O 25: Plasmonics and nanooptics: Light-matter interaction, spectroscopy II

Time: Tuesday 10:30–13:00 Location: MA 041

O 25.1 Tue 10:30 MA 041

Influence of plasmon-induced hot-electrons on the lattice dynamics of graphene — •Marcel Weinhold, Sangam Chatterjee, and Peter J. Klar — Justus Liebig University Giessen, Institute of Experimental Physics I, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

The plasmon-induced excitation of hot-electrons holds an extraordinary potential for light harvesting up to the infrared region of the electromagnetic spectrum. Besides applications in photocatalysis, hot-carrier phenomena enable one to realize various semiconductor-based optoelectronic devices. Graphene is a promising material for utilizing plasmon-induced hot-electrons formed in gold nanoparticles. Since lattice dynamics have a major impact on the transport properties it is important to investigate the influence of gold nanostructures and the injected hot-carriers on graphene's vibrational modes.Therefore, we performed Raman-mappings across individual spherical gold nanoparticles deposited on graphene to both, generate hot-carriers in case of plasmon resonance and determine the corresponding Raman-spectra in order to obtain information on the change in lattice dynamics. We observe a systematic shift in the measured phonon-frequencies related to a coupling between the electronic and phononic system correlating with the applied laser power.

O 25.2 Tue 10:45 MA 041

Zooming in on the Surface: Numerics for Localization of Light on Coated Nanosponges — •Felix Schwarz and Erich Runge — TU Ilmenau, Institut für Physik und IMN MacroNano, 98693 Ilmenau

Nanoporous gold-nanoparticles (nanosponges) are an outstanding example for disorder-induced localization of light and huge field-enhancements, as shown by photoemission from long-lived, highly localized plasmons with unmatched excitation efficiencies [1]. Coated with nonlinear optical materials or quantum dots, these particles could serve as an easy-access tool for quantum optics and ultra-sensitive chemical sensors. However, as the nature of the localization and environment-induced changes remain poorly understood, the integration of these features proves difficult. Simulations are necessary to design structures with optimally tailored disorder properties for the given task. The challenge for these simulations is the required nanometer resolution to confidently resolve details of localized optical modes in thin coatings. We address this challenge by employing transformation optics to gain variable resolution in our simulation methods in addition to effective-medium approaches for domains where high resolution is not necessary. Results for various nanosponge geometries are presented and compared to recent experiments.

[1] G. Hergert et al., Light: Science & Applications (2017) 6, e17075 (2017)

O 25.3 Tue 11:00 MA 041

Vertically coupled complementary antennas as plasmonic nanosensors for the optical sensing of molecules in the mid infrared. — •Gökalp Engin Akinoglu and Michael Giersig — Freie Universität Berlin

Infrared plasmonic nanosensor (IR-PS) for surface enhanced infrared absorption spectroscopy are of great interest for the sensing of biological molecules. Here, we report on a novel design of a IR-PS based on vertically coupled complementary antennas (VCCAs). Fabrication of hexagonal ordered silicon Nanopillar arrays is realized by the combination of nanosphere lithography (NSL) and metal assisted chemical etching(MaCE). First, a hcp monolayer of polystyrene particles is plasma etched to form a non-close packed array which is used as a lithography template during metal deposition to obtain a metallic film with periodically ordered perforations. The latter undergoes MaCE to yield the hexagonaly ordered silicon Nanopillar arrays. Finally, the pillar array is coated with gold to produce a complementary plasmon active perforated film between the pillars and plasmon active disks on top of the pillars. We show that the optical response of the VCCAs is tunable through the geometric dimensions of the structure and we observe enhanced near field intensities from 10^2 up to 10^3.

