DS 25: Organic Electronics and Photovoltaics I (Joint session of CPP, DS, HL and O, organized by CPP)

Time: Tuesday 14:00–15:30 Location: H37

DS 25.1 Tue 14:00 H37

Elucidating the Morphology of Organic Bulk Heterojunction Solar Cells Using Nanoanalytical Transmission Electron Microscopy — •Stefanie Fladischer[1], Tayebeh Ameri[2], Christoph Brabec[2], and Erdmann Spiecker[1] — [1]FAU, CENEM, Erlangen, Deutschland — [2]FAU, i-MEET, Erlangen, Deutschland

Organic photovoltaics is one of the most promising technologies for low cost energy production with the advantages of semi-transparency, flexibility and solution processing. Significant improvement of the power conversion efficiency could be achieved in the last years using novel materials and adapted device engineering. To further improve the efficiency of solar cells the knowledge of the morphology is essential, as it decisively influences the device performance. The morphology of organic bulk heterojunction (BHJ) active layers depends not only on the involved materials but also on their molecular weight and their treatment like thermal annealing and solvent vapor annealing. Analytical Transmission Electron Microscopy (TEM) is a versatile tool to characterize the morphology of organic solar cells concerning on the one hand the interfaces of the various layers and on the other hand the material distribution in BHJ active layers. Combining high-resolution imaging with analytical techniques like electron energy-loss spectroscopy (EELS) and energy filtered TEM (EFTEM) as well as energy-dispersive X-ray spectroscopy (EDXS) the morphology can be determined and thus the device performance can be understood and further improved.

DS 25.2 Tue 14:15 H37

Links between organic solar cell performance and morphological properties — •Daniel Moseguí González[1], Christoph J. Schaffer[1], Stephan Pröller[2], Johannes Schlipf[1], Lin Song[1], Sigrid Bernstorff[3], Eva M. Herzig[2], and Peter Müller-Buschbaum[1] — [1]TU München, Physik-Department, LS Funktionelle Materialien, 85748, Garching, Germany — [2]TU München, Munich School of Engineering, Herzig Group, 85748 Garching, Germany — [3]Elettra Sincrotrone Trieste S.C.p.A., Basovizza, 34149 Trieste, Italy

Many attempts have been made to establish solid links between morphology and performance of organic solar cells (OSCs) as well as the potential suitability of some materials for solar devices. Eventually, many of these attempts have yielded deeper insight into the physics governing excitonic solar cells. In this regard, one of the most innovative approaches consists in the in-operando observation of solar devices under working conditions in time-resolved grazing incidence X-ray scattering experiments. This configuration allows for simultaneous tracking of morphological and electronic properties as a function of time, making the appearing co-dependences among studied parameters more remarkable. The presented work focuses on the first in-operando observations that showed strong correlations between the crystalline state of P3HT:PCBM OSCs' active layers and the open-circuit voltage delivered by the devices. Up to now, this link was only addressed in a multi-step fashion with works featuring interdependences between properties like crystallinity, recombination, energy disorder, open-circuit voltage, or exciton/charge carrier transport.

DS 25.3 Tue 14:30 H37

Strong influence of morphology on charge transport and recombination in solution processed small molecule based solar cells — •Alexey Gavrik[1], Andreas Baumann[2], Yuriy Luponosov[3], Sergey Ponomarenko[3,4], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Bayerisches Zentrum für Angewandte Energieforschung (ZAE Bayern), 97074 Würzburg — [3]Enikolopov Inst Synthet Polymer Mat, 117393 Moscow, Russia — [4]Lomonosov Moscow State University, 119991 Moscow, Russia

Solution processed small molecules (SSM) are promising materials for solar cell (SC) applications due to their well defined structure and high chemical reproducibility. Donor-acceptor-donor layout of SSM provides enhanced exciton splitting, as well as good possibility for effective charge transfer. The blend morphology in a bulk-heterojunction (BHJ) SC is assumed to play a crucial role in the cell performance. Therefore, we set to find optimal BHJ fabrication method keeping track of corresponding transport properties. In this work we studied DTS$(EtHex)_2$-$(2T\text{-}DCV\text{-}Me)_2$:$PC_{60}BM$ BHJ SC using the photogenerated charge carrier extraction technique OTRACE in order to analyze non-geminate recombination and determine charge carrier mobility in context of varying blend morphology. We show that different preparation conditions have a strong impact on the blend morphology and thus on the charge carrier transport (i.e. mobility and recombination rate). Furthermore, introduced modifications allowed to achieve a 4-fold enhancement of SC efficiency up to 4.3%.

