CPP 31: P3: Hybrid Photovoltaics and Preovskites

Time: Tuesday 14:00–16:00 Location: Poster B

CPP 31.1 Tue 14:00 Poster B

Influence of the Solvent on the Charge Transport Dynamics in *ZnO*-based Dye-Sensitized Solar Cells — •Christoph Richter, Max Beu, and Derck Schlettwein — Institute of Applied Physics, Justus-Liebig-University Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen

In electrodeposited *ZnO*-based dye-sensitized solar cells (DSCs) the common solvent is a mixture of 4:1 vol % ethylene carbonate : acetonitrile. Since ethylene carbonate is a solvent with a high viscosity compared to acetonitrile non-negligible contributions to the series resistance were observed. To overcome this problem we have studied different mixtures of 3-methoxypropionitrile, valeronitrile or ethylene carbonate with acetonitrile. A detailed photoelectrochemical analysis was conducted to understand the differences observed in the measured IV-curves. By using intensity modulated current and photovoltage spectroscopy (IMPS, IMVS) and impedance spectroscopy (EIS) the influence of the solvent mixtures on the charge transport and recombination reactions in the DSCs could be clarified. The results, further, provide additional input to an ongoing discussion why *ZnO*-based DSCs generally lack behind the reported efficiencies of TiO_2-based DSCs.

CPP 31.2 Tue 14:00 Poster B

Light harvesting structured titania films prepared by PDMS molds — •Bo Su, Yichuan Rui, and Peter Müller-Buschbaum — TU München, Physik-Department, LS Funktionelle Materialien, James-Franck-Str. 1, 85748 Garching

Due to the high surface to volume ratio and the bicontinuous morphology, foam-like nanostructures are becoming more interesting in photovoltaics. To improve the power conversion efficiency, a light-trapping strategy is widely used in dye-sensitized solar cells (DSSCs) and organic photovoltaics (OPVs). In our study, we demonstrate foam-like structured titania films, which are made by blade coating and soft-molding methods, with an additional superstructure in the micrometer range. The master to implement the superstructure is prepared by photolithography. Then replica molds are made from the master with poly(dimethyl siloxane) (PDMS). Finally, the different light trapping structured titania films are prepared by applying these PDMS molds. After the fabrication of DSSCs, the photocurrent-voltage characteristics of the DSSCs are measured. The morphology of the films is characterized with SEM and AFM. The optical properties are determined by UV/Vis spectroscopy.

CPP 31.3 Tue 14:00 Poster B

Investigation on morphology and optical properties of hybrid perovskites prepared on different substrates — •Amrita Mandal Bera, Dan Ralf Wargulski, Ibrahim Simsek, Sergiu Levcenco, and Thomas Unold — Helmholtz-Zentrum Berlin für Materialien und Energie

Hybrid organometal perovskites have emerged as promising solar absorber material and have exhibited solar cell efficiencies more than 19% to date. The morphology of the perovskite layer is one of the most important parameters which affect solar cell efficiency. CH3NH3PbI3 has been synthesized by the two step method by converting a PbI2 layer into perovskite by immersion in methylammoniumiodide. The perovskite films prepared on different substrates [glass, fluorine doped tin oxide (FTO), FTO with TiO2 blocking layer] have been characterized by x-ray diffraction, scanning electron microscopy and optical microscope imaging. The film morphology depends on substrate type as well as processing parameters (e.g. spinning speed, deposition time and temperature). The processing parameters have been optimized to get good surface coverage. The optical properties have been investigated by measuring absorption and photoluminescence spectra at room temperature. Despite large changes in morphology of the samples they generally exhibit a strong photoluminescence band centered around 1.6 eV.

CPP 31.4 Tue 14:00 Poster B

Investigating the morphology of $CH_3NH_3PbI_{3-x}Cl_x$ highly efficient planar perovskite solar cells — •Johannes Schlipf[1], Lukas Oesinghaus[1], Pablo Docampo[2], Thomas Bein[2], and Peter Müller-Buschbaum[1] — [1]TU München, Physik-Department, LS Funktionelle Materialien, James-Franck-Str. 1, 85748 Graching — [2]LMU München, Department Chemie, Butenandtstr. 11, 81377 München

Organo-metal halide perovskites mark a paradigm shift in photovoltaic research. Recently reported power conversion efficiencies exceeding 15% are possible due to their highly crystalline nature even when processed from solution. However, film morphology is directly connected to the preparation routine and material properties like charge diffusion lengths that are intrinsically linked to photovoltaic performance. We prepare highly efficient planar methylammonium (MA) lead iodide perovskite solar cells via a two-step solution-conversion process, i.e. dipping of a previously deposited PbI_2 thin film into a MA-containing solution [1]. We complement electronic and optical characterization using UV-Vis spectroscopy, EQE and IV measurements with grazing incidence small and wide angle X-ray scattering (GISAXS and GIWAXS). Thereby it is possible to understand the role of film morphology and influence of film properties on solar cell performance. [1] P. Docampo, et al., Adv. Energy Mater, 4, 1400355, 2014

