

HL 76: Poster IIIC

This poster session includes contributions from the following topics:

- Perovskites and photovoltaics - Organic semiconductors - Ultra-fast phenomena

Please put up your poster at the beginning of the session and remove the poster immediately after the session. The person presenting the poster should attend it for at least half of the session duration and indicate the time when to find him/her at the poster.

Time: Thursday 15:00–17:30

Location: P2/4OG

HL 76.1 Thu 15:00 P2/4OG

Collective effects of polyaromatic molecules embedded in rare gas matrices — ●MORITZ MICHELBACH, MATTHIAS BOHLEN, RUPERT MICHELS, and FRANK STIENKEMEIER — Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

Polyaromatic molecules, such as oligoacenes, are promising candidates for organic solar cells. These solar cells can achieve photon-to-current conversion efficiencies beyond the 30% Shockley-Queisser [1] limit. The underlying process responsible for creating multiple charge carriers from a single photon is called singlet fission. In this process, an excited molecule can partially transfer energy to a neighboring ground-state molecule, and thereby create a correlated triplet pair [2]. To investigate collective processes especially singlet fission, we have measured the lifetime of the excited molecule embedded in rare gas matrices. A significant lifetime reduction is observed in the presence of neighboring molecules [3]. As a comparison to isolated molecules on solid cluster surfaces, we use the artificially bound bis-TIPS pentacene molecule [4], which is embedded in superfluid helium nanodroplets.

- [1] W. Shockley and H. J. Queisser, *J. Appl. Phys.* 32, 510 (1961).
- [2] M. B. Smith, J. Michl, *Chem. Rev.* 110, 6891-6936, (2010).
- [3] S. Izadnia et al., *J. Phys. Chem. Lett.* 8, 2068 (2017).
- [4] S. R. Reddy, *J. Phys. Chem. Lett.*, 9, 5979-5986, (2018).

HL 76.2 Thu 15:00 P2/4OG

Laser-induced nonthermal diffusion of impurities and vacancies in Silicon — ●CHRISTELLE INÈS KANA MEBOU, TOBIAS ZIER, and MARTIN GARCIA — Institut für Physik, Universität Kassel, Germany

Laser-induced disordering processes have been studied intensively during the last decades. In this work, we present investigations of a laser induced ordering process which consists in the controlled mobility of crystal defects. In order to study the possibility to guide vacancies by femtosecond-laser pulses we performed ab initio molecular dynamics simulations of laser-excited Silicon with different defect densities using our code CHIVES (Code for Highly Excited Valence Electron Systems). The objective of this study is to determine the impact of laser excitation on defects (vacancies and impurity atoms) migration in Silicon (Si). Starting from initially randomly distributed defects, we simulated the ultrashort time dynamics of the system after laser heating. As a preliminary results we observed the changed mobility of the vacancies.

HL 76.3 Thu 15:00 P2/4OG

Electrochemical and Spectroelectrochemical Characterization of Methoxylated and Fluorinated Bis(bis(8-quinolinyl)amide)₂metal(II) Complexes — ●SOPHIE GÖBEL¹, THI HAI QUYEN NGUYEN¹, HARALD LOCKE², PETER R. SCHREINER², and DERCK SCHLETTWEIN¹ — ¹Justus Liebig University Gießen, Institute of Applied Physics — ²Justus Liebig University Gießen, Institute of Organic Chemistry

Organic semiconductors are targeted for applications in flexible electronic devices such as organic transistors. Intermolecular coupling is strongly influenced by the arrangement of molecules in solid state. In this work, well-stacking bis(bis(8-quinolinyl)amide)₂metal(II) molecules with different central cations (Fe, Cr, Zn, and Mn) as well as their corresponding methoxylated and fluorinated derivatives were analysed in their electronic and optical properties. Cyclic voltammetry of the molecules in solution was performed in a three-electrode setup to estimate the HOMO- and LUMO level of each molecule. Supporting spectroelectrochemical studies were carried out by in situ UV/Vis spectroscopy for a clear assignment of the redox and oxidation waves. By comparing the unsubstituted with the substituted complexes, a down-shift of the energy levels was observed revealing the inductive and mesomeric effects of the methoxy- and fluoro groups altering the

effective electron density in the aromatic core. The obtained values for the energy levels of the different molecules allow good estimations for future investigations of their electrical contact behaviour in devices and performances in thin films.