DS 25.4 Tue 14:45 H37

Direct visualization of charge-extraction in metal-mesh based OPV cells by light-biased LBIC — •Mathias Gruber[1,2], Arne Hendel[1], Vladislav Jovanov[1], Manfred J. Walter[2], and Veit Wagner[1] — [1]Department of Physics and Earth Sciences, Jacobs University Bremen, 28759 Bremen, Germany — [2]PolyIC GmbH & Co. KG, 90763 Fürth, Germany

Metal-mesh based electrode systems are a highly conductive, versatile and unexpensive alternative to ITO-electrodes for organic photovoltaic (OPV) cells. However, as a metal-mesh does not offer full surface conductivity it is usually combined with a less conductive PEDOT:PSS layer, which enables lateral charge-transport in the area in between the metal tracks. The sheet conductivity of this additional lateral conductive layer (LCL) needs to be carefully tuned with respect to the distance of the metal tracks to reduce short circuit current (J_{sc}) losses and additional series resistance due to resistive losses in the LCL material. Usually this is done via electrical simulation or via analysis of IV-measurements of a large number of devices with different LCL sheet conductivities. Here we present a direct way to measure the current collection losses due to PEDOT:PSS sheet resistance by integrating a white light-bias into a LBIC measurement (Light-bias LBIC). We show that we are not only able to directly measure and visualize charge extraction under real device operation conditions but are also able to determine the intrinsic PEDOT:PSS sheet resistance in the operating OPV device.

DS 25.5 Tue 15:00 H37

Morphological Degradation of Polymer-Fullerene Bulk-Heterojunction Solar Cells — •Christoph J. Schaffer[1], Claudia M. Palumbiny[1], Martin A. Niedermeier[1], Christian Burger[1], Gonzalo Santoro[2], Stephan V. Roth[2], and Peter Müller-Buschbaum[1] — [1]TU München, Physik-Department, LS Funktionelle Materialien, James-Franck-Str. 1, 85748 Garching — [2]DESY, Notkestr. 85, 22607 Hamburg

Organic solar cells offer a wide range of advantages based on their mechanical flexibility, their optical tunability and their ease of production in comparison to conventional photovoltaics. However, elongating their lifetime remains the main challenge after efficiencies exceeding the 10% marker have been recently reported [1]. We focus on the stability of the active bulk-heterojunction layer of polymer-fullerene solar cells. Using in-situ GISAXS and simultaneous current-voltage tracking we have previously shown that the active layer is morphologically unstable during operation of a P3HT:PCBM based solar cell, causing device degradation [2]. In our recent work we observe different degradation mechanisms occurring in other polymer-fullerene blends. This knowledge shows that tailored stabilization methods must be found for each specific material system.

[1] S.-H. Liao et al., Scientific Reports 2014, 4, 6813.
[2] C. J. Schaffer et al., Adv. Mater. 2013, 25, 6760.

DS 25.6 Tue 15:15 H37

Illumination dependent parasitic resistances in organic bulk hetero junction solar cells. — •Arne Hendel and Veit Wagner — Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

During outdoor operation, the solar cell is exposed to AM1.5G during noon only. For other daytimes and for indoor applications the performance of the solar cell at lower light intensities is important. In this study, bulk hetero junction solar cells were exposed to light irradiation from 10^{-5} to several suns intensity. We find a strong illumination dependence of the parasitic resistances. For the different light intensities I-V characteristics were performed. In addition the Jsc-Voc analysis

was done to obtain series resistance free I-V measurement. It was found that the series and shunt resistance, which are critical for the solar cell performance, strongly depend on illumination intensity. The light intensity induced conductivity change of the solar cell shows different dependencies for forward and reverse operation. For low light intensities, the shunt resistance can be directly measured via the open circuit voltage assuming the Shockley model for the diode. From these measurements a strong light dependence is obtained. Based on the experimental data a model for the light dependent shunt resistance and series resistance is presented.