O 39: Focus Session: Phonon Polaritons: Opportunities for THz Nanooptics II

Time: Tuesday 14:00–15:30 Location: HE 101

O 39.1 Tue 14:00 HE 101

Highly-confined surface phonon polaritons in metal circular cavities fabricated on a phase change material — •Hisashi Sumikura[1,2], Andreas Hessler[1], Lena Jung[1], Martin Lewin[1], and Thomas Taubner[1] — [1]RWTH Aachen University, Aachen, Germany — [2]NTT Basic Research Laboratories, Atsugi, Japan

To enhance the interaction between light and nanomaterials, the light field should be concentrated into a small volume while overcoming the diffraction limit. In the mid-infrared region, surface phonon polaritons (SPhPs) confined in optical cavities show their strong field concentration. We have studied on metal circular cavities on SiC [1] and laser-induced dielectric cavities in a phase change material on quartz [2] to achieve SPhP confinement.

In this study, we demonstrate cavity-confined mid-infrared SPhPs in a thin film of germanium-antimonide-telluride (GST) deposited on SiC. Scattering-type scanning near-field optical microscopy showed that a 1-μm-diameter metal circular cavity achieves a strong field concentration of the SPhP with a width of less than 250 nm, that is 1/44 of the wavelength of incident light (11.1 μm). In addition, the thermal annealing of the samples switched the SPhP confinement off with a large detuning of the resonance, which is induced by the change in optical constants of phase-changed GST.

[1] T. Wang, P. Li, B. Hauer, D. N. Chigrin, T. Taubner. Nano Lett. 13, 5051 (2013). [2] P. Li, X. Yang, T. W. W. Mass, J. Hanss, M. Lewin, A-K. U. Michel, M. Wuttig, T. Taubner. Nature Mater. 15, 870 (2016).

O 39.2 Tue 14:15 HE 101

Strong Coupling of a Surface Phonon Polariton and an Epsilon Near Zero Mode — •Nikolai Christian Passler[1], Christopher Gubbin[2], Ilya Razdolski[1], Martin Wolf[1], Simone De Liberato[2], Joshua Caldwell[3], and Alexander Paarmann[1] — [1]Fritz-Haber-Institute of the MGP, Berlin,Germany — [2]University of Southampton, UK — [3]Vanderbilt University, Nashville, USA

Surface phonon polaritons (SPhP) supported in polar dielectrics constitute a promising route for the development of low-loss mid infrared (MIR) nanophotonics [1]. In sub-wavelength thin layers, ultrathin film polaritons arise at the longitudinal optical phonon frequency where the dielectric permittivity crosses zero. These intrinsic epsilon near zero (ENZ) polariton modes exhibit immense wavelengths, giving rise to remarkable phenomena like supercoupling or light trapping [2].

Employing an MIR free-electron laser and the Otto geometry for prism coupling [3], we here experimentally map out the dispersions of SPhPs in an ultrathin AlN layer on top of bulk SiC. Our measurements reveal strong coupling of the bulk SiC SPhP to the ENZ mode supported by the thin layer, resulting in ENZ SPhP modes which provide the promising possibility to incorporate ENZ wave propagation attributes into polaritonic nanophotonics.

[1] Caldwell et al., Nanophotonics 4, 44 (2015)
[2] Liberal et al., Nature Photonics 11, 149 (2017)
[3] Passler et al., ACS Photonics 4, 1048 (2017)

O 39.3 Tue 14:30 HE 101

Surface-Enhanced Terahertz Spectroscopy of Organic Molecules — •Lucca Kühner[1], Weiwu Li[2], Frank Neubrech[1,3], Martin Dressel[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart — [2]1st Physics Institute, University of Stuttgart — [3]Kirchhoff-Institute for Physics, University Heidelberg

Mid-infrared (MIR) spectroscopy allows for label-free identification of chemical species by their characteristic intramolecular vibrations and is thus widely used in biology, pharmacy, and medical sciences. For isomeric molecules, e.g., monosaccharides such as glucose and fructose which have the same chemical bonds and similar spatial arrangement, vibrational bands in the MIR region do mostly not provide sufficient specific information. In contrast, terahertz (THz) spectroscopy probes intermolecular interactions in mostly crystalline structures and is thus sensitive to the molecule's conformation. This technique is consequently able to differentiate between isomeric molecules. However, the absorption cross-section of such intermolecular interactions is even lower than for MIR spectroscopy. To overcome this limitation, we are going to extend the concept of surface-enhanced infrared spectroscopy (SEIRS) to the THz wavelength range. In this work, we demonstrate measurements of two crystalline configurations of Glucose in the THz region. By introducing surface-enhanced THz spectroscopy we aim at improved sensitivity.