HL 76.4 Thu 15:00 P2/4OG

Lanthanide Doping of the Double Perovskite Cs₂AgBiBr₆ — ●GIOELE CONFORTO^{1,2}, JONAS HORN¹, FABIAN SCHMITZ², TERESA GATTI², and DERCK SCHLETTWEIN¹ — ¹Justus Liebig University Gießen, Institute of Applied Physics — ²Justus Liebig University Gießen, Institute of Physical Chemistry

Studies on inorganic halide perovskite solar cells showed remarkable improvement of the power conversion efficiency in recent years. An alternative to the extensively studied lead perovskites are double perovskites where Pb²⁺ is replaced by a monovalent and a trivalent cation, e. g. Cs₂AgBiBr₆. This material is not toxic and very stable. However, it has a large indirect band gap, low charge carrier mobility and weak absorption of visible light that decrease their efficiency. In this work, doping of this double perovskite with lanthanide atoms is studied in order to investigate options to decrease the band gap, improve absorption of visible light and enhance photoluminescence. The material is prepared either by a hydrothermal method in HBr or is used directly from a solution in dimethyl sulfoxide (DMSO). Thin films are deposited by spin-coating the (doped) double perovskite on fluorine doped tin oxide (FTO) or quartz glass substrates. Structure and composition are characterized by XRD, Raman and SEM-EDX analysis. In addition, optical properties are investigated by the use of UV-Vis absorption and photoluminescence spectroscopy. Small amounts of Eu led to the expected changes of the lattice constant but do not substantially change the absorption characteristics.

HL 76.5 Thu 15:00 P2/4OG

Light and electron beam induced current analysis of perovskite solar cells — ●FELIX MÜLLER, TOBIAS WESTPHAL, and MICHAEL SEIBT — University of Göttingen, IV. Physical Institute, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

As perovskite solar cells showing promising properties for future photovoltaics it is of interest to investigate their electronic properties. Light beam induced current (LBIC) or electron beam induced current (EBIC) are well-established techniques to study excess carrier recombination, i.e. to measure their diffusion length and to investigate recombination at extended defects. Both methods locally generate excess charge carriers in a certain generation volume beneath the spot where the beam (electron or light) hits the sample resulting in a short circuit current in a charge-separating junction. A current map is generated by scanning the beam over the sample.

As the spot size of an electron beam is typically smaller than the spot size of a laser, EBIC has a potentially higher spatial resolution. Some perovskites, however, suffer from beam damage produced by high energy electrons inside the SEM which is nearly no problem using LBIC. Despite a reduced spatial resolution of LBIC the excitation energy can be varied by using laser diodes with different wavelengths, to be sensitive to different band gaps.

In our present work we have measured LBIC and EBIC maps of the same perovskite samples to compare them regarding the mentioned properties of both methods. Combining the results of both we achieve a more complete picture of the sample's electronic characteristics.

HL 76.6 Thu 15:00 P2/4OG

Temperature-Dependent Impedance Spectroscopy of a Transition Metal Oxide Perovskite Heterojunction — MICHAEL SEIBT¹, CHRISTIAN JOOSS², TOBIAS MEYER¹, BIRTE KRESSDORF², and ●MUCUN YANG¹ — ¹IV. Physical Institute, Uni-Goettingen, Goettingen, Germany — ²Institute of Material Physics, Uni-Goettingen, Goettingen, Germany

Some organic perovskite materials are recently more frequently used for solar cells because of their high efficiency of photovoltaic behaviours. In this work, capacitance-voltage (C-V) characteristics of $\text{Pr}_{0.66}\text{Ca}_{0.34}\text{MnO}_3\text{-SrTi}_{0.998}\text{Nb}_{0.002}\text{O}_3$ perovskite heterojunction is studied by using impedance analyzer, which can calculate the capacitance with the help of impedance spectroscopy. The temperature dependence of C-V measurements is examined in a temperature range between 300 K and 40 K. The frequency dependence of capacitance is also observed in the range from 10^2 Hz up to 10^7 Hz under AC condition. In addition, another factor which might greatly affect the capacitance are the electron's deep level states, which might be partially formed by interface states induced by mismatch of lattice structures at the interface of heterojunction. The deep level states can be charged and discharged only at low frequencies, thus the properties and behaviours of deep level states are investigated under low frequency condition in the range between 10^2 Hz and 10^3 Hz.

