

DS 15: Optical Analysis of Thin Films II

Time: Thursday 11:15–12:45

Location: SCH A 316

Invited Talk

DS 15.1 Thu 11:15 SCH A 316

In-Situ Optical Investigation of Electrochemically Induced Conformational Changes at Solid Liquid Interfaces: A Source of new Electronic States — ●CHRISTOPH COBET — Linz School of Education, Center for Surface- and Nanoanalytics (ZONA), Johannes Kepler University, Altenbergerstr 69, A-4040, Linz, Austria

The electrical potential between an electrolyte and a solid electrode, whether it is a metal, semiconductor, polymer or a bio-membrane, could induce considerable changes in the conformational appearance. In biological systems such conformational changes are well-known e.g. as a control element for the chemistry on one or both sides of a membrane. In periodically ordered thin films or at surfaces, one can observe conformational changes at the atomic length scale which could induce new electronic properties. The interfacial electrical potential is in all cases a very versatile control element. On the one hand, it allows to change the chemical formation potential over a huge range which is otherwise only accessible for example by rather extreme temperature or pressure differences. On the other hand, it offers a very precise control of the thermodynamic equilibrium conditions. With the help of in-situ optical methods like spectroscopic ellipsometry (SE) and reflection anisotropy spectroscopy (RAS), we could study the interplay of the potential induced charge accumulation, the conformational changes and the evolution of (self) localized electronic states. The mechanisms will be discussed by two examples: The electrochemical doping and formation of polarons in polymers and the formation of surface quantum well states at a metal-electrolyte interface.

DS 15.2 Thu 11:45 SCH A 316

Singlet fission and triplet dynamics in pentacene embedded in a surface-anchored metal-organic framework — ●MARTIN RICHTER¹, ZHIYUN XU², PHILIPP LUDWIG³, PAVEL KOLESNICHENKO¹, UWE BUNZ³, CHRISTOF WÖLL², and PETRA TEGEDER¹ — ¹Physikalisch-Chemisches Institut, Universität Heidelberg — ²Institut für Funktionelle Grenzflächen, Karlsruher Institut für Technologie — ³Organisch-Chemisches Institut, Universität Heidelberg

It has been observed, that the rate of singlet fission in pentacene and the lifetime of the generated triplets strongly depend on the molecular arrangement.[1]

Here, a cofacial orientation of pentacene molecules is achieved by embedding them in a surface anchored metal-organic framework (SUR-MOF). Transient absorption spectroscopy has been used to analyze the ultrafast dynamics as well as long lived states after photoexcitation. The observed difference absorption spectra indicate, that after the initial excitation a singlet excited state generates a correlated triplet pair within a few picoseconds that retains singlet character. Subsequent dynamics show the formation of a long-lived species (47us) with triplet character. This exceeds by far the observed lifetime of triplets generated in pentacene thin films (10ns) and may enhance triplet harvesting capabilities in photovoltaic devices.[2]

1.Lubert-Perquel, D., Nat Commun. 2018, 9, 4222

2.Poletayev, A.D., Adv. Mater. 2014, 26, 919-924

DS 15.3 Thu 12:00 SCH A 316

Birefringence of orthorhombic DyScO₃: Towards a terahertz quarter-wave plate — ●JINGWEN LI, CHIA-JUNG YANG, JANNIS LEHMANN, NIVES STRKALJ, MORGAN TRASSIN, MANFRED FIEBIG, and SHOYON PAL — D-MATL, ETH Zurich, Switzerland

