DS 41: [O] Plasmonics and Nanooptics VI (Joint Session DS/O/HL)

Time: Thursday 15:00–18:00 Location: H32

DS 41.1 Thu 15:00 H32

Surface plasmon polaritons on arrays of nanostructures with three-fold symmetry — •David Leipold, Stephan Schwieger, and Erich Runge — Institut für Physik und Institut für Mikro- und Nanotechnologien, Technische Universität Ilmenau

Surface plasmon polaritons (SPPs) are optical excitations that are confined to a metal-dielectric interface. They interact with propagating light if the metal is structured on the scale of the wavelength of the incident light. Here, we consider the coupling properties of quadratic arrays of nano-holes cut into a silver film. In particular, we investigate the influence of nano-holes with three-fold symmetry, which is incompatible with the four-fold symmetry of the array. Our numerical results reproduce aspects of earlier experimental findings [1]. Namely, there are shifts in the SPP-related minima and maxima in the reflectivity of specific reflection orders as function of the polarization of the incident light.

[1] B. Ashall, M. Berndt, and D. Zerulla, *App. Phys. Lett.* **91**, 203109 (2007)

DS 41.2 Thu 15:15 H32

Determination of surface plasmon polariton velocity measured by scattering scanning nearfield optical microscopy — •Brian Ashall and Dominic Zerulla — School of Physics, University College Dublin, Dublin 4, Ireland.

Surface Plasmon Polaritons (SPPs) are electromagnetic waves, propagating at the interface of a metal and a dielectric material, that are coupled to a charge density oscillation of the free electrons of the metal. In order to examine the optical nearfields of SPPs as they interact with nanoscale topography features, the technique of scattering Scanning Nearfield Optical Microscopy (sSNOM) is used. Presented here is an example of direct imaging of standing SPP interference patterns following interaction with a sharp topographic reflector. Analysis of this SPP interference pattern demonstrates a SPP propagation velocity of 0.93 times the speed of light. In addition to this, interaction of SPPs with specifically designed surface patterns will be demonstrated to yield a focussing of the plasmon nearfield.

DS 41.3 Thu 15:30 H32

Surface Plasmon Mapping using Photoelectron Emission Microscopy combined with Huygens principle — •Christian Schneider, Alexander Fischer, Martin Rohmer, Daniela Bayer, Pascal Melchior, and Martin Aeschlimann — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern

Photoelectron emission microscopy (PEEM) is a very powerful tool to investigate electron dynamics simultaneously in time and space with femtosecond temporal and nanometer spatial resolution. This microscopy technique is also suitable to study plasmonic behaviour in metal nanostructures, which combines the advantages of photonics and electronics. In this talk, we will show PEEM measurements of structures exhibiting surface plasmon polariton (SPP) resonances and present a novel simulation method based on Huygens' principle. As only the beating between the exciting light wave and the SPP wave can be observed by PEEM, a direct access to the surface plasmon wave isn't possible. Applying the simple wave model of Huygens in combination with a fast and reliable fitting algorithm to the complex PEEM data allows us to recalculate the propagating SPP wave for different shaped nanostructures. Examples like gold-squares as well as L-shaped structures are presented.

DS 41.4 Thu 15:45 H32

Photoemission Microscopy with Surface Plasmon Polaritons — Niemma Buckanie[1], Nicolai Rass[1,2], Pierre Kirschbaum[1], Michael Horn-von Hoegen[1], and •Frank-J. Meyer zu Heringdorf[1] — [1]Universität Duisburg-Essen, Fakultät für Physik and Center for Nanointegration (CeNIDE), Lotharstrasse 1, 47057 Duisburg, Germany — [2]present address: E.ON Gastransport GmbH, 45141 Essen, Germany

The interaction of frequency doubled femtosecond laser pulses with Silver provides a fantastic opportunity to study surface plasmon polariton (SPP) phenomena in Ag nanostructures. In two photon photoemission microscopy (2PPE PEEM) using femtosecond laser pulses, SPPs are imaged as a superposition of the electric field of the travelling SPP wave with the electric field of the laser pulse that hits the surface under grazing incidence. As the SPP and the fs laser pulse travel at different speeds, a moiré pattern is formed across the island that can be directly imaged in 2PPE PEEM. The period and orientation of the moiré pattern are influenced by the angle between the propagation direction of the SPP wave and the projection of the direction of incidence of the laser pulse into the surface plane. In a pump-probe experiment, where two coherent fs laser pulses are mutually time-delayed, it is possible to shift the moiré pattern across the island, to visualize the propagation of the SPP, and to control the location of maximum intensity behind the particle.