HL 76.7 Thu 15:00 P2/4OG

Optical properties of metal-organic-bis(8-quinolinyl)amide complexes — •NICOLAS BRODA^{1,4}, HARALD LOCKE^{2,4}, PASCAL SCHWEITZER^{3,4}, DETLEV HOFMANN^{1,4}, PETER SCHREINER^{2,4}, DERCK SCHLETTWEIN^{3,4}, and SANGAM CHATTERJEE^{1,4} — ¹I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — ²Institut für Organische Chemie, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — ³Institut für Angewandte Physik, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — ⁴Zentrum für Materialforschung (ZfM), Justus-Liebig-Universität Gießen, 35392 Gießen, Germany

Organic semiconductors are advanced functional materials, for next-generation optoelectronic devices. Here, we report the optical properties of neutral metal-organic complexes with two pincer-type bis(8-quinolinyl)amide (BQA) ligands. In particular, we analyse a series of transition-metal-BQA-complexes where the central metal atom is varied by photoluminescence and absorption spectroscopies. Prominent optical transitions are observed in the spectral range between 350 nm and 900 nm. The transition energies depend on the central metal atom of the BQA complexes, namely Zn, Fe, Mn or Cr. The measurements are analysed in the frame of configuration coordinate models. Our results show that the materials are suitable for organic semiconductors and organic solar cell application.

HL 76.8 Thu 15:00 P2/4OG

Nano-floating gate memory based on lead halide perovskite nanocrystals — •TIANHAO JIANG^{1,2}, MARTIN STUTZMANN¹, XIUJUAN ZHANG², and JIANGSHENG JIE² — ¹Walter Schottky Institut, TUM, Munich, Germany — ²Institute of Functional Nano & Soft Materials, Suzhou, China

Lead halide perovskites have been extensively investigated in a host of optoelectronic devices, such as solar cells, light-emitting diodes, and photodetectors. The halogen vacancy defects arising from halogen-poor growth environment are normally regarded as an unfavorable factor to restrict the device performance. Here, for the first time, we demonstrate the utilization of the vacancy defects in lead halide perovskite nanostructures for achieving high-performance nano-floating gate memories (NFGMs). $\text{CH}_3\text{NH}_3\text{PbBr}_3$ nanocrystals (NCs) were uniformly decorated on CdS nanoribbon (NR) surface via a facile dip-coating process, forming a CdS NR- $\text{CH}_3\text{NH}_3\text{PbBr}_3$ NCs core-shell structure. Significantly, owing to the existence of sufficient carrier trapping states in $\text{CH}_3\text{NH}_3\text{PbBr}_3$ NCs, the hybrid device possessed an ultra-large memory window up to 77.4 V, a long retention time of 12 000 s, a high current ON/OFF ratio of 7×10^7 , and a long-term air stability for 50 days. This work paves the way toward the fabrication of new-generation, high-capacity nonvolatile memories using lead halide perovskite nanostructures.

HL 76.9 Thu 15:00 P2/4OG

Electrical characterization of deep levels inside sulfur hyperdoped silicon based on graded junction calculations — •ERICA F. WARTH PÉREZ ARIAS¹, ARNE AHRENS¹, ANNA L. BAUMANN², WOLFGANG SCHADE², and MICHAEL SEIBT¹ — ¹University of Göttingen, IV. Physical Institute, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — ²Fraunhofer Heinrich Hertz Institute HHI, Am Stollen 19H, 38640 Goslar, Germany

Semiconductor devices are the constituent of a considerable amount of technologies such as transistors, solar cells and LEDs. The perfor-

mance of such devices can be changed by deep defects inside the material, which can lead on one hand to a decreased diffusion length of charge carriers and increased current leakages [1]. On the other hand, deep levels at very high concentrations may form intermediate bands, which is well established for sulfur hyperdoped silicon [2], leading to an increased infrared absorption in the case of solar cells or photodetectors. Nearly exponential sulfur concentration depth profiles have been observed in such materials [3], giving rise to graded p-n junctions.

Therefore, this work analyses the depth profile of deep traps inside sulfur hyperdoped silicon using CV and DLTS measurements, under the implementation of a graded p-n junction model.

[1] K. A. Jackson et. al.; Handbook of Semiconductor Technology, Deep Centers in Semiconductors Vol. 1. WILEY-VCH (2000)

[2] M.T. Winkler et al.; Phys. Rev. Lett. 106, 178701 (2011)

[3] P. Saring, et. al. ; Appl. Phys. Lett. 103, 061904 (2013)

HL 76.10 Thu 15:00 P2/4OG

Thermally evaporated two dimensional perovskites for photovoltaic applications — •ZONGBAO ZHANG, RAN JI, MARTIN KROLL, CHANGSOON CHO, TIM SCHRAMM, FREDERIK NEHM, YANA VAYNZOF, and KARL LEO — Dresden Integrated Center for Applied Physics and Photonic Materials, Dresden, Germany

