CPP 51: Hybrid and Perovskite Photovoltaics III

Time: Thursday 15:00–17:15 Location: GÖR 226

CPP 51.1 Thu 15:00 GÖR 226

Slot-die coating of nanocrystal and bulk perovskite thin films for photovoltaics — •Manuel A. Reus[1], Ahmed Krifa[1], David P. Kosbahn[1], Quinten A. Akkerman[2], Alexander Biewald[3], Lennart K. Reb[1], Matthias Schwartzkopf[4], Andrei Chumakov[4], Stephan V. Roth[4], Achim Hartschuh[3], Jochen Feldmann[2], and Peter Müller-Buschbaum[1,5] — [1]TUM School of Natural Sciences, Chair for Functional Materials, Garching — [2]Nano-Institut München und Fakultät für Physik, LMU München — [3]Department Chemie und CeNS, LMU München — [4]DESY, 22607 Hamburg — [5]MLZ, TUM, Garching

Thin-film solar cells might offer large-scale and cheap production with highly tunable properties, e.g., semi-transparency, color, thickness, or flexibility. Slot-die coated nanocrystal and bulk hybrid perovskite thin films are significant for high-efficiency next-generation solar cell absorber materials. In this work, we show the feasibility of creating high-quality thin films of this material class by the easily scalable and roll-to-roll compatible deposition method of meniscus-guided slot-die coating. We use time-resolved grazing-incidence X-ray scattering to investigate the crystal structure, texture, and morphology of the printed thin films. We track the printing process in real-time and extract parameters describing the quality and kinetics of the printing process. We also present solar cell data with perovskite absorber layers printed from colloidal hybrid perovskite nanocrystal solution.

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Time-resolved structural changes in hybrid perovskites under illumination — •Ivan Zaluzhnyy[1], Linus Pithan[1], Alexander Hinderhofer[1], Rustam Rysov[2], Fabian Paulus[3], and Frank Schreiber[1] — [1]Institute of applied physics, University of Tübingen, Tübingen, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]Center for advancing electronics Dresden, Technical University of Dresden, Dresden, Germany

Hybrid perovskites with mixed halides are known to undergo phase segregation when illuminated by visible light. We used coherent X-ray diffraction at synchrotron sources to reveal the structural changes in the series of $MAPbBr_{(3-x)}I_x$ perovskites illuminated with a white and blue light (broad spectrum and $\lambda \approx 450$ nm, respectively). The experimental data allow us to characterize the initial structure of the perovskite films, observe the changes during the illumination, and estimate the time scales over which these changes take place. Moreover, using x-ray photon correlation spectroscopy (XPCS), we can observe the movement of the domain walls and characterize the mobility of the halide ions. The obtained results allow us to better understand the microscopic mechanisms leading to the halide segregation.

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Investigation of defects inside of mixed halide perovsike solar cells — •Pascal Rohrbeck[1], Yenal Yalcinkaya[1,2], and Stefan A. L. Weber[1,2] — [1]Max Planck Institute for polymer research, department physics at interfaces, Ackermannweg 10, 55128 Mainz, Germany — [2]Johannes Gutenberg University, Department of Physics, Staudingerweg 10, 55128 Mainz, Germany

Understanding the electron and ion dynamics is an important task for improving the lead halide perovskites and related devices. For this task, macroscopic measurement techniques are not sufficient. Therefore, nanoscale characterization methods can play an important role in studying perovskite solar cells. In this study, we investigate the spatial defect distribution in the vicinity of grain boundaries. We introduce local photovoltage, photovoltage decay, and defect mapping via time-resolved Kelvin probe force microscopy (tr-KPFM) methods. We are able to detect and localize areas of increased charge carrier recombination, ion migration, and defects. This will help to understand recombination losses and improve perovskite solar cells on the long run.

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Post-Flight Analysis of Space-Probed Perovskite and Organic Solar Cells by Means of Grazing-Incidence X-Ray-Scattering — •Lennart Klaus Reb[1], Michael Böhmer[1], Benjamin Predeschly[1], Sebastian Grott[1], Christian Ludwig Weindl[1], Goran Ivkovic Ivandekic[1], Renjun Guo[1], Lukas Viktor Spanier[1], Christoph Dreissigacker[2], Jörg Drescher[2], Roman Gernhäuser[1], Andreas Meyer[2], and Peter Müller-Buschbaum[1,3] — [1]TU München, Garching, DE — [2]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Köln, DE — [3]Heinz Maier-Leibnitz-Zentrum, Garching, DE

Thin-film perovskite and organic solar cells exhibit an exceptional power per mass that makes them particularly interesting for space applications. Recently, we launched perovskite and organic solar cells into space on a suborbital rocket flight for the first time [1, 2]. The rocket experiment enables post-flight characterization of the space-probed solar cells, based on Grazing-Incidence Small-Angle and Wide-Angle X-ray Scattering (GISAXS/GIWAXS) to investigate morphological and structural changes in the active layers. The morphology is altered slightly by the space flight and environmental conditions before and after the rocket launch; interestingly, the sole solar cell transport in nitrogen environment modified their active layers compared to the reference solar cells. The crystalline phase, however, does not reveal changes in any solar cell type. [1] L. Reb et al., Joule 4,1880-1892 (2020), doi.org/10.1016/j.joule.2020.07.004. [2] L. Reb et al., Rev. Sci. Instrum. 92 (2021), doi.org/10.1063/5.0047346.

