

CPP 21: Organic Electronics and Photovoltaics III

Time: Wednesday 9:30–12:45

Location: H37

CPP 21.1 Wed 9:30 H37

High-resolution spectroscopic mapping of P3HT:PCBM organic blend films for solar-cell applications — ●XIAO WANG¹, DAI ZHANG¹, KAI BRAUN¹, HANS-JOACHIM EGELHAAF², CHRISTOPH J. BRABEC², and ALFRED J. MEIXNER¹ — ¹Institute of Physical and Theoretical Chemistry, University of Tübingen — ²Konarka Technologies GmbH, Nürnberg

We present a high resolution near-field spectroscopic mapping of the poly(3-hexylthiophene) and [6, 6]-phenyl-C61 butyric acid methyl ester (P3HT:PCBM) blend film upon different thermal annealing.[1] From the simultaneously recorded morphology and spectroscopic information, the interplay among the blend film morphology, the local P3HT:PCBM molecular distribution, and the P3HT photoluminescence (PL) quenching efficiency were discussed. The PL and Raman signals of the electron donor (P3HT) and acceptor (PCBM) have been probed at an optical resolution of approximately 10 nm which allow the direct identification of the chemical nature of the different domains. Moreover, we were able to reveal and quantify local quenching, which is related to the electron transfer from P3HT to PCBM. Based on the experimental results, it is proposed that high resolution near-field spectroscopic imaging proves its clear capability of mapping the local chemical composition and photophysics of the P3HT:PCBM blends on a length of a few nanometers.

[1] X. Wang, et al. *Advanced Functional Materials* (in press)

CPP 21.2 Wed 9:45 H37

Investigations on thickness dependence of electrical characteristics and stability of self-assembled monolayers — ●DANA HABICH — FAU Erlangen-Nürnberg, Institute of Polymer Materials

We investigated the influence of the molecular chain length (n) of aliphatic C $_n$ -phosphonic acids on the electrical characteristics of self-assembled monolayers (SAMs) based on these molecules. SAMs prepared on aluminium/aluminium oxide (Al/AlO $_x$) and conductive indium tin oxide (ITO) substrates behave as molecular dielectric layer. In integrated devices (e.g. capacitors) with activated Al-bottom electrode, the dielectric layer is created from a double-layer AlO $_x$ /SAM. Capacitance and breakdown voltage correlates monotonically with the SAM thickness, the current density at low voltage does not follow the expected correlations in detail. We address this behavior to morphological changes of the SAMs on AlO $_x$, from an amorphous structure for short chains to a crystalline state for longer alkyl chains. To decouple the relative contributions of the AlO $_x$ and the SAM to the insulation, an independent analytical approach to characterize the SAM was chosen: cyclic voltammetry on SAM decorated ITO. The faradic current of a redox active compound in solution is indirect proportional to the molecular chain length. Qualitatively, this observation proofs the conclusions from the capacitor measurements. The system ITO/SAM, further provide an approach for functional coatings on ITO with the possibility to tune addressability and stability of the electrodes. Stability was investigated by static contact angle and STM measurements before and after electrical stress. Ref.: *Org. Electron.* 10 (2009) 1442.

CPP 21.3 Wed 10:00 H37

2D mapping of the Electron Beam Induced Current (EBIC) in organic solar cells — ●PIET REUTER¹, THOMAS RATH², GREGOR TRIMMEL², and PETER HADLEY¹ — ¹Institute of Solid State Physics, TU Graz, A-8010 Graz, Austria — ²Institute for Chemistry and Technology of Materials & Christian Doppler Laboratory for Nanocomposite Solar Cells, TU Graz, A-8010 Graz, Austria

Electron Beam Induced Current (EBIC) measurements were used to produce 2D nanoscale maps for investigating the homogeneity of solar cells. These maps are acquired by putting the electron beam of a scanning electron microscope (SEM) in spot mode and using a programmable sample stage to move the solar cell under the stationary beam. The electron beam generates electron-hole pairs in the solar cell much like light does in normal operation. The variations in the EBIC signal can be attributed to changes in the morphology. By comparing these measurements with morphological information of the devices, one can identify the cause of inferior performance which should then lead to an improvement of further devices. It should be mentioned that long time exposures to an electron beam destroys the organic semiconductors. Studies were performed to determine the acceptable electron

dose during the measurement.