Organic-inorganic hybrid perovskite solar cells have demonstrated remarkable progress recently. Despite their excellent photovoltaic performance, their instability upon exposure to oxygen and moisture remains a critical challenge that needs to be mitigated prior to their commercialization. It has been recently shown that two-dimensional (2D) perovskites exhibit excellent stability, far surpassing that of traditional 3D perovskites. Solar cells with 2D perovskite have recently reached a high efficiency of over 18%. Most commonly, these devices are fabricated via solution processing, which has yet to prove feasibility for industrial mass production, with only very few reports of vacuum evaporated 2D perovskites. Here, we fabricate 2D perovskites ((PEA)₂(MA)_n-1PbnI_{3n+1}, (PEA)₂Csn-1PbnI_{3n+1}) via thermal evaporation and analyze their microstructure, crystallinity and optical properties. We find that the crystal structure of evaporated 2D perovskites is in excellent agreement with previous results reported for solution-processed fabrication. Similarly, the optical properties of the evaporated and solution-processed 2D perovskites are very similar. Our results highlight the efficacy of thermal evaporation as a tool for the formation of 2D perovskites of high electronic quality - a promising route for their integration into a range of optoelectronic applications.

HL 76.11 Thu 15:00 P2/4OG

Multistable circular currents of polariton condensates trapped in ring potentials — •FRANZISKA BARKHAUSEN¹, STEFAN SCHUMACHER^{1,2}, and XUEKAI MA¹ — ¹Department of Physics and CeOPP, Universität Paderborn, Paderborn, Germany — ²College of Optical Sciences, University of Arizona, Tucson, AZ 85721, USA

Vortices occur in a broad range of nonlinear systems. They have been widely investigated in many physical systems and different materials for their fundamental interest and for applications in data storage and information processing. In polariton condensates in planar semiconductor microcavities vortices can be supported and trapped by a ring-shaped potential, for example optically induced using spatially structured non-resonant excitation [1,2]. Here we theoretically study vortices excited non-resonantly in a fabricated ring-shaped external potential. This kind of potential traps the polariton condensate such that different steady-state solutions, oscillating or rotating solutions can be formed, depending on the width and depth of the potential. For a narrow and shallow potential, multistable ring solutions can be stabilized carrying different orbital angular momenta (OAM) but the same ring-shaped density structure. By increasing the confinement of the potential, a higher mode together with the fundamental mode can be excited. Their beating generates an oscillating solution if they have the same OAM or a spatially rotating solution if they have different OAM.

[1] X. Ma and S. Schumacher, Phys. Rev. Lett. 121, 227404 (2018).

[2] X. Ma et al., arXiv: 1907.03171 (2019).

HL 76.12 Thu 15:00 P2/4OG

Photoluminescence studies of organic microcrystals with π -conjugated core/shell molecule — ASWIN ASAITHAMBI¹, KOHEI IWAI², •GUENTHER PRINZ¹, HIROSHI YAMAGISHI², YOHEI YAMAMOTO², and AXEL LORKE¹ — ¹Faculty of Physics and CENIDE, University of Duisburg-Essen, Duisburg, Germany — ²Division of Material Science, Faculty of Pure and Applied Sciences, University of

Tsukuba, Tsukuba, Japan

Organic crystals in optoelectronic devices such as LEDs or solar cells have drawn a lot of attention in the last years. Oligo(p-phenylene vinylene) (OPV) molecules have many interesting properties such as a well-defined architecture and the ability to be modified with functionalized endgroups opening up an exciting number of functional assemblies. π -conjugated core/shell molecules can be grown into crystalline solids.

Here, we report on photoluminescence studies of eye-shaped crystals synthesized from fluorescent π -conjugated core/shell molecules. These crystals emit light in the green spectral range under 405 nm excitation. The spatial profile of the emission is not completely symmetric and depends on the excitation spot within the crystal. This already indicates a special orientation of the molecules within the crystal. XRD data also shows distinct diffraction peaks for these crystals, showing that the molecules are well ordered. Polarization dependent absorption and emission studies show an angle dependent characteristic of the light emission of these crystals, which will be discussed regarding the crystal and molecular orientation.

HL 76.13 Thu 15:00 P2/4OG

Universal short-time response and formation of correlations after quantum quenches — ●KLAUS MORAWETZ — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN, Campus Universitário Lagoa nova, 59078-970 Natal, Brazil

The short-time evolutions of two distinct systems, the pump and probe experiments with a semiconductor and the sudden quench of cold atoms in an optical lattice, are found to be described by the same universal response function. This analytic formula at short time scales is derived from the quantum kinetic-theory approach observing that correlations need time to form. The demand of density conservation leads to a reduction of the relaxation time by a factor of 4 in quench setups. The influence of the finite-trapping potential is derived and discussed along with Singwi-Sjölander local-field corrections including the proof of sum rules. The quantum kinetic equation allows to understand how two-particle correlations are formed and how the screening and collective modes are built up.

