HL 67: Organic Semiconductors: Solar Cells II (Joint Session with DS/CPP/O)

Time: Friday 10:15–12:15 Location: H16

HL 67.1 Fri 10:15 H16

Organic-inorganic heterojunction with P3HT and n-type 6H-SiC: Determination of the band alignment and photovoltaic properties — •Roland Dietmüller, Helmut Nesswetter, Sebastian Schöll, Benedikt Hauer, Ian David Sharp, and Martin Stutzmann — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany

The exact band alignment in organic/inorganic semiconductor heterojunctions is influenced by a variety of properties and difficult to predict. For the organic/inorganic heterojunction made of poly(3-hexylthiophene) (P3HT) and n-type 6H-SiC, the band alignment is determined via current-voltage measurements. For this purpose a model equivalent circuit, combining a thermionic emission diode and space-charge limited current effects, is proposed which describes the behavior of the heterojunction very well. From the fitting parameters, the interface barrier height of 1.1 eV between the lowest unoccupied molecular orbital (LUMO) of P3HT and the Fermi level of 6H-SiC can be determined. In addition from the maximum open circuit voltage of the diodes, a distance of 0.9 eV between the HOMO of P3HT and the conduction band (CB) of 6H-SiC can be deduced. These two values determine the Fermi level of 6H-SiC, which is about 120 meV below the CB, relative to the HOMO and LUMO of P3HT. The 6H-SiC/P3HT heterojunction exhibits an open circuit voltage of 0.55 eV at room temperature, which would make such a heterojunction a promising candidate for bulk heterojunction hybrid solar cells with 6H-SiC nanoparticles.

HL 67.2 Fri 10:30 H16

Hybrid solar cells based on semiconductor nanocrystals and poly(3-hexylthiophene) — •Holger Borchert, Florian Witt, Marta Kruszynska, Nikolai Radychev, Irina Lokteva, Folker Zutz, Marc Daniel Heinemann, Elizabeth von Hauff, Joanna Kolny-Olesiak, Ingo Riedel, and Jürgen Parisi — University of Oldenburg, Department of Physics, Energy and Semiconductor Research Laboratory, Carl-von-Ossietzky Str. 9-11, 26129 Oldenburg, Germany

Semiconductor nanoparticles are promising electron acceptor materials for polymer-based bulk heterojunction solar cells. Size-dependent optical properties enable adaptation of the absorption to the solar spectrum, and the possibility to use elongated nanoparticles should be favorable for efficient electron transport. Despite these potential advantages, efficiencies reported for such hybrid solar cells are still below those of organic polymer/fullerene cells. In the work to be presented, CdSe nanoparticles were prepared by colloidal chemistry and their usability for hybrid solar cells in conjunction with poly(3-hexylthiophene) (P3HT) as electron donor material was studied. Systematic studies of correlations between the device performance and blend morphology are presented. Furthermore, charge separation in the donor/acceptor systems was studied in detail by electron spin resonance (ESR) and photoinduced absorption spectroscopy (PIA). The studies revealed the existence of a large amount of trap states which might be the origin of the limitations for the device efficiency. First results with colloidally prepared CuInS2 nanoparticles are presented as well.

HL 67.3 Fri 10:45 H16

Analysis of space charge limited currents in P3HT-PCBM based bulk heterojunction solar cells — •Sidhant Bom and Veit Wagner — School of Engineering and Science, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

The bulk heterojunction organic photovoltaic (OPV) devices have gained attention due to its applicability in large area printing offering a prospect of significant cost reduction. Our work here focuses on modeling of charge carrier transport in P3HT-PCBM based bulk heterojunction OPV devices sandwiched between ITO/PEDOT:PSS and aluminium electrode using glass substrates. For this purpose different blend ratios of P3HT and PCBM were analyzed.

The mobility determined from the space charge limited current is directly correlated to diffusion constant of the charge carriers, which is a crucial parameter in determining the rate of extraction of dissociated charge carriers. Taking into consideration the variation of mobility with charge carrier density at different operating modes of the OPV cell, a charge carrier density dependent mobility was introduced as opposed to constant mobility. This modification not only leads to a more accurate determination of charge carrier mobility but also gives an insight into the morphology of the blend via an energetic disorder parameter. Surprisingly, in comparison to a pure P3HT device, a bulk heterojunction OPV cell showed a significant reduction in this disorder parameter indicating a PCBM induced improvement of the existing P3HT network.

HL 67.4 Fri 11:00 H16

Spectroscopy of PTCDA deposited on an ultra thin optical fiber from a helium nanodroplet beam. — Tobias Knoblauch, •Matthieu Dvorak, and Frank Stienkemeier — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg im Breisgau

Optical nanofibres can be employed for ultra-sensitive surface spectroscopy of deposited molecules [1,2]. This method shows a good signal to noise ratio with surface coverage as small as 1/1000 of a monolayer, the reason of which stems from the strong evanescent field existing at the interface of optical fibres with sub-wavelength diameter.

