O 59: Poster Wednesday: Plasmonics and Nanooptics 2

Time: Wednesday 18:00–20:00 Location: P4

O 59.1 Wed 18:00 P4

Quantum description of the optical response in metal nanoparticles — •Jonas Grumm, Robert Salzwedel, Malte Selig, and Andreas Knorr — Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Berlin, Germany

The optical response of metal nanoparticles is dominated by the formation of collective electronic resonances, so-called plasmons.

Here, we present a microscopic approach for their temporal dynamics based on the self-consistent treatment of microscopic Boltzmann transport equations and macroscopic Maxwell equations for the electromagnetic fields. Numerical simulations describe the thermalization of the phonons and the relaxation of the electrons upon optical excitation and allow to include nonlinear optical processes in the description.

O 59.2 Wed 18:00 P4

Access to hot electron dynamics in a nanotip via ultrafast THz-streaking — •Dominik Weber, Felix Sommer, Moritz Heindl, and Georg Herink — Experimental Physics VIII - Ultrafast Dynamics, University of Bayreuth, Germany

Field enhancement and localization of single-cycle Terahertz radiation at metallic nanotips forms the basis for a broad range of emerging ultrafast interactions - ranging from ultrafast nearfield and tunnelling microscopy, transient carrier dynamics to strong-field phenomena. We present an experimental access to ultrafast hot electron dynamics at the apex of a free-standing nanotip based on THz-nearfield streaking spectroscopy [1,2]. Using tunable fs-pulses, we induce non-equilibrium electron excitations and transient hot electron distributions. Access to local hot electron dynamics confined to the apex is provided via nonlinear sub-cycle field emission at the peak of the enhanced single-cycle THz-waveform. Based on experimental streaking waveforms, we discuss the impact of excitation conditions on hot electron relaxation and possibilities for external control of ultrafast carrier dynamics.

L. Wimmer et al., "Terahertz control of nanotip photoemission", Nature Physics 10 (2014)

G.Herink et al., "Field emission at terahertz frequencies: AC-tunneling and ultrafast carrier dynamics", New Journal of Physics 16 (2014)

O 59.3 Wed 18:00 P4

Near-field optical investigation of bandgap effects in SnTe — •Christian Justus, Konstantin G. Wirth, Dario Siebenkotten, Lukas Conrads, Sophia Wahl, Matthias Wuttig, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Phase change materials (PCMs) are prime candidates for non-volatile memory solutions[1]. Storage mediums with high memory density require a method for determining material properties with nanometer precision. One such tool to investigate the optical properties of nanostructures is scattering-type scanning near-field optical microscopy (s-SNOM). Thus far, bandgap effects in semiconductors have eluded experimental observation in s-SNOM. Specifically metavalently bonded materials may exhibit a bandgap shift by over a factor of three in reduced dimensions, such as in the case of Tin Telluride (SnTe) with a shift from 0.2 to 0.7 eV[2]. The primary goal of this work is to use s-SNOM to spectoscopically characterize bandgap effects in SnTe thin films. We find good agreement between Fourier-transform infrared spectroscopy (FTIR) and s-SNOM measurements over a spectral range spanning 0.3 to 0.9 eV and are able to identify a bandgap contribution to the spectral s-SNOM data. Our results may help to get a deeper insight into confinement effects on the optical properties of nano-scale PCM structures, such as PCM memory cells, and may provide a valuable tool for the analysis and characterization of PCM memory devices with high storage density.

O 59.4 Wed 18:00 P4

Energy and momentum distribution of surface plasmon-induced hot carriers — •Christopher Weiss[1], Eva Prinz[1], Michael Hartelt[1], Benjamin Stadtmüller[1,2], and Martin Aeschlimann[1] — [1]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, Germany

Investigating the energy and momentum space signature of plasmon-induced hot electrons is essential for understanding novel plasmonic energy conversion schemes. The question remains, if plasmon-induced and photon-induced hot carriers are fundamentally different. For the bulk plasmon resonance, a fundamental difference is known, yet for the technologically important surface plasmons this is far from being settled. Just recently, we identified a similar characteristic signature in the surface plasmon polariton (SPP) emission that distinguishes them from photon-induced electrons [1].

To separate the energy and momentum distribution of the plasmon-induced hot electrons from those of the photoexcited electrons, we employ a two-colour femtosecond time-resolved 2-photon photoemission (2PPE) experiment. The spatial evolution of the photoemitted electrons was observed with energy-resolved photoemission electron microscopy (PEEM) and momentum microscopy during the propagation of an SPP pulse along a gold surface. Building on these findings, we extend this concept to SPPs of single crystalline silver surfaces to investigate the influence of the band structure and material properties.