Phys. Rev. B 90 (2014) 075303, Phys. Rev. E 66 (2002) 022103, Phys. Rev. E 63 (2001) 20102, Phys. Lett. A 246 (1998) 311

HL 76.14 Thu 15:00 P2/4OG

Organic field effect transistors based on PNDIT2 polymers — ●ANNIKA MORGENSTERN¹, APOORVA SHARMA¹, GEORGETA SALVAN¹, DIETRICH R. T. ZAHN¹, and MICHAEL SOMMER² — ¹Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz — ²Polymer Chemistry, Chemnitz University of Technology, D-09107 Chemnitz

Organic field effect transistors (OFETs) based on polymers have attracted significant attention thanks to the availability of high-mobility polymers. Polymers are cost-efficient in production and can be deposited on almost any substrate. There are already numerous studies dedicated top-gate geometry OFETs and p-type polymers. These studies showed that the mobility is highly influenced by the chain length and the crystallinity of the polymer. Studies of n-type polymers in bottom-gate geometry are scarce. Here we present the characterization of bottom-gate OFETs based on the n-type polymer PNDIT2. This geometry is useful, for example, for further measurements of the photoinduced charge transport by light irradiation. The PNDIT2 films were deposited by spin coating onto prestructured substrates having Au source and drain electrodes on top of a 232,4 nm SiO₂ gate dielectric layer. An additional PMMA layer was required to prevent the oxidation of the polymer film. The influence of the molar mass of the polymer, of the crystalline order of the films and of the channel length on the transistor characteristics and the electron mobility was determined.

HL 76.15 Thu 15:00 P2/4OG

Synthesis and nanoscale characterization of perovskite single crystals using scanning probe techniques — ●ANDREI KARABANOV, MARIANELA ESCOBAR, VLADIMIR V. SHVARTSMAN, and DORU C. LUPASCU — Institute for Materials Science and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Universitätsstraße 15, 45141 Essen, Germany

In the last ten years enormous efforts have been put into the research of hybrid perovskites as an absorbing material for solar cells. These

materials show excellent photovoltaic properties not only in single, but also in tandem devices. However, the physical nature and the underlying mechanisms of such excellent photovoltaic performance are still unclear.

Here we report on solution growth of MAPbBr₃ single crystals. We studied the effect of the precursor concentration and temperature on the crystal quality. We found that the high concentrations of precursor in dimethylformamide solvent (0.9-1 g/ml) and the temperature range of 40-50 °C are optimal to get good quality cubic-shaped MAPbBr₃ crystals with the (110) orientation. The dielectric, ferroelectric, and photovoltaic properties of the crystals are studied in details both macroscopically and locally.

HL 76.16 Thu 15:00 P2/4OG

Analysis of semitransparent top contact induced Voc losses and their influences on long term stability in tandem solar cells — ●BOR LI, AMRAN AL-ASHOURI, MARKO JOŠT, EIKE KÖHNEN, MARLENE HÄRTEL, HANS KÖBLER, and STEVE ALBRECHT — HZB, Berlin, Germany

Semitransparent top contact layers are a key element for high efficiency perovskite based tandem solar cells. In addition, these layers, namely atomic layer deposited (ALD) tin oxide (SnO₂) and sputtered indium zinc oxide (IZO) protect the perovskite solar cells against decomposition reactions in humid air and at high temperature, thus improving long term stability. However, they often induce fill factor (FF) and open circuit voltage (Voc) losses due to e.g. improper energetic alignment and/or defect generation during deposition. In this work, these effects are quantified and it is shown how Voc losses can be mitigated by using different additives and ultrathin interlayers between the perovskite absorber and the n-type top contact. By introducing modifications such as LiF interlayer or phenyl ethylammonium iodide (PEAI) additive, the non-radiative recombination losses can be reduced. This is proven by an increased steady-state photoluminescence yield and improvements in Voc. The successful absorber and interface modifications, together with the evaluation of stability and efficiency enhancement, were integrated into monolithic perovskite/silicon tandem solar cells. These modifications aim to increase the performance and stability of perovskite solar cell structures and to get one step closer towards commercial availability of this tandem solar cell technology.

