HL 30: Organic electronics and photovoltaics I (DS, jointly with CPP, HL, O)

Time: Monday 17:15–18:45 Location: H32

HL 30.1 Mon 17:15 H32

Correlation between interface energetics and open circuit voltage in organic photovoltaic cells — •Andreas Wilke[1], James Endres[2], Ulrich Hörmann[3], Jens Niederhausen[1], Raphael Schlesinger[1], Johannes Frisch[1], Patrick Amsalem[1], Julia Wagner[3], Mark Gruber[3], Andreas Opitz[1], Antje Vollmer[4], Wolfgang Brütting[3], Antoine Kahn[2], and Norbert Koch[1,4] — [1]Humboldt-Universität zu Berlin, Institut für Physik, Brook-Taylor-Str. 15, D-12489 Berlin, Germany — [2]Department of Electrical Engineering, Princeton University, Princeton, NJ 08544, USA — [3]Universität Augsburg, Institut für Physik, Universitätsstr. 1, D-86135 Berlin, Germany — [4]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH BESSY II, Albert-Einstein-Str. 15, D-12489 Berlin, Germany

We have used ultraviolet and inverse photoemission spectroscopy to determine the transport gaps (E_{T}) of C60 and diindenoperylene (DIP), and the photovoltaic gap (E_{PVG}) of five prototypical donor/acceptor interfaces used in organic photovoltaic cells (OPVCs). The transport gap of C60 (2.5 ± 0.1) eV and DIP (2.55 ± 0.1) eV at the interface is the same as in pristine films. We find nearly the same energy loss of ca. 0.5 eV for all material pairs when comparing the open circuit voltage measured for corresponding OPVCs and E_{PVG}.

HL 30.2 Mon 17:30 H32

Direct Observation of Charge Separation in Perylene Monoimide Solid State Dye-Sensitized Solar Cells — •Ian Howard[1], Michael Meister[1], Björn Baumeier[1], Henrike Wonnenberger[1], Neil Pschirer[2], Rüdiger Sens[2], Ingmar Brüder[2], Klaus Müllen[1], Denis Andrienko[1], and Frédéric Laquai[1] — [1]Max Planck Institute for Polymer Research, Ackermannweg 10, D-55128 Mainz, Germany — [2]BASF SE

Combining Vis-NIR broadband pump-probe transient absorption spectroscopy with precise measurement of the time-resolved photoinduced Stark effect we demonstrate that it is possible to track not only the rate of charge injection but also the motion of carriers after injection on the critical nanosecond timescale in Solid State Dye Sensitized Solar Cells. In terms of solar cell efficiency our findings have two major impacts. Firstly, we directly observe that the *reductive quenching* pathway previously suggested (wherein a photoexcited dye donates a hole to the hole transport material before then injecting an electron, now from the dye anion state, into the TiO2) is important for obtaining high device efficiencies, especially for NIR absorbing dyes which exhibit a reduced driving force for electron injection directly from the dye exciton. Secondly, we find that many charges return to the interface after following injection, likely due to Coulombic and image charge effects. Screening the charges better, for example by reducing the dielectric contrast or increasing the dye length, should decrease the interfacial charge density and thereby parasitic recombination.

HL 30.3 Mon 17:45 H32

Full electronic structure across a polymer heterojunction solar cell: interface dipoles and influence of light — •Johannes Frisch[1], Patrick Amsalem[1], Jens Niederhausen[1], Marcel Schubert[2], Eduard Preis[3], Antje Vollmer[4], Jürgen P. Rabe[1], Ullrich Scherf[3], Dieter Neher[2], and Norbert Koch[1] — [1]Humboldt-Universität zu Berlin, Germany — [2]Universität Potsdam, Germany — [3]Bergische Universität Wuppertal, Germany — [4]Helmholtz-Zentrum Berlin für Materialien und Energie - Speicherring BESSY II, Berlin, Germany

Controversial discussions concern the dependence of open circuit voltage on the energy offset between the highest occupied molecular orbital level of the donor material and the lowest unoccupied molecular orbital level of the acceptor material in organic photovoltaic cells. Therefore, we investigate the energy level alignment in two bilayer OPVCs comprising the donor poly(3-hexylthiophene) (P3HT) and the acceptors 1-(3-methoxycarbonyl)propyl-1-phenyl[6.6]C61 (PCBM) and poly(9,9'dialklylfluorene-alt- 4,7-bis(2,5-thiendiyl)-2,1,3-benzothiadiazole) (PFTBTT). Ultraviolet photoelectron spectroscopy revealed that notable interface dipoles occur at all interfaces across the OPVC structures for both material combinations. Particularly, the effective electrode work function (after contact formation with the organic material) differs significantly from those of the pristine materials. In addition, we find that negative charges are collected at the metal clusters (that exist in the early stage of cathode formation) due to exciton dissociation at the heterojunction.