DS 41.5 Thu 16:00 H32

Free-Space Excitation of Propagating Surface Plasmon Polaritons — •Jan Renger[1], Romain Quidant[1], Niek van Hulst[1], Stefano Palomba[2], and Lukas Novotny[2] — [1]ICFO-Institut de Ciencies Fotoniques, 08860 Castelldefels (Barcelona), Spain — [2]Institute of Optics, University of Rochester, Rochester, NY 14627, USA

A unique feature of surface plasmon polaritons (SPPs) is that their in-plane momentum is larger than the momentum of free-propagating photons of the same energy. Therefore, it is believed that they can be excited only by evanescent fields created by total internal refection or by local scattering. Here, we provide the first demonstration of free-space excitation of surface plasmons by means of nonlinear four-wave mixing [1]. The process involves the vectorial addition of the momenta of three incident photons, making it possible to penetrate the light cone and directly couple to the SPP dispersion curve. Using this technique, surface plasmons can be launched on any metal surface by simply overlapping two beams of laser pulses incident from resonant directions. The excitation scheme is also applicable to other bound modes, such as waveguide modes, surface phonon-polaritons, and excitations of two-dimensional electron gases. [1] J. Renger et al. Phys. Rev. Lett. accepted (2009)

DS 41.6 Thu 16:15 H32

Femtosecond Surface Plasmon Characterisation on Metallic Dielectric Interfaces — Jose Francisco Lopez-Barbera, Brian Ashall, and •Dominic Zerulla — University College Dublin, School of Physics, Dublin 4, Ireland

As result of the latest advances in ultrashort pulse measurements, it is now possible to investigate ultrashort processes such as surface plasmon polariton (SPP) dynamics on a sub 20 fs time scale. SPPs are one of the fastest events in nature with time scales varying from 100s of attoseconds to 100s of nanoseconds. Using advanced autocorrelation techniques based on optical gating (FROG and GRENOUILLE) in combination with a 12 fs broadband Ti:Sa laser system, we have characterised the resonant photon-SPP coupling processes on metallic thin films. In particular we focus on the excitation, propagation and life-time of the SPPs at high temporal and frequency resolution. We will present surprising insights into the behaviour of SPPs on this short timescales, including data on the interference of the SPP emission with the directly reflected/diffracted channel.

DS 41.7 Thu 16:30 H32

Light guiding in para-hexaphenylene based nanofibers in interaction with a gold substrate studied by photoemission electron microcopy — •Till Leissner[1], Michael Bauer[1], Kasper Thilsing-Hansen[2], Roana Melina de Oliveira Hansen[2], Jakob Kjelstrup-Hansen[2], and Horst-Günther Rubahn[2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Kiel — [2]NanoSYD, Mads Clausen Institute, University of Southern Denmark

Para-hexaphenylene (p-6P) based nanofibers have been proven to support almost loss-free and broadband optical wave guiding up to wavelengths as short as 400 nm [1]. As a dielectric distortion on top of a metallic substrate, they can, additionally, support the localized propagating of interface plasmon modes. P-6P nanofibers may therefore be useful as light-channeling sub-units and highly localized emitters in future ultrafast nanophotonic devices. To address the interaction between optical waveguiding and surface plasmon excitations we deposited well aligned p-6P nanofibers onto microstructured gold films.

Photoemission Electron Microscopy was used to image the local light modes excited by a femtosecond laser pulse. Within the nanofibers, periodic beating patterns are observed which exhibit a strong dependence on the polarization the excitation laser field. The pattern periodicity can quantitatively be modeled and assigned to the interference between a propagating interface plasmon and the excitation light field, thus given evidence for plasmon guiding by the nanofibers.

[1] H.-G. Rubahn et al., Appl. Phys. Lett. 82, 10 (2003)

DS 41.8 Thu 16:45 H32

Surface Plasmon Excitation on Magnetoactive Hybrid Materials — •Dominic Zerulla and Brian Ashall — UCD Dublin, School of Physics, Dublin 4, Ireland

The interaction of surface plasmons polaritons (SPPs) - fluctuations in the electron density at the interface between media with dielectric constants of opposite sign - with magnetically ordered systems has attracted a significant interest in recent years, as a result of the possibility of enhancing magneto-optical properties, like the Faraday and Kerr effect. More recently, research has been focused on the merging of the areas of spintronics and plasmonics, thus developing a new field called spin-plasmonics. Here, we will present a systematic study of the excitation of SPPs on ferromagnetic materials in multilayered structures composed of thin films of nickel, iron, cobalt, capped by a silver layer [1]. The electromagnetic properties of the systems are theoretically and experimentally investigated as a function of the metal layers' thickness and the critical parameters in this study of the interaction between surface plasmon waves and the magneto-active material are discussed. Finally, an optimized structure for the investigations of spin-plasmonic effects in thin films is proposed.

