O 23: Symposium: Ultrafast Nanooptics III

Time: Tuesday 11:15–12:45 Location: H38

O 23.1 Tue 11:15 H38

Mapping the Plasmon Dynamics in Silver Nano-particles using Phase-Resolved PEEM — Jörg Lange[1], Martin Rohmer[1], Daniela Bayer[1], Christian Schneider[1], Carsten Wiemann[1], Martin Aeschlimann[1], and •MIchael Bauer[2] — [1]Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern — [2]Institut für Experimentelle und Angewandte Physik, CAU Kiel, 24098 Kiel

Phase-resolved Two-Photon Photoemission (PR-2PPE) in combination with Photoemission Electron Microscopy (PEEM) is used to locally address the femtosecond dynamics associated with localized surface plasmon excitations (LSP) in well-defined silver nano-particles. At a lateral resolution in the sub-50 nm regime we are able to map the phase evolution of the particle-internal field as governed by the plasmon resonance energy and resonance width with sub-femtosecond accuracy. An illustrative example that will be presented is the observation of the dephasing process of the local field response between two neighbouring particles exhibiting differing plasmon energies. Furthermore we find particle-internal lateral inhomogenities in the dynamical response to the external laser-field, which we assign to the phase propagation of the excited plasmon mode through the particle.

O 23.2 Tue 11:30 H38

Efficient modelling of nonlinear wave propagation and radiation dynamics in nano-photonic systems — •Kurt Busch, Michael König, Jens Niegemann, Martin Pototschnig, and Lasha Tkeshelashvili — Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany

Time-domain simulations play a very prominent role in the investigation and design of three-dimensional micro- and nano-photonic structures. In many cases, these strongly scattering systems need to be modeled on long time-scales with high precision. Such high accuracy, combined with unconditional stability and efficient performance, can be achieved via an operator-exponential method based on Krylov-subspace techniques[1].This approach is capable of handling optically anisotropic, lossy and dispersive materials as well as CFS-PML boundary conditions. Therefore, it is very well suited to study most experimentally relevant photonic nano-structures. Furthermore, it is straightforward to extend the scheme to handle nonlinear wave propagation, wave mixing phenomena and coupled systems, where similar accuracy and performance characteristics are achieved.

[1] J. Niegemann, L. Tkeshelashvili, and K. Busch, "Higher-order time-domain simulations of Maxwell's equations using Krylov-subspace methods", J. Comput. Theor. Nanosci., in press

O 23.3 Tue 11:45 H38

Light confinement via grating coupling of surface plasmons onto nanoscopic metal tips — •Claus Ropers[1], Catalin Neacsu[1], Thomas Elsässer[1], Martin Albrecht[2], Markus Raschke[1,3], and Christoph Lienau[1,4] — [1]Max-Born-Institut, D-12489 Berlin — [2]Institut für Kristallzüchtung, D-12489 Berlin — [3]Department of Chemistry, University of Washington, Seattle, WA 98195-1700 — [4]Institut für Physik, Carl von Ossietzky Universität Oldenburg, D-26129 Oldenburg

Localized and delocalized surface plasmon polaritons (SPPs) promise an unprecedented amount of microscopic light control and confinement. Structuring the surface of metals with nanometer precision allows for a tailoring of the SPP excitation and propagation. This may lead to new forms of nano-focusing, as proposed theoretically for tapered SPP waveguides. In this context, the achievement of highly localized light at the apex of a metal nano-tip is particularly desirable, as currently most apertureless near-field optical techniques are affected by considerable far-field background light.

Here, we realize a local femtosecond light source by focusing SPPs on nano-fabricated metallic tips with with radii down to 10 nm. By the use of focused ion beam milling, one-dimensional gratings are written onto the tip shaft, several micrometers away from the apex. Illumination of the grating with a broadband 7-fs Ti-sapphire oscillator leads to resonant excitation of SPPs, which travel to the tip apex and are reradiated. The clear spatial separation of the excitation from the tip end carries great potential as a novel light source in near-field microscopy.