HL 30.4 Mon 18:00 H32

Optoelectronic Properties Of Zinc(II)-Phthalocyanine — •Michael Kozlik, Sören Paulke, Marco Gruenewald, Roman Forker, and Torsten Fritz — University of Jena, Institute of Solid State Physics, Helmholtzweg 5, 07743 Jena, Germany

Zinc phthalocyanine (ZnPc) is an organic molecule which is used in organic optoelectronic devices, such as OLEDs and organic solar cells. Bulk material is represented mainly in form of the metastable α-ZnPc, while the stable β-ZnPc is less conductive [1]. We show the critical transformation temperature as well as optical and morphological differences between both phases. Description and simulation of the performance of organic devices make use of material parameters. In our work we present the determination of the optical constants and the exciton diffusion length. Experimental methods are UV-Vis spectroscopy and external quantum efficiency. By transmittance and reflectance spectra we derive the real and imaginary part of the refractive index [2]. In combination with the derived parameters we show the performance of a simplified photovoltaic cell and identify the region of exciton dissociation and exciton diffusion length.

References

[1] K. Wihksne et al., J. Chem. Phys. 34 (1961) 2184.

[2] M. Kozlik et al., Org. Electron. 13 (2012) 3291.

HL 30.5 Mon 18:15 H32

The operational mechanism of ionic transition metal complex-based light-emitting electrochemical cells — •Sebastian B. Meier[1,2], Stephan van Reenen[3], Henk J. Bolink[4], Martijn Kemerink[3], Wiebke Sarfert[2], and Albrecht Winnacker[1] — [1]Department of Materials Science VI: Materials for Electronics and Energy Technology, University of Erlangen-Nuremberg, Germany — [2]Siemens AG, Corporate Technology, CT RTC MAT MPV-DE, Erlangen, Germany — [3]Department of Applied Physics, Eindhoven University of Technology, The Netherlands — [4]Instituto de Ciencia Molecular, Universidad de Valencia, Spain

Light-emitting electrochemical cells (LECs) are promising candidates for cost-efficient next generation solid-state lighting and signage applications. They feature only a single, solution-processible active layer comprising a luminescent material in an ionic environment which allows for charge carrier injection from air-stable electrodes and low operating voltages. The operational mechanism of LECs has been the subject of an intense debate ever since their discovery. Evidence for electrochemical doping has been demonstrated for polymer-based devices, whereas LECs comprising ionic transition metal complexes (iTMCs) have almost exclusively been stated to operate via an electrodynamic mechanism. We used fluorescence as well as scanning Kelvin probe microscopy on planar iTMC-LECs to elucidate their mechanism of work. Our results illustrate profound evidence for electrochemical doping in these kind of LEC devices and highlight that the position of the established p-i-n junction is not fixed but migrates during device operation.

HL 30.6 Mon 18:30 H32

Effective Charge Carrier Lifetimes in Organic Solar Cells Prepared by Coevaporation of $C60$ and $CuPc$ in different mixtures and geometries — •André Dragässer and Derck Schlettwein — Institute of Applied Physics, Justus-Liebig-University Giessen, Giessen, Germany

Evaporated organic solar cells can lead to efficiencies of technical relevance if the interface of donor and acceptor molecules is optimized for the interplay of exciton dissociation, charge transport and recombination. The effective lifetime of the charge separated state is of central relevance. Intensity- modulated photovoltage spectroscopy with parallel impedance spectroscopy is a suitable method of analysis. Organic solar cells consisting of the well-established semiconductor materials $CuPc$ and $C60$ were prepared by physical vapor deposition on an ITO substrate, modified with $PEDOT:PSS$. The cells were completed by a back contact of BCP as a buffer and aluminum. Cell architectures of planar junctions, bulk heterojunctions or planar-mixed heterojunctions were studied for different film thickness of the components. IV-measurements in the dark and under varied illumination intensities provided basic device characteristics. Detailed measurements of the short-circuit photocurrent and the open-circuit photovoltage under static or intensity-modulated illumination with different wavelength were performed to determine the average charge carrier lifetime in the devices which was related to the respective charge carrier density obtained by impedance spectroscopy. Recombination reactions and, in particular, the influence of trap states will be discussed.