[1] Hartelt et al., ACS Nano 15, 12 (2021), 19559–19569

O 59.5 Wed 18:00 P4

Near-field optical investigation of few layer graphene — •Lina Jäckering, Konstantin Wirth, Christian Justus, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Few layer graphene (FLG) samples usually consist of various stacking orders, which show different optical and electronical properties. Direct imaging and characterization of stacking domains in FLG samples can be done with scattering scanning near-field optical microscopy (s-SNOM) [1]. S-SNOM is outstanding for its nanoscale resolution of about 20 nm and its capability to image buried structures [2]. Thus, it allows to characterize encapsulated FLG samples as they are used in transport devices. Previous s-SNOM investigations focussed on the excitation of free charge carriers in FLG at about 0.1 eV [3,4]. Recently, FLG stackings have been identified by exciting interband transitions (0.27 – 0.56 eV) [1,5]. Interband resonances of FLG have only been measured at punctual energies or small energy regimes. Here, we investigate trilayer graphene and bilayer graphene in the spectral range of 0.27 – 0.9 eV, providing a deeper understanding of their near-field optical response, particularly of their interband resonance. Furthermore, we identify different stacking domains in FLG samples encapsulated in hexagonal boron nitride. Our findings provide a promising technique to select stacking domains for fabrication of transport devices.

1. Kim et al., ACS Nano, **9**, 7 (2005); 2. Jeong et al., Nanoscale, **9**, 12 (2017); 3. Fei et al., Nature **487**, 82 (2012); 4. Jiang et al., Nat. Mater. **15**, 840 (2016); 5. Wirth et al., arXiv: 2203.07971v1 (2022)

O 59.6 Wed 18:00 P4

Photoemission electron microscopy of Ag nanostructures on silicon substrates — •Muhamed Sewidan, Katharina Engster, Kevin Oldenburg, Sylvia Speller, and Ingo Barke — Rostock University, Rostock, Germany

We study electronic and optical coupling phenomena between plasmonic nano-objects, organic molecules, and the substrate. Localized plasmons created in metal nanostructures can lead to enhanced multiphoton photoelectron emission under pulsed light excitation. In a photoemission electron microscope (PEEM) individual particles of sub-15 nm size can be easily distinguished, providing access to the single-particle plasmon properties for a large number of species simultaneously [1]. We present results on the spatially resolved photoemission dependence on wavelength, polarization, and the surface composition for size-selected Ag particles and nanostructure arrays prepared by nanosphere lithography on silicon. [1] K. Oldenburg et al., J. Phys. Chem. C 123, 1379 (2019)

O 59.7 Wed 18:00 P4

Inelastic electron-photon scattering with broadband optical pulses — •Niklas Müller, Rasmus Lampe, Gerrit Vosse, Christopher Rathje, and Sascha Schäfer — Institute of Physics, University of Oldenburg, 26129 Oldenburg, Germany

The inelastic scattering of fast electrons at spatially confined light fields has recently enabled new techniques in ultrafast transmission electron microscopy (UTEM) [1,2,3] but is typically performed with narrow bandwidth light pulses. Here, we study the interaction of fast electrons with broadband, strongly chirped light fields. Optical pulses are generated in a home-build noncollinear optical parametric amplifier (NOPA) [4] with a spectral width of up to 200 nm in the visible range. Light reflection at an aluminum coated silicon nitride membrane leads to an intense multicolor near-field at which we inelastically scatter femtosecond electron pulses forming photon sidebands in the electron energy spectrum. The spectral sideband position changes with the relative timing between electron and light pulse according to the instantaneous frequency of the driving laser field. Different parameter regimes of electron and light chirp and their impact on inelastic scattering patterns are discussed.

[1] G. De Abajo and M. Kociak, New J. Phys. 10, 073035 (2008) [2] Barwick et al., Nature 462, 902-906 (2009) [3] Feist et al., Nature 521, 200-203 (2015) [4] G. Cerullo and S. De Silvestri, Rev. Sci. Instrum. 74, 1 (2003)

O 59.8 Wed 18:00 P4

Probing Excitons-Photon interaction in WSe2 beyond the Non-Recoil Approximation — •Fatemeh Chahshouri, Masoud Taleb, and Nahid Talebi — Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany

Cherenkov radiation from electrons propagating in materials with a high refractive index have applications in particle-detection mechanisms. However, the theory of the Cherenkov radiation has been treated up to now using the non-recoil approximation, which neglects the effect of electron deceleration in materials. Here, we report on the effect of the electron-beam deceleration on the radiated spectrum and exciton-photon interactions in nm-thick WSe2 crystals beyond the non-recoil approximation. The calculation of the Cherenkov radiation is performed by simulating the energy distribution of an electron beam propagating inside a thick WSe2 using the Monte Carlo method, and ascertaining the radiating power from electron beams with Liénard-Wiechert retarded potentials. Using this approach, we numerically demonstrate that in thick flakes the radiation due to the electron-beam deceleration is the dominating radiation mechanism. Our numerical findings agrees well with the experimental cathodoluminescence spectra. We further demonstrated that the captured CR in thick slabs could cause Fabry-Perot resonances that emerge as fine structures in the acquired CL spectra and demonstrate the fully coherent process of CR emission, happening due to its phase-matched excitation nature. Our findings pave the way for an accurate design of particle scintillators and detectors, based on the strong-coupling phenomenon.