HL 61: THz and MIR physics in semiconductors

The session covers the THz and MIR physics in semiconductors.

Time: Friday 10:45–11:45 Location: H14

HL 61.1 Fri 10:45 H14

Multi-photon Stark spectroscopy of ultrafast THz waveforms
— •Fabian Brütting, Moritz B. Heindl, and Georg Herink — Experimental Physics VIII, University of Bayreuth, Germany

Microscopic electric waveforms can be encoded into luminescence modulations through the quantum-confined Stark effect, enabling ultrafast "videography" of local electric fields up to THz frequencies. This technique, known as Quantum-probe field microscopy (QFIM), relies on the coupling of momentary electric fields with electronic transitions in colloidal quantum dots, with detection achieved via pump-probe microscopy [1].

Here, we propose two-photon absorption (TPA) as a novel probing regime for accessing the THz-driven Stark effect. Unlike conventional Stark spectroscopy, which relies on linear one-photon absorption, TPA operates under different selection rules, resulting in distinct interaction dynamics. In particular, depending on the specific transitions being probed, we observe a sign flip of the nonlinear electro-absorption contribution relative to the linear signal. Consequently, the overall electro-absorption signal is either enhanced, reduced or even inverted compared to the linear signal.

Therefore, two-photon Stark spectroscopy offers potential for improving QFIM detection sensitivity and provides a novel strategy for the ultrafast manipulation of the optical properties in low-dimensional semiconductors.

[1] Heindl, Moritz B., et al. "Ultrafast imaging of terahertz electric waveforms using quantum dots." *Light Sci. Appl.* 11.1 (2022): 5.

HL 61.2 Fri 11:00 H14

Characterization of SiC epilayers with terahertz time-domain spectroscopy
— •Joshua Hennig[1,2], Jens Klier[1], Stefan Duran[1], Christian Röder[3], Franziska Beyer[3], Kuei-Shen Hsu[4], Jan Beyer[4], Nadine Schüler[5], Nico Vieweg[6], Katja Dutzi[6], Georg von Freymann[1,2], and Daniel Molter[1] — [1]Department of Materials Characterization and Testing, Fraunhofer ITWM, Kaiserslautern — [2]Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau — [3]Department Energy Materials and Test Devices, Fraunhofer IISB, Erlangen — [4]Institute of Applied Physics, Technische Universität Bergakademie Freiberg — [5]Freiberg Instruments GmbH, Freiberg — [6]TOPTICA Photonics AG, Gräfelfing

Silicon carbide (SiC), being a wide-bandgap and robust, temperature-stable semiconductor, is an up-and-coming material that already has applications in power electronics and in high-temperature environments. While the characterization of the electrical and optical properties of bulk semicondcutors with terahertz time-domain spectroscopy (TDS) has already been demonstrated, many applications make use of thin layers with thicknesses of a few tens of microns. Using the Drude model, we performed simulations with varying thicknesses and charge carrier densities of SiC epilayers showcasing the opportunities and possible limitations of TDS to characterize SiC epilayers. Finally, TDS measurements demonstrating the validity of the simulations were used to determine the charge carrier density of SiC epilayers.

HL 61.3 Fri 11:15 H14

Diminishing topological Faraday effect in thin layer samples
— Christian Berger, Florian Bayer, Laurens W. Molenkamp, and •Tobias Kiessling — Physikalisches Institut, University of Würzburg, Am Hubland, D-97074 Würzburg, Germany

A striking feature of three-dimensional topological insulators (TIs) is the theoretically expected topological magnetoelectric (TME) effect, which gives rise to additional terms in Maxwell's laws of electromagnetism with an universal quantized coefficient proportional to half-integer multiples of the fine-structure constant. In an ideal scenario one therefore expects also quantized contributions in the magnetooptical response of TIs.

We review this premise by taking into account the trivial dielectric background of the TI bulk and potential host substrates, and the often present contribution of itinerant bulk carriers. We show (i) that one obtains a nonuniversal magnetooptical response whenever there is impedance mismatch between different layers and (ii) that the detectable signals due to the TME rapidly approach vanishingly small values as the impedance mismatch is detuned from zero.

HL 61.4 Fri 11:30 H14

Unraveling the Microscopic Mechanism of Displacive Excitation of Coherent Phonons in a Bulk Rashba Semiconductor
— •Peter Fischer[1], Julian Bär[1], Moritz Cimander[1], Volker Wiechert[1], Oleg Tereshchenko[2], and Davide Bossini[1] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, D-78457 Konstanz, Germany — [2]Nowosibirsk, Russia

Optically driven lattice excitations have recently been intensively investigated as a means to manipulate the macroscopic properties of quantum materials. In solids with an electronic band gap, it is well-established that coherent phonons can be excited by laser pulses with photon energies exceeding the band-gap energy. However, the dominant microscopic mechanism has still not been pinpointed: Neither experimentally nor theoretically has it been possible to disentangle the effect of a photo-induced change in the charge-carrier density from an increase of the carrier temperature. We perform time-resolved pump-probe spectroscopy on the Rashba semiconductor BiTeI. Tuning the pump-photon energy from the visible to the mid-infrared allows us to excite both interband and barely accessible intraband transitions. As a result, we determine that the lattice modes are mainly driven by the increased carrier temperature. In addition, the phonon coherence time in the intraband regime proves robust against an increase in laser fluence. These findings provide new insights for the development of schemes addressing the coherent structural manipulation of solids.