on Huygens principle, we can experimentally and theoretially show that by altering the spectral intensity of a 30 fs laser pulse at 800 nm using a Mach-Zehnder-interferometer, we are able to shift the electrical field energy in a controlled manner. First consistent results comparing simulated and measured data of a Fresnel type focusing device show a very good agreement.

O 74.7 Thu 17:30 MA 005

Transmission of Light through Magnetic Nanocavities — •Piotr Patoka, Michael Hilgendorff, and Michael Giersig — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

The transmission of light through a metallic film stack on a transparent substrate, perforated with a periodic array of cylindrical holes/nanocavities, is studied. The structure is fabricated by using self-assembled nanosphere lithography. Since one layer in the film stack is made of a ferromagnetic metal (iron), exposure of the structure to a solution containing iron oxide nanoparticles causes nanoparticle accumulation inside the nanocavities. This changes the dielectric constant inside the nanocavities and thus affects the light transmission. Simulations are in good agreement with experiment, and show large sensitivity of the response to the amount of iron oxide nanoparticles deposited. This could be used in various sensor applications.

O 74.8 Thu 17:45 MA 005

Time-Resolved PEEM Investigation of the Interaction of Surface Plasmons with Hot Spots — •Martin Wiesenmayer, Alexander Fischer, Pascal Melchior, Christian Schneider, Daniela Bayer, and Martin Aeschlimann — University of Kaiserslautern, Department of Physics, 67663 Kaiserslautern, Germany

In our talk we present a spatially and time-resolved investigation of a rough, polycrystalline silver surface. The acquisition of phase resolved autocorrelation traces ($h\nu = 1.55$ eV and 3.1 eV, p- and s-polarized) enables a detailed analysis of such data, especially with respect to the interference fringes. The interaction of the laser induced surface plasmons with local hot spots on the silver surface is the focus of our work. We observe a significant broadening of the autocorrelations which exceeds the dephasing times of a smooth metal surface. Using photoemission electron microscopy (PEEM) allows for a parallel detection in the micron regime (field of view below 20 μm) which is crucial for the interpretation of the observed broadening effects. Our investigations contribute to a deeper understanding of the time dependent evolution of the local near field enhancement on rough silver surfaces, as used in surface enhanced Raman scattering (SERS).

O 74.9 Thu 18:00 MA 005

Dispersion control of propagating surface plasmons on nanoporous gold — •Neha Sardana[1,2] and Jörg Schilling[1] — [1]Centre for Innovation Competence SiLi-nano, Martin Luther University of Halle-Wittenberg, Karl-Freiherr-von-Fritsch-Str. 3, 06120 Halle (Saale), Germany — [2]International Max Planck Research School for Science and Technology of Nanostructures, Weinberg 2, 06120 Halle (Saale), Germany

Surface Plasmons (SPs) have wavelengths shorter than light and allow its strong confinement hence forming the backbone of current subwavelength optics. Their dispersion relation on plane metal/dielectric surfaces follows directly from Maxwell equations and is given as $k_x=(\omega/c)*\sqrt[2]{[\varepsilon_m*\varepsilon_d/(\varepsilon_m+\varepsilon_d)]}$, where k_x describes the wave vector of the SP and ε_m and ε_d are the dielectric constants of the metal and dielectric respectively. To control the dispersion of the SPs, normally ε_d is varied. An increase in ε_d causes a red shift of the SP at constant k_x or an increase of k_x for constant SP frequency ω. However in our experiments we explore the same possibility by changing the value of ε_m by introducing nanoporosity by dealloying method into the metal. Reflection measurements in the Kretchmann configuration are used to determine the dispersion relation of the SP on nanoporous gold/air interface. A characteristic dip in reflectivity, which shifted to shorter wavelength with increasing angle of incidence, was identified. This shift is compared with the Bruggeman effective medium theory. The experimental analysis proves that SP dispersion relation can be controlled by porosity of metal leading to larger flexibility in SP devices.

O 74.10 Thu 18:15 MA 005

Excitation of radial and other complex polarization states in special optical fibers by long period fiber gratings — •Christoph Zeh[1], Rico Illing[1], Bernd Köhler[1], Jörg Opitz[1], and Lukas M. Eng[2] — [1]Fraunhofer Institut für Zerstörungsfreie Prüfverfahren, Institutsteil Dresden, Maria-Reiche-Str. 2, 01109 Dresden — [2]Institut für Angewandte Photophysik, TU Dresden, 01069 Dresen

Radial polarization has drawn much attention in recent years, especially in the nano-optics and plasmonics community, because of its enhanced focusing properties as well as its ability to efficiently excite plasmons in radially symmetric structures.

Here, we present polarization mode excitation by long period fiber gratings (LPGs) in a special optical fiber. LPGs are able to efficiently transfer energy between co-propagating modes of the fiber. Since the field of a waveguide can always be represented as a set of mode fields with respective amplitudes and phases, polarization control is achieved by controlling the relative amplitudes and phases of the guided modes. We will demonstrate the use of a tunable acoustic LPG for this task and compare the results to other mechanical and UV-induced gratings.

The special fiber used in the above experiments is simulated by the multiple multipole technique (MMP) for a better understanding of the mode fields. This results in the transverse vector fields and propagation constants of the modes. The latter are necessary for designing the LPGs and for understanding the measurement results.