Helium nanodroplet isolation (HENDI) spectroscopy is a powerful technique to analyze the vibrational structure of molecules as well as excitonic transitions of complexes and nanostructures at low temperatures [3]. In the present case, helium droplets are used to form complexes of PTCDA molecules having organic semiconducting properties and deposit them on an ultra thin fibre. In this way it is expected to link spectroscopic data obtained in the ultra-cold and interaction-free environment and film spectra.

[1] F. Warken et al., Optics Express 15, 11952 (2007)
[2] A. Stiebeiner et al., Optics Express 17, 21704 (2009)
[3] M. Wewer and F. Stienkemeier, Phys. Rev. B 67, 125201 (2003)

15 Min. Coffee Break

HL 67.5 Fri 11:30 H16

Evaporated Mixed Films of Electron Acceptor and Donor Molecules as Model Systems of Bulk Hetero Junction Materials — •André Dragässer, Max Beu, Christopher Keil, and Derck Schlettwein — Institute of Applied Physics, Justus-Liebig-University Giessen, Germany. email:schlettwein@uni-giessen.de

The formation of evaporated blends of organic donor and acceptor molecules has gained interest recently for active interlayers in organic photovoltaic cells and organic field effect structures. For example photovoltaic efficiencies in the 4 % range could be reached recently by research groups in Dresden, Hong Kong or Michigan for mixed blends of C_{60} and PcCu. It is well known that each individual compound is sensitive in its electrical properties to environmental influence (e.g. H_2O, O_2, etc.) and so will be the interplay of the molecules in this complex material. In this contribution we therefore report about the combination of electron donor and acceptor molecules, e.g. C_{60} and PcCu, as evaporated bulk heterojunction in simple model systems. Photovoltaic cells consisting of these layers were built in high vacuum and characterized in-situ with IV-measurements in the dark and under illumination. The influence of oxygen, air and conditioning of the films in vacuum will be discussed.

HL 67.6 Fri 11:45 H16

Role of the Charge Transfer State for Organic Solar Cells — •Carsten Deibel[1], Alexander Wagenpfahl[1], Thomas Strobel[1,2], and Vladimir Dyakonov[1,3] — [1]Experimental Physics VI, Julius-Maximilians-University of Würzburg, Germany — [2](now at Cavendish Laboratory, University of Cambridge, UK) — [3]Functional Materials for Energy Technology, Bavarian Centre for Applied Energy Research (ZAE Bayern), Würzburg, Germany

In organic bulk heterojunction solar cells, the charge transfer (CT) state is the intermediate but crucial step between exciton dissociation and charge transport to the electrodes. It is important for both, open circuit voltage and photocurrent.

The maximum open circuit voltage of organic bulk-heterojunction solar cells was recently shown to be given by the energy of the CT state (Nat. Mater. 8 (2009) 904). For P3HT:PCBM solar cells, it is around 1.1eV, whereas the open circuit voltage is only around 600 mV. This discrepancy was assigned to nonradiative recombination, although the

details are still unknown. Performing macroscopic device simulations with input parameters resulting from a comprehensive experimental characterization, we discuss the relative contributions of surface and bulk recombination to this difference. Concerning the impact of the CT state on the photocurrent: we recently performed Monte Carlo simulations of CT dissociation, finding that the fast local charge carrier transport can explain the high quantum yields in polymer solar cells. Also, we were able to show that CT diffusion to the electrodes before complete dissociation is a potential loss mechanism.

HL 67.7 Fri 12:00 H16

Numerical simulation of s-shaped organic bulk-heterojunction solar cell current–voltage characteristics — •Alexander Wagenpfahl[1], Daniel Rauh[1], Carsten Deibel[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Julius-Maximilians University of Würzburg, Am Hubland, D-97074 Würzburg — [2]Bavarian Center for Applied Energy Research (ZAE Bayern e.V.), Am Hubland, D-97074 Würzburg

Organic solar cell devices based on semiconducting polymer–fullerene blends occasionally possess current–voltage characteristics showing an s-shaped behavior. A strong effect of this kind easily reduces the solar cells working efficiency to a minimum. The detailed origin of the double diode behavior is still unknown. Using a poly(3-hexylthiophene) : phenyl-C61-butyric acid methyl ester (P3HT:PCBM) blend as active layer, we will present how such an s-shape is experimentally achieved using a plasma etch process on the transparent hole conducting anode (indium tin oxide). By considering a finite surface recombination in a device simulation program, we show that this s-shape can be calculated, only by assuming finite charge extraction velocities from the active layer to the metallic electrodes. The resulting charge carrier accumulation at the surfaces thereby changes the current transport from ohmic to space charge limited. By analyzing the found dependencies we will demonstrate under which conditions this effect influences the solar cell performance.