O 39.4 Tue 14:45 HE 101

Phonon-Polaritonic Bowtie Nanoantennas: Controlling Infrared Thermal Radiation at the Nanoscale — Tao Wang[1], Peining Li[1], Dmitry N. Chigrin[1,2], Alexander J. Giles[3], Francesco J. Bezares[4], Orest J. Glembocki[3], Joshua D. Caldwell[3,5], and •Thomas Taubner[1] — [1]RWTH Aachen University, Aachen, Germany — [2]DWI Leibniz Institute for Interactive Materials, Aachen, Germany — [3]U.S. Naval Research Laboratory, Washington DC, USA — [4]Universidad de Puerto Rico, Cayey, Puerto Rico — [5]Vanderbilt University, Nashville, TN, USA

A conventional thermal emitter exhibits a broad emission spectrum with a peak wavelength depending upon the operation temperature. Narrowband thermal emission can be realized with periodic gratings or single microstructures hosting Surface Phonon-Polaritons (SPhPs) [1-3], offering lower losses and higher resonance quality factors than the commonly used Surface Plasmon Polaritons (SPPs). Here, we investigate the coupling of adjacent phonon-polaritonic nanostructures, specifically deeply sub-diffractional bowtie-shaped silicon carbide nanoantennas. We employ infrared far-field reflectance spectroscopy and compare it with full-wave electromagnetic simulations and near-field optical nanoimaging. We experimentally demonstrate that the nanometer-scale-gaps can control the thermal emission frequency while retaining emission linewidths as narrow as 10 cm-1[4].

[1] J. J. Greffet et al, Nature 416, 61 (2002). [2] J. A. Schuller et al, Nature Photon. 3, 658 (2009). [3] J. D. Caldwell, et al., Nanophotonics 4, 44 (2015). [4] T. Wang et al., ACS Photonics 4, 1753 (2017).

O 39.5 Tue 15:00 HE 101

Nonlinear nanophotonics with localised phonon polaritons — •Simone De Liberato and Christopher Gubbin — School of Physics and Astronomy, University of Southampton, Southampton, UK

Phonon polaritons localised in nanometric resonators are a promising platform to develop polaritonic applications in the terahertz and mid-infrared regions. This is due to their extremely small mode volumes, long lifetimes, and large nonlinearities; as well as the relative ease with which nanoresonators with features at the 100nm scale, are fabricated.

In this talk I will present our recent results in this field. I will start with the experimental demonstration of strong coupling between localised and propagative phonon polariton modes in SiC nanopillar arrays [1]. I will then review a series of theoretical works in which, by investigating nonlinear properties of localised phonon polaritons, we demonstrate the possibility to exploit them to empower a novel generation of terahertz and mid-infrared devices [2-4].

[1] C. R. Gubbin, F. Martini, A. Politi, S. A. Maier, and S. De Liberato, Phys. Rev. Lett. 116, 246402 (2016)
[2] C. R. Gubbin, S. A. Maier, and S. De Liberato, Phys. Rev. B 95, 035313 (2017)
[3] C. R. Gubbin and S. De Liberato, ACS Phot. 4, 1381 (2017)
[4] C. R. Gubbin and S. De Liberato, ACS Phot. 10.1021/acsphotonics.7b00863 (2017)

O 39.6 Tue 15:15 HE 101

Towards nanoscale time-domain-spectroscopy at low-repetition-rate terahertz sources — •Thales V. A. G. de Oliveira[1,2], Frederik Kuschewski[1], Sergey Kovalev[1], Eduardo J. H. Lee[3], Nilesh Awari[1], Bert Green[1], Susanne C. Kehr[2], Michael Gensch[1], and Lukas M. Eng[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf. Bautzner Landstraße 400, D-01328 Dresden — [2]Technische Universität Dresden. Nöthnitzer Straße 61, D-01187 Dresden — [3]. Universidad Autónoma de Madrid. Calle Francisco Tomás y Valiente 7, E-28049, Madrid

Nanoscopy in the deep THz regime is particularly interesting as the interactions leading to THz resonances, absorption or emission (i.e. interactions of spins, lattice, and charge carriers) are occurring on a much smaller length scale as compared to the wavelengths of the corresponding electro-magnetic fields. As the tool of choice, scattering-type scanning near field optical microscopy (s-SNOM) at THz wavelengths

was previously demonstrated with superb spatial resolution when operated in the time domain. In this talk we report on the implementation of s-SNOM for time-domain-spectroscopy and nanoimaging near or even under the Nyquist-Shannon sampling limit, using broadband table-top sources and a unique accelerator-based super-radiant THz light source at low-repetition-rate (1 - 200 kHz). Operation at low repetition rates is of great importance for a variety of pump-probe experiments, which require THz probing at few 100 kHz or lower, since the typical recovery time after optical excitation in many interesting material systems can be on the order of a few μs.