# DS 8: Organic Electronics and Photovoltaics III (jointly with CPP, HL, O)

Time: Monday 18:00–19:45 Location: CHE 91

DS 8.1 Mon 18:00 CHE 91

**Studying the electric potential of organic solar cells** — •Michael Scherer[1,2,3], Tobias Jenne[1,2,3], Rebecca Saive[1,2,3], Felix Schell[1,2,3], Robert Lovrincic[1,2,3], and Wolfgang Kowalsky[1,2,3] — [1]InnovationLab GmbH, Heidelberg — [2]TU Braunschweig — [3]Universität Heidelberg

Despite steadily increasing efforts in the research on organic semiconductors, many of the models applied in the field are restricted to small clusters of molecules or model systems only, thus lacking prediction when it comes to full devices. With scanning Kelvin probe microscopy (SKPM) accompanied by device simulations we try to access the physics of entire OSC devices and bridge the gap between the molecular and the macroscopic understanding.

Our scanning probe station is placed within the vacuum of a scanning electron microscopy (SEM)/focused ion beam (FIB) cross beam system. We prepare OSC cross sections with the FIB and place the cantilever under SEM observation right at the cross section. Thus we are able to investigate the potential distribution of OSCs in situ with SKPM.

The SKPM measurements are backed by IV characterization and device simulations. Varying the parameter of the active layer/contact interface, we investigate their impact on the potential distribution and the device characteristics of the OSC. In IV measurements and cross sectional SKPM measurements we check the validity of the applied models and identify loss mechanisms and their localization in the solar cell device.

DS 8.2 Mon 18:15 CHE 91

**Correlation of electric properties and interface band alignment in organic light-emitting diodes** — •Maybritt Kühn[1,2], Eric Mankel[1,2], Christof Pflumm[3], Thomas Mayer[1,2], and Wolfram Jaegermann[1,2] — [1]Technische Universität Darmstadt, Institute of Materials Science, Surface Science Division — [2]InnovationLab GmbH, Heidelberg — [3]Merck KGaA, Darmstadt

Organic light-emitting diodes consist of several functional organic layers sandwiched between two electrodes with different work functions. At the current onset voltage the applied electric field is high enough that charge carrier injection and transport begins. In some device structures the onset voltage increases with increasing thickness of the emission layer. We present a detailed study on this up to now unpredictable phenomenon by combining IV-measurements and interface investigations using photoelectron spectroscopy (XPS/UPS). We focus on two isomers synthesized by Merck that serve as matrix material in the emission layer-one showing the changes in onset voltage the other not. The complex device architecture was reduced to a model device system using NPB as hole-transport layer and the undoped isomers as emission layer. The shift in onset voltage can still be observed in the model devices as well in hole-only devices derived from the model system. By stepwise evaporation of the respective isomer onto NPB we performed PES-interface experiments and analyzed the band alignment between NPB and the isomers in an integrated UHV system. It was found that the hole injection barrier is larger by about 200 meV in case of the isomer showing the observed shift in onset voltage.

DS 8.3 Mon 18:30 CHE 91

**Temperature dependent exciton diffusion length in ZnPc** — •Bernhard Siegmund[1], Johannes Widmer[1], Simone Hofmann[1], Moritz Riede[2], and Karl Leo[1] — [1]Institut für Angewandte Photophysik, Dresden, Germany — [2]Current address: Clarendon Laboratory, Oxford, England

The photo-current of organic solar cells is the result of a multi-step process. It includes the generation and diffusion of excitons as well as their separation into free charge carriers, the transport to the electrodes, and their final extraction. One bottleneck for highly efficient devices is the short exciton diffusion length in organic materials.

In this work, the singlet exciton diffusion length $\ell_{\mathrm{diff}}$ in the absorber material ZnPc is studied. For this purpose, the photo-current of organic solar cells, incorporating ZnPc and $C_{60}$ in a flat heterojunction architecture, is measured and modelled as a multi-step process. $\ell_{\mathrm{diff}}$ is extracted from a thickness variation of the absorber layer, as not yet encountered in the context of modelling the photo-current to determine $\ell_{\mathrm{diff}}$ before. Measurements at varying temperature between 200 K and 370 K reveal a thermal activation of the diffusion length above 310 K. This is interpreted as promotion of the excitons to higher energies with a density of states allowing for enhanced hopping transport. The activation energy is considered as a measure for the energetic disorder of the excitonic states. These investigations aim for a better understanding of exciton migration in order to design materials with longer exciton diffusion lengths for highly efficient organic solar cells.