CPP 31.5 Tue 14:00 Poster B

Electrical atomic force microscopy on perovskite films — •Ilka M. Hermes, Victor W. Bergmann, Simon A. Bretschneider, Frédéric Laquai, Rüdiger Berger, and Stefan A.L. Weber — Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany

Organolead trihalide perovskite solar cells have reached power conversion efficiencies (PCE) of more than 20%, yet not enough is known about the physics within the perovskite layer. Unusual effects have been reported, such as strong hysteretic behavior in the photocurrent-voltage curves of the cells. It remains unclear how this effect is related to the high PCE and if mechanisms like ferroelectricity or the accumulation of trapped charges cause the hysteresis. One way to tackle these questions is to investigate the nanoscale function of perovskite films, e.g. by atomic force microscopy in working devices [1].

In this work, the electronic and electromechanical properties of perovskite films were studied on nanometer scale with electrical atomic force microscopy methods. With piezoresponse force microscopy (PFM), the local piezoelectric response was visualized, providing information on possible ferroelectric domains within the film. Conductive atomic force microscopy (CAFM) was used to measure the local photocurrent. With Kelvin probe force microscopy (KPFM) contact potential variations and light-induced potential changes could be locally resolved. These experiments help to improve the understanding of the working principles of perovskite solar cells.

[1] Bergmann, V.W. et al (2014); Nature Comm. 5, 5001

CPP 31.6 Tue 14:00 Poster B

Novel approaches for tuning optical and electronic properties of perovskites and their application in hybrid thin film solar cells — •Lukas Oesinghaus, Johannes Schlipf, and Peter Müller-Buschbaum — TU München, Physik-Department, LS Funktionelle Materialien, James-Franck-Str. 1, 85748 Garching

Recently, Docampo et al. reported achieving an efficiency of up to 15.4% for solution processed planar heterojunction perovskite solar cells by using a simple two-step sequential deposition process [1].

We use a similar method, where a PbI2 film is spin cast and subsequently converted to perovskite in a mixed solution of methylammonium iodide (MAI) and methylammonium chloride (MACl), which results in a better film homogeneity as compared to single-step solution deposition and larger diffusion lengths as compared to films prepared with pure MAI solutions. Thus the overall photovoltaic performance is increased. We tune the morphology and the properties of the interfaces adjacent to the charge selective electrodes. This has an effect on the photovoltaic performance, which is characterized by UV-Vis, IV and EQE measurements. With AFM and SEM complementary structure information is achieved.

[1] Docampo et al., Adv. Energy Mater., 2014, 4, 1400355.

CPP 31.7 Tue 14:00 Poster B

Lifetime of photogenerated charge carriers in methylammonium lead halide perovskite solar cells studied by transient photovoltage/photocurrent — •David Kiermasch[1], Stefan Väth[1], Andreas Baumann[2], and Vladimir Dyakonov[1,2] —

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In the last few years solar cells based on organo-metal halide perovskites attracted a lot of attention. Since the first publication of a solar cell with a perovskite absorber in 2009, the efficiency nowadays reaches up to 20 %. Despite that, there is a lack of understanding on the working principles in this new kind of solar cells, like the transport and the recombination of the photogenerated charge carriers. We prepared methylammonium lead halide perovskite solar cells, namely $CH_3NH_3PbI_3$ and $CH_3NH_3PbI_{3-x}Cl_x$ in a planar configuration. The lifetime and the concentration of photogenerated charge carriers are studied by transient photovoltage/photocurrent and charge extraction experiments. We discuss our results for different device configurations.

CPP 31.8 Tue 14:00 Poster B

Recombination Dynamics in Perovskite Solar Cells probed by Time-Delayed-Collection-Field (TDCF) Experiments — •Andreas Paulke[1], Samuel D. Stranks[2], Henry J. Snaith[2], Dieter Neher[1], and Thomas J.K. Brenner[1] — [1]Institute of Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Str.24-25, D-14476 Potsdam-Golm, Germany — [2]Department of Physics, University of Oxford, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, United Kingdom

Time-Delayed-Collection-Field (TDCF) experiments are applied to working perovskite ($CH_3NH_3PbI_{3-x}Cl_x$) solar cells with different device architectures. In TDCF, charges generated by a nanosecond optical pulse are extracted by a large reverse voltage pulse. Thereby, the delay between the photoexcitation and the extraction is tuned over a wide range, with a minimal delay of 10ns. This allows to probe the temporal evolution of the photogenerated charges and quantify nongeminate recombination losses in the device. For comparison, the charge carrier dynamics of an all-organic device (PTB7:PC71BM) with similar performance is studied under comparable illumination conditions. We find that the predominant recombination mechanism in perovskite solar cells is very different from that of the organic cell. In particular, while the charge carrier dynamics in the all-organic cell can be described by purely bimolecular recombination with a time and fluence independent BMR coefficient, the dynamics in mesoporous-TiO_2/Perovskite/Spiro and planar PEDOT:PSS/Perovskite/PCBM devices is characterized by a slow-down of the recombination rate over several microseconds.