CPP 21.4 Wed 10:15 H37

Analysis of Metallic Conduction at the Interface of TTF and TCNQ Crystals. — ●VIKTOR ATALLA, MINA YOON, and MATTHIAS SCHEFFLER — Fritz-Haber-Institut der MPG, Berlin, Germany

Organic materials are promising candidates for a next generation of electronic devices, since they offer a variety of new intriguing electronic phenomena while being environmentally friendly, low cost, and mechanically flexible. Here we study the interface of tetrathiofulvalene (TTF) and 7,7,8,8-tetracyanoquinodimethane (TCNQ) organic molecular crystals which was found to exhibit metallic conduction [1] whereas the individual crystals are large band-gap semiconductors. Using quantum mechanical first-principles approaches employing the FHI-aims code [2] basic properties of monomers, dimers, and individual crystals are investigated. We construct interfaces between the two types of crystals and study the electronic band structures of the interface-induced states, which are relevant to the charge transport properties of the material. Depending on the relative orientation of the crystals the band structures were found to indicate metallic conduction at the interface. Furthermore the energetics of the polaron is investigated by calculating the geometry relaxation energy. For monomers of TTF and TCNQ this is found to be in the order of 0.1 eV, indicating that the electron-lattice interaction is an important parameter for charge transport in this system. [1] H. Alves et al., *Nat. Mat.* 7, 574 (2008). [2] V. Blum et al., *Comp. Phys. Comm.* 180, 2175 (2009).

CPP 21.5 Wed 10:30 H37

Structural analysis of photoactive polymer blend films on textured polymeric and inorganic substrates — ●ROBERT MEIER¹, MATTHIAS A. RUDERER¹, GUNAR KAUNE¹, ALEXANDER DIETHERT¹, FABIAN MARKL¹, VOLKER KÖRSTGENS¹, JOHANNES WIEDERSICH¹, STEPHAN V. ROTH², and PETER MÜLLER-BUSCHBAUM¹ — ¹TU München, Physik Department LS E13, James-Frank-Straße 1, 85747 Garching — ²HASYLAB at DESY, Notkestraße 85, 22603 Hamburg

Due to their large chemical variety photoactive conducting polymers are of great interest for versatile applications such as organic photovoltaics. In order to improve the device characteristics not only the polymer film but also the rest of the device has to be optimized regarding light absorption and charge carrier separation. Therefore the focus of this work is put on the use of structured substrates in order to improve the light absorption and the overall device performance. A new route based on solution casting is introduced to structure the electron blocking PEDOT:PSS layer. Absorption spectra of polymer blend films spincoated on such structured substrates show promising aspects for their suitability for organic photovoltaics. In addition the inner film morphology of a polymer blend based on M3EH-PPV and F8BT spincoated on structured channel-like substrates is investigated using GISAXS measurements. The obtained results show a dependence of the film morphology and the topographic shape on the etched depth of the channels. The study is complemented with atomic force and scanning electron microscopy measurements.

15 min. break

CPP 21.6 Wed 11:00 H37

Structural and morphological changes in P3HT thin film transistors applying an electric field — ●DEEPAK KUMAR TIWARI¹, SOUREN GRIGORIAN¹, ULLRICH PIETSCH¹, HEINZ FLESCH^{1,2}, and ROLAND RESEL^{1,2} — ¹University of siegen, siegen, Germany — ²Graz University of technology

We report on electric field dependent crystalline structure and morphological changes of drop casting and spin coated poly(3-hexylthiophene) (P3HT) thin films. In order to probe the morphological changes induced by an applied electric field the samples were covered with thin source/drain electrodes separated by a small channel of 2 mm width. A series of x-ray reflectivity, X-ray grazing incidence out-of-plane and in-plane scans have been performed as function of the applied electric voltage. The (100) peak shows a decrease in intensity with increase of the applied electric field. This might be caused by Joule heating and the creation of current induced defects in the P3HT film. On other hand the (020) peak intensity shows much stronger changes with

applied field. Considering the z -stacking direction the measured effect can be directly related to a change in the electric transport. The observed changes in structure are reversible and the current-voltage cycle can be repeated several times. For X-ray reflectivity major changes have been found close to critical angle of total external reflection indicating the film becomes less dense and increases in surface roughness with increase of the voltage. This change in surface behaviour could be confirmed by in-situ AFM measurements.

