HL 23: Plasmonics and Nanooptics II: Light-Matter Interaction

Time: Monday 15:00–16:45 Location: TRE Ma

HL 23.1 Mon 15:00 TRE Ma

Three-electron photon interaction mediated by localized plasmons — Peter-Jan Peters and •Richard Berndt — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, 24098 Kiel

The light emission from a scanning tunneling microscope operated on Ag(111) surfaces at 5 K is analyzed from low conductances G to values approaching the conductance quantum. Optical spectra reveal emission due to localized plasmons with photon energies exceeding the applied bias more than twice ($h\nu > 3eV$). The emission intensity varies in a non-monotonic fashion with G. An empirical model reproduces the scaling of the photon yield and the optical spectra near the thresholds for two-electron and three-electron processes. While some heating of the electron gas occurs, the predominat part of the light emission is due to coherent processes.

HL 23.2 Mon 15:15 TRE Ma

AlN/GaN multilayer interface phonons studied with mid-IR second-harmonic phonon spectroscopy — •Christopher J. Winta[1], Nikolai Passler[1], Ilya Razdolski[1], D. Scott Katzer[2], Ioannis Chatzakis[3], Neeraj Nepal[2], David J. Meyer[2], Chase T. Ellis[2], Joseph G. Tischler[2], Alexander J. Giles[2], Sandy Gewinner[1], Wieland Schöllkopf[1], Martin Wolf[1], Joshua D. Caldwell[2], and Alexander Paarmann[1] — [1]Fritz-Haber-Institut der MPG, Faradayweg 4–6, 14195 Berlin — [2]U.S. Naval Research Laboratory, Washington, D.C. 20375 — [3]NRC Postdoctoral Fellow (residing at NRL, Washington D.C. 20375)

Combining multiple atomic-scale layers of polar crystals allows for active modification of phonon lifetimes, frequencies and hence engineering of Reststrahlen band spectral positions. Specifically, new interface optical phonon modes emerge in these so-called crystalline hybrids (XHs). The atomic-scale layer thicknesses allow for tuning of these modes, opening up a new class of engineered materials [1].

In our experiments, we study the nonlinear response of an AlN/GaN 27-layer superlattice material on a SiC substrate with varying layer thicknesses ranging from ∼2 to 4 nm independently for both constituents by means of mid-IR second-harmonic phonon spectroscopy [2]. The higher spectral resolution of SHG as compared to reflectivity allows us to uniquely assign peaks to specific modes. In consequence, we are able to identify interface phonons by their layer thickness dependent behavior. [1] Caldwell et al., Nat. Nanotechnol. **11**, 9–15 (2016); [2] Paarmann et al., Phys. Rev. B **94**, 134312 (2016)

HL 23.3 Mon 15:30 TRE Ma

Second Harmonic Generation from Surface Phonon Polaritons in Silicon Carbide — •Nikolai Christian Passler, Ilya Razdolski, Martin Wolf, and Alexander Paarmann — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

Surface Phonon Polaritons (SPhP) have recently emerged as novel building block for mid-infrared (MIR) nanophotonic applications, promising to possibly overcome the intrinsic loss problem of plasmonics [1]. SPhPs arise in polar dielectrics due to optical phonon resonances leading to negative permittivity between transverse and longitudinal optical phonon frequencies. Furthermore, SPhPs exhibit tremendous field enhancements, driving the lattice atoms into a strongly nonlinear regime. Hence, SPhPs might grant a frequency-tunable access to vibrational-driven transient transitions of material phases.

Here, we use linear and nonlinear MIR spectroscopy [2], revealing the resonant second harmonic generation (SHG) arising from propagating SPhPs in SiC in the Otto geometry. Our experiments employ intense, tunable and narrowband MIR pulses from a free-electron laser. Corresponding to the absorption dip in our reflectivity spectra, we observe a strongly enhanced SHG yield at the SPhP resonance. Furthermore, we develop a matrix formalism for anisotropic multilayer wave propagation, allowing for precise prediction of the linear and non-linear properties of SPhPs.

[1] Caldwell et al., Nano Letters (2014) [2] Paarmann et al., APL (2015)

HL 23.4 Mon 15:45 TRE Ma

Charge dynamics in organic materials imaged with nanosecond and nanometer resolution. — •Anna Rosławska[1], Pablo Merino[1], Christoph Grosse[1,2], Markus Etzkorn[1], Klaus Kuhnke[1], and Klaus Kern[1,3] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany — [2]NanoPhotonics Centre, Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, UK — [3]École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

