O 87: Mini-Symposium: Infrared nano-optics I

Time: Thursday 10:30–12:30 Location: R2

Opening remarks

Paper discussion O 87.1 Thu 10:35 R2

In-Situ Thin Film Nanoscale Hydrogenography in Magnesium Plasmonics — •Harald Giessen, Julian Karst, Florian Sterl, Heiko Linnenbank, and Mario Hentschel — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Magnesium is an active plasmonic material that can switch from metallic to dielectric optical properties when undergoing hydrogenation. We perform s-SNOM phase contrast measurements to image the phase transition from Mg to MgH2 on the nanometer scale. This reveals the diffusion mechanism of hydrogen in free-standing Mg thin films in nanoscopic detail.

Paper discussion with expert panel members

Prof. S.A. Maier (LMU München), Prof. P. Klarskov Pedersen (U Aarhus), Prof. O. Mitrofanov (UCL London, UK) and Prof. J. Karst (U Stuttgart)

O 87.2 Thu 11:30 R2

The Role of Polarization in Resonant s-SNOM — •Felix G. Kaps[1], Hamed Aminpour[1], Susanne C. Kehr[1], and Lukas M. Eng[1,2] — [1]Technische Universität Dresden, Germany — [2]ct.qmat, Dresden-Würzburg Cluster of Excellence - EXC 2147, Technische Universität Dresden, Germany

Scattering scanning near-field optical microscopy (s-SNOM) is known to be highly polarization-dependent. Most commonly, p-polarized light is employed to excite the tip-sample system with an electric field standing perpendicular to the sample surface, with only a few works commenting on polarization control to e.g. suppress unwanted far-field contributions [1] or local 3D vector field steering [2].

Here, we explore the fundamental role of polarization in s-SNOM by theoretically and experimentally controlling and analyzing the polarization of both incident and scattered light. Particularly, we compare our experimental findings obtained at mid-infrared wavelengths to polarization-dependent simulations that include the full near-field measuring setup [3]. One eye-catching outcome is, that resonant sample excitation using s-polarized light (E-field parallel to the sample surface) may achieve significant signal strengths and a polarization-specific signature, enabling a novel route for nanoscale polarization-sensitive surface characterization.

[1] M. Esslinger et al., Rev. Sci. Instrum. 83, 033704 (2012).
[2] K.-D. Park and M.B. Raschke, Nano Lett. 18, 2912 (2018).
[3] H. Aminpour et al., Opt. Express 28, 32329 (2020).

O 87.3 Thu 11:45 R2

Vector Microscopy - Nonlinear Photoemission Microscopy Reveals Plasmonic Fields — •David Janoschka[1], Pascal Dreher[1], Yannik Paul[1], Timothy Davis[1,2,3], Bettina Frank[2], Michael Horn- von Hoegen[1], Harald Giessen[2], and Frank-J. Meyer zu Heringdorf[1] — [1]Faculty of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany. — [2]4th Physics Institute, University of Stuttgart, 70569 Stuttgart, Germany. — [3]School of Physics, University of Melbourne, Parkville, Victoria 3010 Australia

Exploring the topology of electromagnetic near-fields is one of the central topics in nano-optics. To investigate spatiotemporal details of the topology on a local scale intrinsically requires knowledge of the time-dependent local electric field vectors. While time-resolved photoemission microscopy (TR-PEEM) has been established as an excellent tool to study the dynamics of nano-optical fields at surfaces, the vectorial nature of the fields was not accessible so far.

Here, we present the new method of 'vector microscopy' as a local field vector sensitive development of TR-PEEM. We use femtosecond laser pulses to excite and probe surface plasmon polaritons (SPPs) in tailored nanostructures. Using two different probe laser pulses of orthogonal polarization at the same pump-probe delay enables us to extract the in-plane component of the SPP's near-field. The out-of-plane field component is reconstructed using Maxwell's equations. We apply the new vector microscopy method to complex topological SPP fields. We demonstrate reconstruction of the electric and the magnetic field, and extract the topological properties in time and space.

O 87.4 Thu 12:00 R2

Amplitude- and phase-resolved infrared nanoimaging and nanospectroscopy of polaritons in liquid environment — •Divya Virmani[1], Andrei Bylinkin[1], Irene Dolado[1], Eli Janzen[2], James H. Edgar[2], and Rainer Hillenbrand[3,4] — [1]CIC nanoGUNE BRTA, Donostia, Spain. — [2]Kansas State University, Tim Taylor Department of Chemical Engineering, Durland Hall, Manhattan,USA — [3]CIC nanoGUNE BRTA and Department of Electricity and Electronics, UPV/EHU, Donostia, Spain. — [4]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain.

Polaritons are well known for their ability to focus light to deep subwavelength sized spot allowing for highly sensitive analysis of bio(chemical) substances and processes. Nanoimaging of the polaritons evanescent fields is critically important for experimental mode identification and field confinement studies. In this work, we describe two setups for scattering-type scanning near-field optical microscopy (s-SNOM) based polariton nanoimaging and spectroscopy in liquid. We first demonstrate the mapping of near-field distribution of plasmonic metal antennas in liquid with a normal-incidence mid-infrared s-SNOM setup. We then demonstrate our total internal reflection (TIR) setup for infrared nanoimaging and nanospectroscopy of ultra-confined propagating phonon polaritons (PhPs) on h-BN flakes. Our work lays the foundation for s-SNOM based polariton interferometry in liquid for future exploitation, for example, in-situ studies of strong coupling between polaritons and molecular vibrations or chemical reactions at the bare or functionalized surfaces of polaritonic materials.

O 87.5 Thu 12:15 R2

Tunable s-SNOM for nanoscale infrared optical measurement of electronic properties of bilayer graphene — •Konstantin G. Wirth[1], Heiko Linnenbank[2,3], Tobias Steinle[2,3], Luca Banszerus[4], Eike Icking[4], Christoph Stampfer[4], Harald Giessen[2,3], and Thomas Taubner[1] — [1]Institute of Physics (IA), RWTH Aachen — [2]4th Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart — [3]SI Stuttgart Instruments GmbH, 70771 Leinfelden-Echterdingen — [4]2nd Institute of Physics (IIA), RWTH Aachen University, 52074 Aachen

The stacking and rotation of individual graphene layers changes its band structure, opening up new physical properties. Local probing of their electronic properties at the nanoscale is usually done by scanning tunneling microscopy, which requires electrical contact. Optical measurements such as infrared absorption or Raman spectroscopy, work for non-contacted and encapsulated samples, but are limited in lateral resolution by diffraction to a few micrometer. Here we directly probe the electronic properties of bilayer graphene (BLG) using s-SNOM measurements with a broadly tunable laser source over the energy range from 0.3 to 0.54 eV. We tune an OPO/OPA system around the interband resonance of Bernal stacked BLG and extract amplitude and phase of the scattered light. This enables us to retrieve and reconstruct the complex optical conductivity resonance in BLG around 0.39 eV with nanoscale resolution. Our technique opens the door towards nanoscopic noncontact measurements of the electronic properties in complex hybrid 2D and van der Waals material systems.