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Simulation of the impact of processing conditions on the perovskite film morphology — •Martin Majewski, Olivier Ronsin, and Jens Harting — Forschungszentrum Jülich GmbH, Helmholtz Institute Erlangen- Nürnberg (IEK-11), Dynamics of Complex Fluids and Interfaces, Cauerstraße 1, 91058 Erlangen, Germany

The solution-processed perovskite layer forms complex structures during drying. This morphology of the dry film heavily influences the efficiency of the final solar cell. The impact of the physical mechanisms on the morphology, like for example nucleation and evaporation rate, in a drying, crystallizing wet film is not really understood yet. Therefore a better understanding of the interplay of these phenomena is needed. We will present phase field simulations which are capable to describe the main physical processes like: evaporation, diffusion, spontaneous nucleation, crystal growth and advection, to investigate the impact of processing conditions on the final morphology of the perovskite film. Comparisons of the simulation to the theory will be presented. First simulations of drying solutions, including all physical phenomena, will be shown and compared to experiments.

15 min. break

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Influence of mesoporous-TiO_2 on mobile ion migration and charge extraction of perovskite solar cells — •Patrick Dörflinger[1], Valentin Schmid[1], Yong Ding[2], Mohammad Khaja Nazeeruddin[2], and Vladimir Dyakonov[1] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Group for Molecular Engineering of Functional Materials, Institute of Chemical Sciences and Engineering, EPFL Valais, Sion 1950, Switzerland

Hybrid lead halide perovskite solar cells have reached over 25% power conversion efficiency in the past years but still suffer from poor long term stability. Therefore, increasing attention is given to interfacial engineering. Especially the interplay of the transport layer with the perovskite layer is essential, determining various key properties like the ability of charge extraction or surface recombination. In this study, the potential of different mesoporous TiO_2 electron transport layers (ETL) with focus on the mobile ions is investigated. Therfore, concentration and diffusion of mobile ions, often linked to device degradation, is analyzed by measuring open-circuit voltage decay (OCVD). Furthermore, measuring the photoluminescence quenching efficiencies (PLQE) between open-circuit and short-circuit conditions of complete devices allows to study charge extraction and link the obtained results to device performance. These studies prove the advantage of using a mesoporous-TiO_2 layer made of single-crystalline nanoparticles as an ETL.

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Interferometric Bulk Access in Pump-Probe Microspectroscopy of $MAPbBr_3$ Crystals — •Tobias Seewald[1], Ulrich J.

Bahnmüller[2], Sebastian Polarz[2], and Lukas Schmidt-Mende[1] — [1]Department of Physics, University of Konstanz, Germany — [2]Institute of Inorganic Chemistry, Leibnitz University Hannover, Germany

We present a microspectroscopic study on individual facets of $MAPbBr_3$ crystals synthesized via an aerosol method controlling the exposed lattice planes. Transient reflection and photoluminescence spectra collected from single few μm facets allow to correlate the findings to micromorphology and lattice termination. Internal reflection of the probe pulse is found to form Fabry-Pérot resonances in the sub-band gap spectral region, which sensitively respond to the modified refractive index upon photoexcitation. Comparing one- and two-photon pump absorption, the dynamics of bulk and surface states can be distinguished on ps timescales.

CPP 51.8 Thu 17:00 GÖR 226

An alternative non-invasive technique for studying hybrid perovskite solar cells' in-situ degradation — •Chikezie Williams Ugokwe[1,2], Zekarias Teklu Gebremichael[1,2], Kehinde Ogunmoye[1,2], Ulrich S. Schubert[1,2], and Harald Hoppe[1,2] — [1]Center for Energy and Environmental Chemistry Jena (CEEC Jena), Friedrich Schiller University Jena, Philosophenweg 7a, 07743 Jena, Germany — [2]Laboratory of Organic and Macromolecular Chemistry (IOMC), Friedrich Schiller University Jena, Humboldtstrasse 10, 07743 Jena, Germany

The main obstacle to the commercialization of hybrid organic-inorganic perovskite (HOIP) solar cells is stability. Hence understanding degradation routes within the solar cell is essential. Traditional characterization methods have so far either monitored global properties, which precludes a better knowledge of local degradation processes, or induced some type of degradation, which conflates results in in-situ degradation studies of perovskite solar cells. In this paper, we describe a non-invasive technique for the in-situ analysis of the degradation of the active layer of an inverted HOIP solar cell. Utilizing the phenomenon of coherent light propagation in thin film layer stacks, we were able to see lead (II)iodide formation over time in a fully functional perovskite solar cell, which is an undeniable by-product of degradation. We were able to quantify the vertical distribution of the degradation product along the thickness of the active layer by using the measured reflectance of the entire solar cell as the input data for the optical modeling.