O 25.4 Tue 11:15 MA 041

Dopant-Induced Plasmon Decay in Graphene — •Dino Novko — Freie Universität, Institut für Chemie und Biochemie, Berlin

Unique properties of graphene plasmons, such as their tunability and low decay rates, have opened up many new pathways to control the electromagnetic energy on the nanoscale. Thus far the experimental studies have reported on graphene plasmons with up to far- or mid-infrared energies, which is achievable with the standard field gating techniques. On the other hand, theory predicts that chemically doped graphene could support plasmon excitations up to telecommunication or even visible frequencies. Apart from that, the presence of dopant may influence electron scattering mechanisms in graphene and thus impact the plasmon decay rate. Here I show a first-principles study of these effects in single-layer and bilayer graphene doped with various alkali and alkaline earth metals [D. Novko, Nano Lett. (2017)]. I find new dopant-activated damping channels: loss due to out-of-plane graphene and in-plane dopant vibrations, and electron transitions between graphene and dopant states. The latter excitations interact with the graphene plasmon and together they form a new hybrid mode. The study points out a strong dependence of these features on the type of dopants and the number of layers, which could be used as a tuning mechanism in future graphene-based plasmonic devices.

O 25.5 Tue 11:30 MA 041

Electrodynamic simulations of 2D random spectrometer in the very near-infrared regime — •Paris Varytis[1,2], Dan-Nha Huynh[2], Wladislaw Hartmann[3,4], Wolfram Pernice[3,4], and Kurt Busch[1,2] — [1]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, Newtonstr 15, 12489 Berlin, Germany — [3]University of Münster, Institute of Physics, Wilhelm-Klemm-Str.10, 48149 Münster, Germany — [4]University of Münster, CeNTech - Center for Nanotechnology, Heisenbergstr. 11, 48149 Münster, Germany

Random spectrometers are suitable for portable sensing and efficient lab-on-a-chip functionality. Here, a comprehensive study of a random spectrometer based on 2D planar waveguiding structures in the very near-infrared and visible regime is presented. Our silicon-nitride-based integrated-optical layout is analyzed for both, TE and TM polarizations, by means of Mie theory and electromagnetic simulations using the Discontinuous Galerkin Time-Domain method. It is shown that in the diffusive regime the spectral resolution depends on single scattering properties such as the scattering efficiency and asymmetry parameter. Moreover, shifting from the near-infrared to the visible regime, the transport mean free path is reduced due to the stronger scattering and therefore enhanced effective optical path leads to higher spectral resolution.

O 25.6 Tue 11:45 MA 041

Modematching for helical plasmonic resonators — •Thorsten Feichtner[1], Katja Höflich[2], 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 2Würzburg, Germany — [2]Helmholtz Zentrum für Materialien und Energie Berlin, Hahn-Meitner-Platz 1, D-14109 Berlin, Germany

Mode-matching is a novel theoretical approach for the description of optical coupling between a plasmonic device and multiple emitters or receivers [1]. Here we apply the method to describe the far-field coupling of nanometer-sized metal helices [2] to circular polarized light, proving the viability and flexibility of mode-matching. We also show that a 1D model is sufficient to describe qualitatively the complex scattering behavior of the helical plasmonic nano resonator.

[1] Feichtner, T., Christiansen, S., & Hecht, B. (2017). PRL, 119(21), 217401.

[2] Haverkamp, C., Höflich, K., Jäckle, S., Manzoni, A., & Christiansen, S. (2017). Nanotechnology, 28(5), 55303.

O 25.7 Tue 12:00 MA 041

Size dependence of coupling strength in hybrid plasmon-exciton nanoparticles — •Felix Stete[1,2], Phillip Schossau[1], Wouter Koopman[1], and Matias Bargheer[1,3] — [1]Institut für Physik & Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany — [2]Humboldt-Universität zu Berlin,

School of Analytical Sciences Adlershof (SALSA), Unter den Linden 6, 10099 Berlin, Germany — [3]Helmholtz Zentrum Berlin, Albert-Einstein-Str. 15, 12489 Berlin, Germany

The coupling strength in plasmon-exciton core-shell nanoparticles is mostly measured by tuning the plasmon resonance and subsequently fitting the resulting anticrossing relation. However,the plasmon tuning is usually induced by changing the particle size or shape. In this case an investigation of the size dependence of the coupling strength is not possible.

We tune the plasmon resonance via layer-by-layer deposition of polyelectrolytes and thus without changing the size or shape of the particles [1]. With this technique we investigate plasmon-exciton nanorods of different sizes to reveal a strong dependence of the coupling strength on the particle size. For small nanoparticles the coupling becomes very strong and single emitter strong coupling is within reach.