The dynamics of charges and bound pairs of charge carriers (excitons) determines the performance of organic optoelectronic devices, such as light emitting diodes or solar cells. Precise nanoscale characterization of light emission at the nanosecond timescale can help to improve the efficiency of such devices. Here, by using low-temperature Scanning Tunneling Microscopy-induced Luminescence (STML) we probe the charge dynamics on defect-related light emission centers in C_{60} thin films. We apply 100 ns long square voltage pulses [1] to the tunnel junction and record transients of the emitted light with sub-nanosecond resolution as a function of injection current and lateral distance from the emission center. Analysis of luminescence transients discloses time constants ranging from 5 ns to 50 ns depending on the position in space. They can be attributed to hole and electron injection rates to the defect state. Our approach allows mapping the transients on a grid and therefore obtaining light intensity videos with sub-nanosecond time resolution at the ultimate molecular scale.
[1] C. Große, *et al.*, Appl. Phys. Lett., 103, 183108 (2013)

HL 23.5 Mon 16:00 TRE Ma

Single solid state quantum emitter coupled to a resonant plasmonic antenna array — •Markus Pfeiffer[1,2,3], Paola Atkinson[4], Armando Rastelli[4], Oliver G. Schmidt[4], Harald Giessen[3], Markus Lippitz[5,2,3], and Klas Lindfors[1,2,3] — [1]Department of Chemistry, University of Cologne, Luxemburger Str. 116, 50939 Köln, Germany — [2]Max Planck Institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart, Germany — [3]Fourth Physics Institute and Research Center SCOPE, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [4]Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany — [5]Experimental Physics III, University of Bayreuth, Universitätsstrasse 30, 95447 Bayreuth, Germany

Plasmon resonant arrays or meta-surfaces shape optical fields and the local density of states. They provide large regions of enhanced emission from emitters and greater design flexibility than single nanoantennas. This makes them of great interest for engineering optical absorption and emission. Here we study the coupling of single self-assembled semiconductor quantum dots to plasmonic meta-surfaces. We investigate the influence of spectral properties of the nanoantenna array and the position of the emitter in the unit cell of the structure. We observe a resonant enhancement due to emitter-array coupling in the far-field regime and find a clear difference from the interaction of an emitter with a single antenna.

HL 23.6 Mon 16:15 TRE Ma

Plasmon-exciton coupling in microcavities — •Igor Shavrin[1], Mario Hentschel[2], Daniel E. Gómez[3,4], Dirk Hertel[1], Klaus Meerholz[1], Timothy J. Davis[3,4], Harald Giessen[2], and Klas Lindfors[1] — [1]Department of Chemistry, University of Cologne, Luxemburger Str. 116, 50939 Köln, Germany — [2]4^{th} Physics Institute and Research Center SCOPE, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [3]CSIRO, Materials Science and Engineering, Private Bag 33, Clayton, Victoria, 3168, Australia — [4]Melbourne Centre for Nanofabrication, Australian National Fabrication Facility, Clayton VIC 3168, Australia

Strong interactions between plasmons and excitonic states are interesting due to the extreme field confinement in plasmon resonant structures [1]. So far strong plasmon-exciton coupling has been achieved by placing the excitonic material in the near-field of a metal nanostructure. This however results in strong quenching of fluorescence.

Here we study the plasmon-exciton coupling mediated by a microcavity mode. We fabricate gold nanorod antennas in a wavelength-thick thin-film microcavity with the antennas positioned at one of the field anti-nodes using dielectric spacer layers. At the other anti-node we deposit a thin film of merocyanine molecules. These molecules form large J-aggregates that exhibit excitons with a strong dipole moment and therefore resulting in enhanced light-matter coupling. We observe

three avoided crossings in reflection spectra that are well explained by a model with three coupled oscillators.

[1] J. Bellessa *et al.*, Phys. Rev. Lett. **93**, 036404 (2004).

HL 23.7 Mon 16:30 TRE Ma

Double Modematching for Metal Nanoantennas — •Thorsten Feichtner[1], Silke Christiansen[2,3], and Bert Hecht[1] — [1]Nano-Optics & Biophotonics Group, Department of Experimental Physics 5, Röntgen Research Center for Complex Material Research (RCCM), Physics Institute, University of Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [3]Max Planck Institute for the Science of Light, Günther-Scharowsky-Straße 1, 91058 Erlangen, Germany

The efficient coupling of photons from propagating far-fields to nanoscale volumes is a fundamental problem in quantum optics and at the heart of light-matter interaction. A common model system is the coupling between a point-like two-level quantum emitter (QE) and the continuum of radiative modes, which can be expressed in terms of the frequency-dependent partial local density of states (LDOS) at the QE position. Resonant plasmonic nanoantennas can be designed to strongly localize fields into a small volume leading to a LDOS enhanced by a factor of 10^5 and possibly beyond.

Here a description of power transfer between a QE and an optical antenna resembling a three-dimensional mode matching formalism is developed[1]. After introducing a second dipole in the far-field, another mode-matching step leads to a set of novel optical antenna design guidelines for QE emission enhancement. Accordingly a plasmonic cavity antenna (PCA) geometries is devised and compared to an established dipolar two-wire antenna geometry.

[1] T. Feichtner, S.H. Christiansen, and B. Hecht; arXiv:1611.05399