HL 43: Ultra-fast phenomena

Time: Wednesday 9:30–10:45 Location: EW 202

HL 43.1 Wed 9:30 EW 202

Bandgap behaviour of ultrashort laser pulse excited silicon — •Bernd Bauerhenne, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik - Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

After an intensive ultrashort laser pulse excites silicon, it melts within the next 500 fs. Due to the drastic changes of the atomic positions, the band gap vanishes after ~120 fs and so molten silicon becomes metallic. We studied this effect ab inito with LDA DFT molecular dynamics simulations.

HL 43.2 Wed 9:45 EW 202

Ultrafast coherent phonon dynamics during the phase transition of the quasi one-dimensional Ta_2NiSe_5 — •Selene Mor[1], Marc Herzog[1], Claude Monney[1,2], Martin Wolf[1], and Julia Stähler[1] — [1]Fritz-Haber-Institut der MPG, Dep. of Phys. Chem., Berlin, Germany — [2]Institut für Physik, University of Zürich, Switzerland

Ta_2NiSe_5 is a layered compound in which atomic chains are aligned in layers, forming a quasi one-dimensional crystal structure. At 328 K, the system shows a structural change accompanied by an electronic phase transition (PT) from a low temperature (LT) (potentially excitonic) insulator to a semiconductor. Our aim is to unveil the microscopic mechanisms underlying this PT by investigating the non-equilibrium dynamics after optical excitation. The system is excited with a femtosecond laser pulse at 800 nm and the mid-infrared (MIR) transient optical response is monitored by ultrafast optical spectroscopy. We observe a fast rise of transient reflectivity, which decays exponentially within 2-3 ps. This incoherent response is superimposed by several coherent phonon oscillations. In particular, we observe a 4 THz phonon that is specific of the LT phase, which is confirmed by temperature dependent Raman spectroscopy. The time evolution of this LT phase phonon reveals a finite lifetime of few ps. Furthermore, a non linear behavior is observed for both the coherent and incoherent response as a function of excitation fluence. The fluence and sample temperature dependence suggest that the PT can be driven by photoexcitation on an ultrafast timescale.

HL 43.3 Wed 10:00 EW 202

Ultrafast exciton dissociation and coherent polaron formation in polymer fullerene blends observed by femtosecond spectroscopy — •Ephraim Sommer[1], Antonietta De Sio[1], Carlo A. Rozzi[2], Margherita Maiuri[3], Julien Rehault[3], Giulio Cerullo[3], and Christoph Lienau[1] — [1]Institut für Physik, Carl von Ossietzky Universität, 26129 Oldenburg, Germany — [2]Istituto Nanoscienze Consiglio Nazionale delle Ricerche (CNR), Centro S3, via Campi 213a, 41125 Modena, Italy — [3]Istituto di Fotonica e Nanotecnologie CNR, Dipartimento di Fisica, Politecnico di Milano, 20133 Milano, Italy

Blends of conjugated polymers (P3HT) and fullerene (PCBM) derivatives are prototype systems of organic photovoltaic devices. The primary charge-generation mechanism involves a light-induced electron transfer from the polymer to the fullerene acceptor.

Here we show ultrabroadband (500-1400nm) pump probe measurements with sub 15-fs time resolution of a pristine polymer thin-film and a blend of P3HT and PCBM, which reveal direct signatures of ultrafast charge dissociation. In particular we trace the dynamics of the interface excitons in the blended material. We find that they dissociate into charge transfer excitons within about 50fs [1]. In addition we find in both pristine and blended films evidence for an ultrafast buildup of polaron pair states. We analyze and discuss the ultrafast polaron pair dynamics on the basis of pump probe and coherent two-dimensional spectroscopy.

[1] S. M. Falke et al. Science 344, 1001-1005 (2014)

HL 43.4 Wed 10:15 EW 202

Asynchronous Optical Sampling of Rolled-up GaAs/InGaAs Superlattices — •Delia Brick[1], Martin Schubert[1], Chuan He[1], Martin Grossmann[1], Vivienne Meier[2], Guodong Li[2], Daniel Grimm[2], Oliver G. Schmidt[2], and Thomas Dekorsy[1] — [1]Universität Konstanz, Deutschland — [2]IFW Dresden, Deutschland

Strained bilayers of different materials can be rolled up to form radial superlattices by controlled release of the bilayers which were deposited on a sacrificial layer [1]. This new kind of rolled-up superlattices has not only a broad field of applications but is also interesting by itself [1,2]. It is important for these tubes to be uniform and defect free, therefore it is of great interest to characterize the superlattice tubes through a fast, non-invasive method like femtosecond pump-probe spectroscopy using asynchronous optical sampling (ASOPS) [3].

Rolled-up GaAs/InGaAs superlattices are optically excited and detected by ASOPS. The acoustic phonon modes are analyzed. The folding of the dispersion relation of the superlattice can be measured and it is possible to determine the quality of the layers by seeing large changes in the spectra. Scans over the length of the tubes can provide information on the homogeneity. Furthermore measurements at different temperatures are performed to measure phonon lifetimes.

References: [1] Deneke et al; Journal of Physics D: Applied Physics; 103, 233114 (2009) [2] Angelova et al; Applied Physics Letters; 100, 201904 (2012) [3] Ristow et al, Applied Physics Letters; 103, 233114 (2013)

HL 43.5 Wed 10:30 EW 202

Nonlinear Coupling of Phonons to Ferroelastic Domain Walls in $SrTiO_3$ Observed by Ultrafast Light Scattering from Phonons — •Lena Maerten, André Bojahr, Matthias Rössle, and Matias Bargheer — Insitut für Physik und Astronomie, Universität Potsdam, Germany

We excite high amplitude strain waves in $SrTiO_3$ (STO) using metal transducer films and monitor the strain propagation by ultrafast broadband transient reflectivity experiments. The phonon oscillations observed in temperature dependent measurements give access to the linear and nonlinear acoustic response of STO in the 100 GHz range across its ferroelastic transition. We interpret the linear response as a coupling to the ferroelastic soft mode and the nonlinear behaviour as a strain dependent coupling of phonons to ferroelastic domain walls [1]. We evaluate the wavevector dependent attenuation of the excited phonon modes and discuss, how the presence of domain walls affects the sound attenuation in STO in different temperature regimes.

[1] L. Maerten, A. Bojahr, M. Rössle, M. Gohlke and M. Bargheer, Coupling of GHz phonons to ferroelastic domain walls in $SrTiO_3$, Phys. Rev. Let., accepted