[1] F. Stete et al., ACS Photonics, 4, 1669-1676, 2017

O 25.8 Tue 12:15 MA 041

Tunability of ferroelectric superlenses in the mid-infrared regime — •Lukas Wehmeier[1], Jonathan Döring[1], Stephan Winnerl[2], Susanne C. Kehr[1], and Lukas M. Eng[1] — [1]Technische Universität Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany

A superlens utilizes negative permittivity materials to create optical near-field images beyond the diffraction limit [1]. Ferroelectric perovskites are preferential candidates for designing superlenses at infrared (IR) wavelengths [2,3,4] since they intrinsically possess a negative permittivity close to a sample phonon resonance [5]. Nevertheless, superlensing is usually restricted to a narrow spectral range, only. This inherently screams for superlenses with optical tunability.

In this presentation, the evanescent image formed by bulk ferroelectrics and ferroelectric superlenses is inspected by applying scattering scanning near-field optical microscopy and spectroscopy. Particularly, we focus on the impact of the ferroelectric polarization; we will show, that polarization control via applying external electric fields provides a great potential for superlens tuning via local-scale optical anisotropies.

[1] J. B. Pendry, Phys. Rev. Lett. 85, 3966 (2000).
[2] T. Taubner et al., Science 313, 595 (2006).
[3] S. C. Kehr et al., Nat. Commun. 2, 249 (2011).
[4] S. C. Kehr et al., ACS Photonics 3, 20 (2016).
[5] S. C. Kehr et al., Phys. Rev. Lett. 100, 256403 (2008).

O 25.9 Tue 12:30 MA 041

Low-temperature scattering scanning near-field optical microscopy — •Tobias Nörenberg[1], Jonathan Döring[1], Denny Lang[1,2], Susanne C. Kehr[1], and Lukas M. Eng[1] — [1]Technische Universität Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany

Scattering scanning near-field optical microscopy (s-SNOM) is a powerful technique to probe the sample's local dielectric function far beyond the diffraction limit. Applications of s-SNOM include investigations of ferroelectric domains [1], plasmonic resonances [2], superlensing [3], just to name a few. Here, we present a s-SNOM LHe-cryostat setup that uniquely operates from 4 to 300 K [4]. Additionally, we combine this setup with a narrowband free-electron laser for mid-IR to THz sample excitation at $\lambda = 4 - 250\mu m$.

This presentation not only answers the technological challenges faced when implementing the low-temperature s-SNOM but, furthermore, also delineates the interesting scientific questions of in situ monitoring phase transitions in multiferroics, or differentiating microscopic phase coexistences and electronic excitations of prospective materials.

[1] J. Döring et al., Appl. Phys. Lett. **105**, 053109 (2014).
[2] P. Patoka et al., Opt. Express **24**, 1154-1164 (2016).
[3] S. C. Kehr et al., Nat. Comm. **2**, 249 (2011).
[4] D. Lang et al., Rev. Sci. Instrum., submitted (2017).

O 25.10 Tue 12:45 MA 041

Chemical enhancement contribution in surface enhanced Raman scattering — •Bo Liu[1], Peter Lemmens[1,2], Rainer Stosch[3], and Bernd Güttler[3] — [1]IPKM, TU-BS, Braunschweig, Germany — [2]LENA, TU-BS, Braunschweig, Germany — [3]PTB, Braunschweig, Germany

In the fields of clinical chemistry, biotechnology, pharmacy, food industry and metrology, surface enhanced Raman scattering (SERS) is of enormous importance [1]. For a better insight into the complex light-matter interaction processes that lead to a signal enhancement, it is essential to experimentally distinguish and quantify the contributions from chemical (CMs) and electromagnetic mechanisms (EM) [2]. Here, we present an approach to estimate the relative CMs response of each Raman mode via analysing light induced degeneration of target molecules on designed metal/semiconductor SERS substrates [3]. Our work thereby provides a potential tool for understanding the CMs at the level of each mode. Work supported by DFG-RTG 1952/1 "NanoMet", Braunschweig-IGSM, and DFG-LE967/17-1. [1] Hampel, et al., Measurement Science and Technology (2017). [2] Kneipp, J. Phys. Chem. C 37, 21076 (2016). [3] Liu, et al., Nanotechnology 28, 195201 (2017).