The energy scale of THz light corresponds to plenty of the fundamental collective excitations in materials, such as phonons, magnons, and heavy fermions. This makes THz light an ideal tool to investigate the low-energy excitations and non-equilibrium processes in solid-state systems. With the growing interest in studying the aforementioned collective phenomena, manipulating the polarization of THz light becomes necessary. However, prevailing THz waveplates, such as quarter-wave plates (QWPs) for generating circularly polarized THz light, typically

suffer from various problems, including bulky size, complex fabrication, or narrow working ranges. Here, we present a broadband THz QWP based on a 50- μm -thick (110)-cut orthorhombic DyScO₃ (DSO) crystal. We show a polarimetry measurement to verify the polarization of the output CP-THz light and prove that our DSO plate behaves like a QWP over a broad frequency range of 0.50-0.70 THz with a phase tolerance of $\pm 3\%$. We believe that our results expand the choices of broadband THz QWPs, as well as the possibilities of simple and compact achromatic THz QWPs by combining DSO crystals. Most importantly, as a common substrate for growing various thin films, DSO shows its potential as a compact built-in broadband THz waveplate for thin film research with circularly polarized THz light. [1]

[1] Appl. Phys. Lett. **118**, 223506 (2021).

DS 15.4 Thu 12:15 SCH A 316

Temperature Dependence of Coherent Phonon Oscillations in Metavalently Bonded Solids — ●TIMO VESLIN¹, FELIX HOFF¹, JULIAN MERTENS¹, JONATHAN FRANK¹, and MATTHIAS WUTTIG^{1,2,3} — ¹I. Institute of Physics (IA), RWTH Aachen University — ²Jülich-Aachen Research Alliance (JARA FIT and JARA HPC) — ³PGI 10 (Green IT), Forschungszentrum Jülich GmbH

Femtosecond optical pump probe measurements are carried out in order to detect changes in the reflectivity of the material response of MBE grown metavalently bonded (MVB) materials on sub-ps timescales. MVB differs significantly from metallic, ionic and covalent bonding. Examination of reflectivity changes due to the coherent phonon response provides insight into the ultrafast lattice dynamics and relaxation of MVB materials. To this end, the mechanism of dispersive excitation of coherent phonons (DECP) is used to analyse the highly symmetric A1 modes. The material response consists of the ultrafast carrier excitation and a slower carrier relaxation together with a damped harmonic phonon oscillation measured in the transient reflectivity trace. The temperature dependence of the frequency, lifetime and oscillation amplitude of the coherent phonon A1 mode in Sb₂Te₃, GeTe and Bismuth will be presented. This allows to identify phonon coupling effects and dephasing mechanisms, as well as the temperature dependence of phonon frequencies. Furthermore, the results are supported by optical and structural data recorded at room temperature. These measurements will help to better understand the MVB mechanism which governs phase change materials.

DS 15.5 Thu 12:30 SCH A 316

Identification of different polymorphs of a zone-cast perylene diimide derivative with low-frequency Raman and infrared scanning near-field microscopy — ●NADINE VON COELLEN, CHRISTIAN HUCK, NIKLAS HERRMANN, PETRA TEGEDER, and JANA ZAUMSEIL — Institute of Physical Chemistry, Heidelberg University, Germany

Small-molecule organic semiconductors are prone to form multiple thin film polymorphs. As their charge transport characteristics may vary substantially, effective and fast polymorph characterization techniques are necessary. Here, zone-cast films of perfluorobutyl dicyanoperylene-carboxydiimide (PDIF-CN₂) were studied with X-ray diffraction (XRD), confocal low-frequency Raman microscopy and infrared scanning near-field microscopy (IR-SNOM). Based on low-frequency Raman spectra and XRD, two different thin film polymorphs of PDIF-CN₂ were identified, which form depending on the solvents used for deposition. While confocal Raman microscopy is limited in the spatial resolution of areas, the near-field infrared technique (IR-SNOM) offers the unique possibility of both infrared microscopy and spectroscopy with a spatial resolution down to ~ 10 nm. We demonstrate that it is possible to discriminate between neighboring crystalline regions of the two PDIF-CN₂ polymorphs by means of IR-SNOM using slight differences in IR absorption. As a non-destructive technique, IR-SNOM may even enable in-situ investigations of thin semiconducting films in functional devices.