HL 76.17 Thu 15:00 P2/4OG

Coherent Dynamics in Rhenium Disulphide Studied by Ultrafast Electron Diffraction — ●AHMED HASSANIEN, ARNE UNGEHEUER, MASHOOD TARIQ MIR, ARNE SENFTLEBEN, and THOMAS BAUMERT — Institute of Physics and CINSaT, University of Kassel, Heinrich-Plett-Strasse 40, D-34132 Kassel, Germany

Coherent phonons are interesting phenomena where lattice vibrations are coherently excited by the impact of an ultrashort laser pulse. While pump-probe-based reflectometry experiments provide an indirect visualization for such coherent phenomena [1], Ultrafast electron diffraction represents a direct visualization of the coherent atomic oscillations providing an insight into the electron-phonon coupling strength [2]. Using a highly compact femtosecond electron diffractometer developed in our group [3], we were able to probe the coherent structural dynamics of mechanically-exfoliated few-layers ReS₂ revealed on a picosecond time scale, following the photoexcitation by femtosecond laser pulses. ReS₂ shows highly anisotropic structure due to which its optical properties showed significant polarization-dependence compared to TMDCs of hexagonal structure [4]. In this work we also concluded about the dependence of the electron-phonon coupling strength on the polarization state of the excitation pulse.

References: [1] Ishioka, Kunie, et al. Journal of Physics:Condensed Matter 31.9 (2019):094003. [2] Chatelain, Robert P., et al. Physical review letters 113.23 (2014):235502. [3] Gerbig, C., et al. New J. Phys. 17.4 (2015):043050. [4] Cui, Yudong, et al. Scientific Reports 7 (2017):40080.

HL 76.18 Thu 15:00 P2/4OG

Progress in the Vapour Deposition of Organic-inorganic Hybrid Metal-halide Perovskite Thin-films — ●JULIANE BORCHERT¹, IEVGEN LEVCHUK², LAVINA C. SNOEK¹, MATHIAS ULLER ROTHMANN¹, HENRY J. SNAITH¹, LAURA M. HERZ¹, CHRISTOPH J. BRABEC², and MICHAEL B. JOHNSTON¹ — ¹Clarendon Laboratory, Department of Physics, University of Oxford — ²Materials for Electronics and Energy Technology (i-MEET), FAU Erlangen-Nürnberg, Erlangen, Germany

Hybrid metal-halide perovskites are promising semiconductors for use

in solar cells, LEDs and other optoelectronic devices. Especially their application in solar cells has attracted a lot of research attention in recent years, due to the rapid rise of solar cell efficiencies for these materials. Record efficiencies have now reached to above 24%. Co-evaporation of perovskite thin-films for solar cells offers many advantages such as precise thickness control, pinhole free planar films and compatibility with a large range of different substrates. The very planar films achieved with co-evaporation have enabled in-depth optoelectronic studies of perovskite materials. Furthermore co-evaporation is a promising technique for the upscaling of perovskite solar cells to commercial scales. Some challenges remain, including optimisation of the process control and relatively small crystallites in the deposited films. Additionally, it is more challenging to achieve mixed compositions with co-evaporation than with solution processing. Here we present recent progress made to address these challenges.

HL 76.19 Thu 15:00 P2/4OG

Transient negative thermal expansion in HgTe/CdTe heterostructures by heating transverse phonons — ●MATTHIAS RÖSSLE¹, MARC HERZOG², JAN PUDELL², WOLFRAM LEITENBERGER², MAXIMILIAN MATTERN^{1,2}, LUKAS LUNCZER³, CLAUDIUS SCHUMACHER³, HARMUT BUHMANN³, LAURENS MOLENKAMP³, and MATIAS BARGHEER^{1,2} — ¹Helmholtz-Zentrum Berlin für Materialien und Energie, Germany — ²Institut für Physik und Astronomie, Universität Potsdam, Germany — ³Physikalisches Institut EP3, Universität Würzburg, Germany

We investigate the transient negative thermal expansion of semimetallic HgTe and semiconducting CdTe by using synchrotron-based time-resolved X-ray diffraction. At $T = 20$ K, far below the Debye temperature of both materials, the selective optical excitation of the HgTe top layer with an ultrashort near-infrared laser pulse leads to a rapid expansion of HgTe that is followed by a long lasting contraction. The CdTe substrate is compressed by the HgTe thin film expansion, and subsequently CdTe contracts due to thermally excited transverse phonon modes. This shows that negative thermal expansion is manifest on ultrafast timescales, consistent with the negative Grüneisen coefficient for transverse phonons in semiconducting materials with sphalerite crystal structure. At $T = 200$ K, far above the Debye temperature of both materials, the expansion driven by longitudinal acoustic phonons is prevalent. We simulate the lattice dynamics in an elastic model where transient thermal stresses are calculated via heat diffusion based on equilibrium thermoacoustic properties.