[1] L. Sapienza, D. Zerulla, "Surface Plasmon Excitation on Magnetoactive Materials", Phys. Rev. B 79, 033407 (2009)

DS 41.9 Thu 17:00 H32

Loss compensation of surface plasmon polaritons in multilayer structures with optically pumped gain media — Patrick Scholz[1,2], •Stephan Schwieger[1], and Erich Runge[1] — [1]Institut für Physik and Institut für Mikro- und Nanotechnologien, Technische Universität Ilmenau, 98693 Ilmenau, Germany — [2]Climate Science Division, Alfred Wegener Institut für Polar- und Meeresforschung, 27570 Bremerhaven, Germany

Surface plasmon polaritons (SPPs) that are excited at metal gratings have large losses due to metallic absorption and re-radiation into propagating far-field modes. These losses can be possibly compensated by energy transfer from thin layers of optically excited media, such as semiconductor quantum wells in close vicinity to the metal surface [1,2]. In this contribution, the loss compensation is investigated theoretically as a function of the geometry of the sample. Parameters, such as the grating period, the slit width, the thickness of the metal film, and the spatial separation between the quantum well and the metal are varied. Furthermore, the formation of coupled SPP-exciton modes and some of their properties, as, e.g., their life times, propagation lengths, and group velocities, are discussed.

[1] P. Vasa, R. Pomraenke, S. Schwieger, Yu. I. Mazur, Vas. Kunets, P. Srinivasan, E. Johnson, J. E. Kihm, D. S. Kim, E. Runge, G. Salamo, and C. Lienau, *Phys. Rev. Lett.* **101**, 116801 (2008).
[2] S. Schwieger, P. Vasa, and E. Runge, *Phys. Stat. Sol. (b)* **245**, 1071(2008).

DS 41.10 Thu 17:15 H32

Electrically influencing the surface plasmon dispersion relation — •Brian Ashall[1], Michael Berndt[2], and Dominic Zerulla[1] — [1]School of Physics, University College Dublin, Dublin 4, Ireland. — [2]Max Planck Institute of Molecular Cell Biology and Genetics, 01307 Dresden, Germany.

Surface Plasmon Polaritons (SPPs) are a resonant coupling of electromagnetic radiation to charge density oscillations of the conduction electrons at the surface of a metal. As this SPP charge density oscillation is based on electron movement, it is intuitive to consider the possibility of influencing SPPs with an applied electric current, which also moves the charges to which the SPPs are coupled. This possibility to directly influence SPPs is examined experimentally, along with indirect electrical influences, such as electric Joule heating. Additionally, the inverse process is examined; i.e. the potential for the creation of a direct net movement of electrons by propagating SPPs. The possibility for this to occur is supported by the fact that the electromagnetic waves describing SPPs possess electrical field components along the propagation direction of the plasmons, and so they should have some potential to move the charge carriers to which they are coupled.

DS 41.11 Thu 17:30 H32

Efficient Coupling of Single NV Centres to Surface Plasmon Polaritons — •Bernhard Grotz[1], Merle Becker[1], Sebastian Macke[2], Julia Tisler[1], Gopalakrishnan Balasubramanian[1], Fedor Jelezko[1], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart, Germany — [2]Max-Planck-Institut für Metallforschung, Stuttgart, Germany

When light interacts with metal surfaces it excites electrons which can form propagating charge-density waves called surface plasmon polaritons. These collective electronic excitations have many applications due to their ability to produce strong electric fields localized to subwavelength distance scales. It was shown that nanodiamonds containing single nitrogen-vacancy (NV)centres can be attached efficiently to silver nanowires where they are used to excite single surface plasmon polaritons [1]. We discuss recent approaches to address this problem and in particular how to increase the coupling strength between NV and nanowires.

[1] R. Kolesov, B. Grotz, G. Balasubramanian, R. J. Stöhr, A. A. L. Nicolet, P. R. Hemmer, F. Jelezko & J. Wrachtrup, Wave-particle duality of single surface plasmon polaritons, Nature Physics 5, 470-474 (2009)

DS 41.12 Thu 17:45 H32

Plasmonic Collimation for near-IR Laser Diodes — •Xinghui Yin[1,2], Justin White[3], Mark Brongersma[3], and Thomas Taubner[1,2] — [1]RWTH Aachen — [2]Fraunhofer-Institut für Lasertechnik — [3]Stanford University

It is known that one can use gratings to couple freely-propagating light to plasmon modes. Ebbesen [1] examined the reverse process at a metallic slit-grating structure and discovered a beaming effect. Subsequently, Capasso [2] successfully combined such a structure with a Quantum Cascade Laser at a mid-infrared wavelength of $\lambda = 9.8\ \mu$m to reduce the beam divergence in one direction.

In our work, we investigate plasmonic collimators for laser diodes at near-infrared wavelengths. We focus on optimizing the structure parameters for $\lambda = 960$ nm. In this region, it is important to take the higher surface plasmon propagation losses into consideration. Also, we examine the efficiency of plasmonic collimation compared to conventional laser diode collimation by cylindric lenses.

The simulations are carried out using a 2D Finite Difference Frequency Domain code developed by J. White. Using the obtained parameters, we fabricate the plasmonic collimator and characterize it.

[1] Ebbesen et al., 2002, Vol 297, Science
[2] Capasso et al., Nature Photonics, 2008