DS 8.4 Mon 18:45 CHE 91

**The effect of gradual fluorination on the opto-electronic properties of $F_n$ZnPc/$C_{60}$ bilayer cells** — •M. Brendel[1], A. Steindamm[1], A. Topczak[1], and J. Pflaum[1,2] — [1]Exp. Phys. VI, JMU Würzburg, 97074 Würzburg — [2]ZAE Bayern, 97074 Würzburg

The respective position of energy levels at the donor/acceptor heterojunction is crucial for the resulting parameters of an organic solar cell. For instance the open circuit voltage ($V_{oc}$) is correlated to the energy difference between the highest occupied molecular orbital (HOMO) of the donor and the lowest unoccupied molecular orbital (LUMO) of the acceptor, the so-called effective band gap ($E_{g,eff}$). To gain insights into this correlation, tailoring of energy levels by chemical modification is a powerful approach. In this contribution, we investigate the impact of gradual fluorination of zinc phthalocyanine on the opto-electronic properties of $F_n$ZnPc/$C_{60}$ (n=0,4,8,16) bilayer cells. Upon fluorination, HOMO and LUMO levels are shifted towards lower energies. The gain in $V_{oc}$ for $F_4$ZnPc/$C_{60}$ and $F_8$ZnPc/$C_{60}$ by 11% and 23% respectively, compared to ZnPc/$C_{60}$, confirms qualitatively the expected energy level scheme. Besides, the differences between $e \cdot \Delta\ V_{oc}$ and $\Delta E_{g,eff}$ hint at the occurrence of dipoles and their gain in strength with increasing degree of fluorination. As will be shown, this dipol can be correctly accounted for in a plate capacitor geometry, considering image charges at the interface induced by electronegative fluorine in the immediate vicinity of $C_{60}$ molecules. We thank S. Sundarray and P. Erk from BASF for providing $F_4$ZnPc. Financial support by the DFG (program SPP1355) and the BMBF (GREKOS program).

DS 8.5 Mon 19:00 CHE 91

**Effect of Counter-Anions During Electrodeposition on the Charge Transport Dynamics in Sensitized *ZnO* Solar Cells** — •Christoph Richter, Max Beu, and Derck Schlettwein — Institute of Applied Physics, Justus-Liebig-University Giessen, Germany

Thin porous *ZnO*/*EosinY* films have been electrochemically deposited from oxygen-saturated aqueous solution. During the electrochemical deposition chloride or perchlorate as different counter-anions have been used. After the removal of *EosinY* with *KOH* the films have been sensitized with the indoline dye D149. These electrodes were used in dye-sensitized solar cells (DSCs) and the charge transport dynamics were studied with electrochemical impedance spectroscopy (EIS), intensity modulated current/voltage spectroscopy (IMPS/IMVS) and IV-curves. Doping of the *ZnO* films by *Cl* alters the charge transfer dynamics by filling of otherwise unoccupied states in *ZnO* and changing the concentration of available trap states. By changing the counteranion to perchlorate well-reproducible results could be obtained which open the way to further improvements in DSCs.

DS 8.6 Mon 19:15 CHE 91

**Efficiency roll-off in organic light-emitting diodes: influence of emitter position and orientation** — •Caroline Murawski[1], Philipp Liehm[1,2], Simone Hofmann[1], Karl Leo[1], and Malte C. Gather[1,2] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]present address: SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews KY16 9SS (UK)

In this contribution, we study the efficiency decrease of organic light-emitting diodes (OLEDs) at high brightness (so-called roll-off).[1] We find a strong influence of the emitter-cathode distance and the transition dipole orientation of the emitter molecules on the roll-off by comparing two phosphorescent emitters (Ir(MDQ)2(acac) and Ir(ppy)3).[2] The measurements are modeled using triplet-triplet-annihilation (TTA) theory. A comparison of experiment and theory reveals the critical current density and the TTA rate constant and shows that the differences in roll-off behavior are predominantly caused by a change of the decay rates inside the OLED cavity. In order to provide guidelines for designing OLEDs with optimal high-brightness efficiency, we model the roll-off as a function of the emitter-cathode distance, emitter dipole orientation, and radiative efficiency.

[1] C. Murawski, K. Leo, and M.C. Gather, Adv. Mater. 10.1002/adma.201301603 (2013).

[2] C. Murawski, P. Liehm, K. Leo, and M.C. Gather, Adv. Funct. Mater. 10.1002/adfm.201302173 (2013).

DS 8.7 Mon 19:30 CHE 91

**Solution-based planarization layers for organic solar cells on flexible silver nanowire transparent electrodes** — •Jan Ludwig Bormann[1], Franz Selzer[1], Nelli Weiss[2], Lars Müller-Meskamp[1], and Karl Leo[1] — [1]Institut für Angewandte Photophysik, TU Dresden — [2]Physikalische Chemie, TU Dresden

Flexible transparent electrodes made of silver nanowires (AgNWs) are an emerging research field for different optoelectronic devices such as organic transistors, organic light emitting diodes (OLED) and organic photovoltaics (OPV). They exhibit excellent electrical and optical properties (sheet resistance of 11 Ohm/sq at 85% transmittance) and are suitable for the application on flexible substrates. These transparent electrodes show high roughness and therefore require a planarization layer for fabricating efficient small molecule devices.

In this work, solution-based organic materials are processed with spin coating to planarize the AgNW electrode. A solution processed small molecule layer acts as planarizing layer and as hole transport layer in organic solar cells with a bulkheterojunction comprising the fullerene C60 as acceptor and different small molecule donor layers (oligothiophenes and phtalocyanines) . The efficiency of these devices is comparable or even better to reference devices with indium tin oxide (ITO) as transparent electrode.