O 69: Poster Session V: Poster to Mini-Symposium: Infrared nano-optics III

Time: Wednesday 10:30–12:30 Location: P

O 69.1 Wed 10:30 P

Nano-scale analysis of Phase Change Material thin films using a Scattering-type Scanning Near-field Optical Microscope (s-SNOM) — •Oxana Maurer, Julian Barnett, Konstantin Wirth, Lisa Schäfer, Matthias Wuttig, and Thomas Taubner — Institute of Physics (IA), RWTH Aachen

Phase Change Materials (PCMs) possess two or more different states with a distinct contrast in optical and electrical properties. The states can be switched in a reversible and non-volatile manner, leading to applications in optical and electrical data storage, but also in photonics and thermoelectrics. PCMs exhibit a bonding mechanism referred to as metavalent bonding (MVB)[1], which is characterised by a competition between electron localisation and delocalisation. Based on theoretical calculations, indications of MVB seem to persist down to the 2D limit [2], e.g GeTe shows PCM properties down to a few bilayers and its band gap is increasing for decreasing film thickness. To verify this, the optical near-field response of ultrathin PCM films are investigated with a scattering-type Scanning Near-field Optical Microscope (s-SNOM). Until now, a fundamental understanding of band gap effects on the s-SNOM contrast is lacking. Therefore, our measurements are combined with theoretical modelling to gain insight into the s-SNOM contrast changes introduced by band gaps.

[1] B. J. Kooi, M. Wuttig (2020) Adv. Mater. 32, 1908302
[2] I. Ronneberger, et al. (2020) Adv. Mater. 30, 2001033

O 69.2 Wed 10:30 P

Infrared super-resolution microscopy of phonon polariton modes by sum-frequency generation — •Richarda Niemann[1], Sören Wasserroth[1], Guanyu Lu[2], Christopher R. Gubbin[3], Martin Wolf[1], Simone De Liberato[3], Joshua D. Caldwell[2], and Alexander Paarmann[1] — [1]Fritz-Haber-Institut, Berlin, Germany — [2]Vanderbilt University, Nashville, USA — [3]University of Southhampton, Southhampton, UK

Nanophotonics is based on the subdiffractional localization of light by surface polariton modes. Its devices enable the modulation of light matter interaction on the nanometer scale by specifically designed subdiffractional nanostructures. Inherently, though, the spatial resolution for optical characterization of the polaritonic modes is limited by the diffraction limit. Here, we demonstrate a novel approach that overcomes this limitation by using Infrared-Visible Sum-Frequency Generation (IR-VIS-SFG) wide-field microscopy.

After the first SFG microscopy study of a nanophotonic system [1], we here demonstrate subdiffractional spatial resolution of $<1\ \mu$m when imaging phonon polariton modes in SiC nano pillar structures at a wavelength of $\lambda \approx 11\ \mu$m using the wide-field approach. The wide tunability of the infrared free-electron laser [2] used as the infrared light source enables full spectral mapping of the polaritonic modes in various simple subdiffractional structures, providing access to the polariton mode formation for the first time.

[1] Kiessling et al., ACS Photonics, (2019)
[2] Schöllkopf et al., Proc. of SPIE (2015)

O 69.3 Wed 10:30 P

Plasmonic antenna coupling to hyperbolic phonon polaritons for sensitive and fast mid-infrared photodetection with graphene — •Sebastian Castilla[1], Ioannis Vangelidis[2], Varun-Varma Pusapati[1], Jordan Goldstein[3], Tetiana Slipchenko[4], Luis Martin-Moreno[4], Dirk Englund[3], Klaas-Jan Tielrooij[5], Rainer Hillenbrand[6], Elefteris Lidorikis[2], and Frank Koppens[1] — [1]ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain — [2]University of Ioannina — [3]Massachusetts Institute of Technology — [4]University of Zaragoza — [5]Catalan Institute of Nanoscience and Nanotechnology (ICN2) — [6]CIC nanoGUNE

In this work, we show the realization of a new concept room temperature ultrafast infrared photodetector that exceeds any commercial technology. It has a response time of <15 nanoseconds (setup limited), while at the same time showing excellent sensitivity: we extracted a NEP down to 82 pw/$\sqrt{Hz}$ at 6 μm. Our approach consists in exploiting the efficient coupling of plasmonic antennas with hyperbolic phonon-polaritons (HPPs) in hBN for highly concentrate mid-infrared light into a graphene pn junction in order to overwhelm its low absorption and small photoactive area. The antennas plasmonic resonances spectrally overlap within the upper reststrahlen band of hBN (6-7 μm), thus launching efficiently these HPPs and guiding them with constructive interferences towards the photodetector active area. These experimental results are in excellent quantitatively agreement with a novel multiphysics model, which includes optical, thermal and electrostatic simulations.

O 69.4 Wed 10:30 P

Spectrally resolved near-field response of mid-IR phonon-polariton antennas — •Andrea Mancini[1], Christopher R. Gubbin[2], Rodrigo Berté[1], Francesco Martini[2,3], Alberto Politi[2], Emiliano Cortés[1], Yi Li[1,4], Simone De Liberato[2], and Stefan A. Maier[1,5] — [1]Chair in Hybrid Nanosystems, Nanoinstitute Munich, LMU München, Germany — [2]School of Physics and Astronomy, University of Southampton, United Kingdom — [3]Istituto di Fotonica e Nanotecnologie - CNR, Via Cineto Romano, Italy — [4]School of Microelectronics, Southern University of Science and Technology, Shenzhen, China — [5]Department of Physics, Imperial College London, United Kingdom

As the optical behavior of metals approaches the one of perfect conductors at longer wavelengths, the efficiency of plasmonic antennas for light confinement is reduced in the infrared (IR) range. Efficient field confinement in the mid-IR, which can be particularly useful for ultra-sensitive and chemically-selective spectroscopy of molecular vibrations, can be achieved with antennas supporting localized surface phonon polaritons. Due to the presence of evanescent waves that do not propagate, far-field measurements cannot fully characterize the behavior of antennas in the near-field region. We employ scattering-scanning near field optical microscopy to unveil the spectral near-field response of 3C-SiC antenna arrays. We compare far-field and near-field spectra, and demonstrate the existence of a mode with no net dipole moment, absent in far-field spectra, but of importance for applications that exploit the heightened electromagnetic near fields.