HL 76.20 Thu 15:00 P2/4OG

Coupling dynamics of coherent acoustic phonons in a Graphite–MoS₂ heterostructure observed by ultrafast electron diffraction — ●ARNE UNGEHEUER, AHMED HASSANIEN, ARNE SENFTLEBEN, MASHOOD MIR, and THOMAS BAUMERT — University of Kassel, Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), D-34132 Kassel, Germany

We investigate the coupling dynamics of coherent acoustic phonons in a Graphite–MoS₂ heterostructure, excited with a femtosecond laser pulse. Since the MoS₂ layer is transparent at our excitation wavelength of 785 nm, the coherent acoustic phonons are first excited exclusively in the Graphite layer. The subsequent coupling dynamics between the two materials are then probed with an ultrashort electron pulse imaging the transient by varying the delay time between pump- and probe-pulse. Furthermore we aim to coherently control these dynamics by using a double-pulse sequence for excitation. Amplification or annihilation of the coherent acoustic phonons in the Graphite layer can be achieved by adjusting the time-delay between the two excitation pulses.

HL 76.21 Thu 15:00 P2/4OG

Investigating 2D block array for OLED light outcoupling — ●DINARA SAMIGULLINA¹, PAUL-ANTON WILL¹, SIMONE LENK¹, LYDIA GALLE², STEFAN KASKEL², and SEBASTIAN REINEKE¹ — ¹Integrated Center for Applied Physics and Photonic Materials, TU Dresden — ²Chair of Inorganic Chemistry I, TU Dresden

Organic Light-Emitting Diodes (OLEDs) have already been established in the industry and have a high potential in the future in backlight-free displays, portable displays and lighting applications. However, to achieve high efficiency, the light outcoupling needs to be improved because the high refractive index of organic materials limits light extraction. Some of the generated light remains trapped in the OLED due to total internal reflection. For this reason, light outcoupling structures are used to extract light from the OLED and increase

the External Quantum Efficiency (EQE).

In this work, 2D TiO₂ block arrays were implemented to the bottom-emitting OLEDs to increase the amount of extracted light by scattering. Different periods of the blocks were investigated with an ultimate goal to achieve maximum EQE improvement. All the samples with the outcoupling structures showed an efficiency increase. The highest EQE is 23.6% for the blocks with a period of 700 nm and height of 90 nm. The enhancement is 16.3%. Additionally, the effectiveness of the structures, i.e. the fraction of extracted photons, was calculated according to reference [P.-A. Will et al., Adv.Fun.Mat., 29, 1901748 (2019)].

HL 76.22 Thu 15:00 P2/4OG

Irradiance dependent photoresponse organic near infrared photodetectors for distance measurement — ●YAZHONG WANG¹, CHRISTOPH LUNGENSCHMIED², KARL LEO¹, and DONATO SPOLTORE¹ — ¹iapp, tu dresden, dresden, germany — ²trinamix gmbh, industries-trasse 35, 67063 ludwigshafen am rhein, germany

Focus-Induced Photoresponse (FIP) technique is a new and elegant optical distance measurement solution. Organic near infrared (NIR) optical distance photodetectors based on FIP technique are irradiance dependent which is realized by inserting an extraction barrier for holes within the photodetectors. In this work, the barrier is introduced by replacing the normal hole transporting layer (HTL) material with a deeper highest occupied molecular orbital (HOMO) HTL material into an organic solar cell device. Holes are piled up by the extraction barrier, which increases the probability of charge recombination. With increasing irradiance, which can be achieved by decreasing the illumination spot area on the photodetector, the probability of charge recombination is becoming higher and higher. We demonstrate the organic NIR optical distance photodetectors with detection area up to 2.52 cm² and detection wavelengths at 850 nm and 1060 nm. Such NIR photodetectors have highly potentials to be utilized as robust, low-cost and simple optical distance measurement setup.

HL 76.23 Thu 15:00 P2/4OG

Transient negative thermal expansion and Poisson effect — ●MARC HERZOG¹, ALEXANDER VON REPPERT¹, and MATIAS BARGHEER^{1,2} — ¹Institut für Physik und Astronomie, Universität Potsdam — ²Helmholtz-Zentrum Berlin für Materialien und Energie

Negative thermal expansion (NTE) and the Poisson effect have been mainly studied in thermal equilibrium. Here we discuss the two phenomena in the context of strain waves generated by ultrafast excitation of various material systems that exhibit NTE in thermal equilibrium. These materials range from simple semiconductors to various spin- or charge ordered phases such as (anti-)ferromagnets and ferroelectrics. As NTE can be generally understood from increasing entropy with decreasing volume, we discuss ultrafast entropic stresses as the driver of lattice dynamics.

