HL 63: Focus Session: Nanoscale Light-matter Interaction II

The focus session highlights recent breakthroughs in resolving the optoelectronic properties of individual nanostructures down to the atomic scale. Moreover, the session introduces the rich field of surface polaritons, confined electromagnetic modes through which light can be guided on subwavelength scales.

The session is the second part of the focus session on nanoscale light-matter interaction.

Time: Friday 12:00–13:15 Location: H14

HL 63.1 Fri 12:00 H14

Super-resolution imaging of nanoscale inhomogeneities in hBN-covered and encapsulated few-layer graphene — •Lina Jäckering, Konstantin G. Wirth, Lukas Conrads, and Thomas Taubner — I. Institute of Physics (IA), RWTH Aachen University

Encapsulating few-layer graphene (FLG) in hexagonal boron nitride (hBN) can cause nanoscale inhomogeneities in the FLG, including changes in stacking domains and topographic defects.[1] Due to the diffraction limit, characterizing these inhomogeneities is challenging. Recently, the visualization of stacking domains in encapsulated four-layer graphene (4LG) has been demonstrated with phonon polariton (PhP)-assisted near-field imaging.[2] However, the underlying coupling mechanism and ability to image subdiffractional-sized inhomogeneities remain unknown. Here, we retrieve direct replicas and magnified images of subdiffractional-sized inhomogeneities in hBN-covered trilayer graphene (TLG) and encapsulated 4LG, enabled by the hyperlensing effect.[3] This hyperlensing effect is mediated by hBN*s hyperbolic PhP that couple to the FLG*s plasmon polaritons. Using near-field microscopy, we identify the coupling by determining the polariton dispersion in hBN-covered TLG to be stacking-dependent. Our work demonstrates super-resolution and magnified imaging of inhomogeneities, paving the way for the realization of homogeneous encapsulated FLG transport samples to study correlated physics.

[1] Geisenhof et al. ACS Appl. Nano Mater. **2**, 6067 (2019). [2] Liu et al. Nat. nanotech. **19**, 188-195 (2024). [3] Li et al. Nat. Commun. **6**, 7507 (2015).

HL 63.2 Fri 12:15 H14

Optical and Electrical Properties of Copper Oxide * Polyvinyl Alcohol Nanocomposites for Solar Cell Applications — •Ahed AL-Faouri[1,2], Mahmoud Abu-Kharma[1], and Mahmoud Hatem[1] — [1]Department of Physics, Faculty of Science, Al-Balqa Applied University, Al-Salt, Jordan — [2]Basic Sciences Department, Faculty of Arts and Sciences, Al-Ahliyya Amman University, Amman, Jordan

Copper oxide nanoparticles (CuO-NPs) were successfully synthesized at ambient temperature using an easy and eco-friendly method, employing the aqueous extract of bougainvillea leaves as reducing and stabilizing agents. First, a thin film of pure polyvinyl alcohol (PVA) was prepared via solution casting. Subsequently, four CuO-PVA nanocomposites were fabricated through solution casting at concentrations of (13, 30, 40, and 51) wt%. The optical and electrical properties of the synthesized CuO NPs, pure PVA, and CuO-PVA thin films were investigated using a UV-Vis spectrophotometer and a Keithley electrometer.

The band gap (Eg) of prepared CuO-NPs was 2.74 eV. The separation of this band gap renders CuO-NPs a suitable material for solar energy conversion and could potentially be used as an active layer material in solar cells., Furthermore, the four prepared CuO-PVA showed that the optical band gap decreased from 4.42 eV (pure PVA) to 3.34 eV (50%CuO-PVA). Further, increased DC electric conductivity was observed