O 23.4 Tue 12:00 H38

Multiphoton-Photoemission Microspectroscopy of Polystyrene Microspheres — •Gerhard Lilienkamp, Florian Lindla, Christoph Senft, and Winfried Daum — Instuitut für Physik und Physikalische Technologien, TU Clausthal, Leibnizstraße 4, 38678 Clausthal-Zellerfeld

Previous multiphoton-photoemission microscopy (PEEM) studies have focused on metallic and magnetic nanostructures. We have extended the application of multiphoton-PEEM to a dielectric system. Polystyrene (PS) microspheres with diameters between 300 nm and 1000 nm deposited on an oxidized Pt substrate have been imaged using a photoelectron microscope with 400 nm (3.1 eV) femtosecond laser excitation. Despite of a minimum energy of 7.6 eV required to excite electrons from the HOMO of PS to the vacuum level [1], strong photoemission from the microspheres is observed upon illumination with 3.1 eV laser photons. Analysis of the dependence of the photoemission on the power density of the laser pulses yields a nearly pure quadratic dependence for the Pt substrate consistent with two-photon photoemission while the emission from PS contains both linear and quadratic contributions. This finding can be rationalized in terms of a population of an unoccupied state in PS by two-photon excitation with a lifetime that is large compared to the time between two consecutive laser pulses (12.5 ns). Using energy-resolved PEEM, we observed laser-induced photoconductivity of PS which is consistent with a highly filled intermediate state.

[1] C.B. Duke et al. Phys. Rev. B 187 (1978) 571

O 23.5 Tue 12:15 H38

Nanoscale force manipulation in the vicinity of a metal nanostructure — C. Spindler[1], T. Brixner[1], J. Carcía de Abajo[2], and •W. Pfeiffer[3] — [1]Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Instituto de Optica, Serrano 121, 28006 Madrid, Spain — [3]Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, 33516 Bielefeld, Germany

The tight focus of Gaussian beams is commonly used to trap dielectric particles in optical tweezers. The corresponding field distribution generates a well-defined trapping potential that is only marginally controllable on a nanometer scale. Here we investigate the influence of a metal nanostructure that is located in the vicinity of the trapping focus on the trapping potential by calculating the corresponding field and force distributions. Even for an excitation wavelength that is tuned far from the plasmonic resonance of the nanostructure the trapping potential is significantly altered by the presence of the nanostructure. For the given nanostructure, i.e. a ring of spheres that is illuminated in axial direction, a stronger localization of the focus in all directions is observed. The superposition of this non-resonant Gaussian field with a planar wave illumination that is tuned on the plasmonic resonance gives a handle to modify the trapping potential. Polarization and intensity of the resonant illumination allows modifying the equilibrium position of the trapping potential providing thereby means to steer dielectric particles with nanometer precision.

O 23.6 Tue 12:30 H38

Dephasing time and damping mechanisms of surface plasmon polaritons in gold nanoparticles — •Nils Borg, David Blazquez Sanchez, Christian Hendrich, Frank Hubenthal, and Frank Träger — Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology - CINSaT, Universität Kassel, Heinrich-Plett-Straße 40, D-34132 Kassel

The ultrafast electron dynamics in gold nanoparticles (NPs) was studied by measuring the dephasing time T_2 of the surface plasmon polariton by means of persistent spectral hole burning. The dephasing time of gold grown on sapphire and TiO_2 substrates was measured as a function of photon energy and the particle size. Dephasing times ranging from 5 to 17 fs were extracted. Furthermore, an explicit influence of the reduced dimension of the NPs has been determind, which plays a role for NPs with radii below 12 nm already. Most importantly, a dependence of T_2 on the decreasing particle dimensions which fulfilled a $1/R$-dependence was found and we could obtain a damping parameter for gold on sapphire of $A = (0.32 \pm 0.06)$ nm/fs. Comparison with other measurements as well as with theoretical predictions could identify surface scattering and Landau-damping as the most important mechanisms. Recent further experiments on gold NPs supported on

TiO_2 showed a further reduction of the dephasing time. For example, for NPs with a radius of approximately 13 nm we observed a decrease from $T_2 \approx 15$ fs for NPs grown on sapphire to $T_2 \approx 12$ fs for NPs grown on TiO_2 at a photon energy of 1.65 eV. This indicates an additional damping mechanism, i.e. chemical interface damping.