HL 76.24 Thu 15:00 P2/4OG

Effects of controlled slot-die-printing on halide perovskite films — ●MEIKE KUHN, CHRISTOPHER GREVE, and EVA M. HERZIG — Dynamik und Strukturbildung - Herzig Group, Universität Bayreuth, Universitätsstr. 30, 95447 Bayreuth, Germany

Perovskite solar cells gained a lot of interest because of their steeply increasing efficiency in the last years. But Perovskite materials in general are of strong interest due to their transport properties which are strongly linked to their nanostructure. There are different ways to deposit perovskite films, but for fabrication of large-area films methods like spin coating are hard to realize. So it is important to improve the fabrication of films by printing. By using a slot-die-printing system, we test different environmental control parameters and solvents to get a homogeneous perovskite layer. These parameters determine the structure of the perovskite layer [1] and thus the transport performance.

References

[1] Filonik, Oliver; Thordardottir, Margret E.; Lebert, Jenny; Pröller, Stephan; Weiß, Sebastian; Haur, Lew J.; Priyadarshi, Anish; Fontaine, Philippe; Müller-Buschbaum, Peter; Mathews, Nripan; Herzig, Eva M., Energy Technology, 7(10), 1900343, 2019

HL 76.25 Thu 15:00 P2/4OG

Surface charge-carrier dynamics of CsPbBr₃ inorganic perovskite — ●FELIX TRUNK, JANEK RIEGER, THOMAS FAUSTER, and DANIEL NIESNER — Lehrstuhl für Festkörperphysik, Friedrich-

Alexander University Erlangen-Nürnberg (FAU), Staudtstr. 7, D-91058 Erlangen, Germany

Several models have been proposed to understand the outstanding long lifetimes of charge carriers in lead-halide perovskites. Amongst others, there is an ongoing debate about the role of the organic ion on the charge-carrier cooling. We investigated the femto- to picosecond dynamics of conduction-band electrons at the surface of the purely inorganic perovskite CsPbBr₃.

Time-resolved bichromatic two-photon photoelectron spectroscopy with femtosecond time-resolution was carried out on epitaxially grown films with well-defined crystalline surfaces. The position of the conduction-band minimum indicates that our samples are intrinsic. Therefore, the carrier dynamics is dominated by electron-phonon scattering rather than electron-electron scattering.

In a systematic study, we could identify three different time regimes. After the initial cooling we can detect a second time constant before the charge carriers recombine.

The poster will focus on a comparison of carrier dynamics for different sample temperatures and thicknesses. From the latter we can distinguish carrier recombination at the surface from their diffusion into the bulk.

HL 76.26 Thu 15:00 P2/4OG

Universal Pure Aromatic Hydrocarbon Hosts for High-Efficiency Phosphorescent Organic Light-Emitting Diodes —

•QIANG WANG^{2,3}, FABIEN LUCAS¹, CASSANDRE QUINTON¹, LIANG-SHENG LIAO², ZUO-QUAN JIANG², and CYRIL PORIEL¹ — ¹Univ Rennes, CNRS, ISCR- UMR 6226 35000 Rennes, France — ²Institute of Functional Nano & Soft Materials, Soochow University Suzhou 215123, P. R. China — ³Institut für Physik & IRIS Adlershof Humboldt-Universität zu Berlin 12489 Berlin, Germany

In the field of phosphorescent organic light-emitting diodes (PhOLEDs), heteroatoms are prescriptively used to design host materials with controlled optoelectronic properties. To date, all the very high-efficiency universal hosts reported incorporate heteroatoms. However, one of the inherent issues of heteroatom-based hosts is the fragile heteroatom bonds, which causes instability in device performance. Here, we show that pure aromatic hydrocarbons hosts designed with the spirobifluorene scaffold are highly efficient and versatile hosts for PhOLEDs. With external quantum efficiencies of 27.1%, 26.0% and 27.3% for red, green and blue PhOLEDs respectively, this work not only reports the first example of high-efficiency pure hydrocarbon host in RGB PhOLEDs but also among the highest performance reported universal host. The overall performance demonstrates that pure aromatic hydrocarbons can provide new perspectives in the design of functional materials for PhOLEDs.