HL 63.3 Fri 12:30 H14

Accessing phase and group velocities of terahertz surface plasmon polaritons in graphene using near-field spacetime imaging — •Simon Anglhuber[1], Martin Zizlsperger[1], Eva A. A. Pogna[2], Yaroslav A. Gerasimenko[1], Anastasios D. Koulouklidis[1], Imke Gronwald[1], Svenja Nerreter[1], Leonardo Viti[3], Miriam S. Vitiello[3], Rupert Huber[1], and Markus A. Huber[1] — [1]Regensburg Center for Ultrafast Nanoscopy (RUN) and Department of Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche (CNR-IFN), Milano, I-20133, Italy — [3]NEST, CNR - Istituto Nanoscienze and Scuola Normale Superiore, Piazza San Silvestro 12, 56127, Pisa, Italy

The combination of light and matter properties in surface polaritons offers unprecedented opportunities for controlling energy flow and information processing at the nanoscale. Here, we present a novel THz near-field imaging approach to visualize polariton propagation directly in the time domain. Our method allows for the extraction of phase and group velocities, as well as damping. Thus, it reveals substantial insights into the polariton dispersion curve, even for strongly damped modes. Additionally, we show that our analysis can be expanded to two dimensions, directly visualizing polariton propagation in arbitrary directions, which is especially valuable for anisotropic materials. Finally, the method offers an intuitive approach to visualize non-equilibrium polariton propagation, e.g. upon photoexcitation. Thereby, we achieve subcycle control over polariton dynamics.

HL 63.4 Fri 12:45 H14

Inelastic electron-light interaction probed by holographic scanning transmission electron microscopy — •Nora Bach[1,2], Tim Dauwe[1,2], Murat Sivis[1,2], and Claus Ropers[1,2] — [1]Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Germany

Quantitative phase-contrast imaging of electrostatic potentials is an important application in transmission electron microscopy. Recently developed techniques have overcome the challenge to measure phase profiles inherited from optical fields, but offer only limited variability in tailoring the electron-light interactions and require a highly coherent electron source [1,2]. In this contribution, we introduce scanning transmission electron microscopy with spatially separated coherent electron probes [3] for the full imaging of complex optical near fields at a nanostructure with high spatial resolution. In the far field, these electron probes interfere to form a hologram from which we reconstruct phase shifts induced both by elastic scattering processes and by stimulated inelastic interactions. One particular advantage of STEM holography is the relaxed coherence requirements, which could be central to improving time-resolved imaging of electric and magnetic fields on the nanoscale.

[1] Gaida et al., Nat Commun. 14, (2023)
[2] Gaida et al., Nat. Photon. 18 (2024)
[3] Fehmi et al., J. Phys. D: Appl. Phys. 51 (2018)

HL 63.5 Fri 13:00 H14

Unraveling ultrafast exciton dynamics in a monolayer of the magnetic semiconductor CrSBr — •Jakob Schlosser[1], Christian Meineke[1], Martin Zizlsperger[1], Marlene Liebich[1], Nilofar Nilforoushan[1], Kseniia Mosina[2], Sophia Terres[3], Alexey Chernikov[3], Zdenek Sofer[2], Markus A. Huber[1], Matthias Florian[4], Mack Kira[4], Florian Dirnberger[3], and Rupert Huber[1] — [1]University of Regensburg, Regensburg — [2]University of Chemistry and Technology Prague, Prague — [3]Dresden University of Technology, Dresden — [4]University of Michigan, Ann Arbor

Among van der Waals semiconductors, CrSBr stands out as both its bulk and monolayer forms host tightly bound, quasi-1D excitons in a magnetic environment. Despite the strong attention these quasiparticles have attracted, their lifetimes remained unknown. Terahertz spectroscopy can directly probe the dynamics of all electron-hole pairs, independently of interband selection rules. Yet the corresponding far-field foci substantially exceed the lateral sample dimensions. Here, we combine terahertz polarization spectroscopy with near-field microscopy to study the dynamics of bound and unbound electron-hole pairs in bulk CrSBr and extract the nonequilibrium dielectric function of the monolayer in a model-free manner. Interestingly, the femtosecond decay of paramagnetic excitons in monolayer CrSBr is found to be 30 times shorter than the determined lifetime in bulk material. Our results mark the first direct access to the ultrafast dielectric response of quasi-1D excitons in CrSBr, to advance the development of quantum devices based on ultrathin van der Waals magnets.