CPP 21.7 Wed 11:15 H37

Thickness dependent structural order in P3HT films - a key parameter for high OFET mobility — ●BENEDIKT GBUREK, RICHAR SHARMA, TORSTEN BALSTER, and VEIT WAGNER — School of Engineering and Science, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

Applications of organic electronics require cheap and fast production methods on flexible substrates. Following these goals, top-gate OFETs on PET foils were used to analyze the dependence of the device characteristics on the crucial parameter of semiconductor layer thickness. The organic semiconductor, regio-regular P3HT, and the gate insulator were deposited by spin-coating under atmospheric conditions.

The charge carrier mobility was found to be rather low for extremely thin layers of several nanometers only. However, with increasing layer thickness, mobility increases by two orders of magnitude until a "saturation thickness" of 50 nm, above which it remains constant.

Further details of the ordering were extracted according to the Vissenberg-Matters model with gate-voltage dependent mobility $\mu = \mu_0 ((V_{GS} - V_{th})/1V)^\gamma$, where γ is directly related to the width of the density of states. The analysis reveals that the disorder parameter γ decreases from 3.1 to 1.0 over the examined thickness range, which explains the low mobility of thinner films by higher energetic disorder.

This analysis proves to be highly advantageous as it represents the whole transfer curve, gives better comparability and offers more physical insight. Our study demonstrates the crucial role of layer thickness tuning for improved film structure and optimum material performance.

CPP 21.8 Wed 11:30 H37

Deposition of P3HT via dip coating onto transistors with channel lengths below 1 μm — ●SILVIU BOTNARASH, STEVE PITNER, and VEIT WAGNER — School of Engineering and Science, Jacobs University Bremen, Campus Ring 1, D-28759, Germany

A high quality interface between the organic semiconductor and the oxide is crucial for the high performance of an OFET. A good surface treatment is imperative, but it will lower the surface energy of the oxide, making it difficult to spin coat on it uniform semiconductor layers from solvents like chloroform or toluene. We report on the usage of the dip coating technique to achieve highly ordered layers of regioregular poly(3-hexylthiophene) (rr-P3HT). By varying the removal speed of the silicon substrate from solution, the concentration of the solution or both, one can achieve ultrathin layers of rr-P3HT which permit to analyze OFET properties in the sub-monolayer regime. Decreasing the channel length of the transistors down to the range of the contour length of the rr-P3HT is expected to improve the characteristics of the OFET's. An additionally applied electric field between the source and drain electrodes during dip coating facilitates the trapping of P3HT molecules on the electrodes increasing the performance of the device. We used rr-P3HT with an average contour length of 80-100 nm. Compared to previously reported results for chloroform based solutions, the same concentration range of rr-P3HT in toluene displayed better characteristics, which is believed to be due to lower evaporation rate of toluene. Subsequent drying in a nitrogen rich atmosphere over a period of up to 24 h positively influences the performance of the OFET's.

CPP 21.9 Wed 11:45 H37

Semitransparent small-molecule organic solar cells — ●JAN MEISS¹, CHRISTIAN UHRICH², STEFAN SONNTAG², WOLF-MICHAEL GNEHR², MARTIN PFEIFFER², KARL LEO¹, and MORITZ RIEDE¹ — ¹Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany — ²heliatek GmbH, Liebigstraße 26, 01187 Dresden, Germany

Semitransparent, colourful solar cells are of interest for a wide range of applications, e.g. sun shading of residential and office buildings or cars. Previously, among organics-containing devices, only semitransparent dye-sensitized solar cells showed power conversion efficiencies (PCE) that allowed first meaningful applications, whereas semi-transparent small-molecule organic solar cells (OSC) were limited to PCE well below 1%.

We present small-molecule semitransparent OSC deposited by thermal vacuum evaporation on ITO-coated glass. The organic materials include absorber materials and doped dedicated charge transport layers. Due to our unique device architecture, the top electrode is ITO-free, consisting only of an ultra-thin multi-layer metal film.

The OSC exhibit light transmission in the visible range of 30-50% with PCE of over 2%. Organic capping layers are used to significantly lower reflection and increase transmission without significant loss of PCE. Furthermore, we have achieved first large-area semitransparent tandem OSC with 3.5% PCE at 20-40% transmission in the visible range on 4cm², which show the potential of this type of device for large-scale building integration.

CPP 21.10 Wed 12:00 H37

Stability optimisation of small molecule organic solar cells — ●MARTIN HERMENAU, KARL LEO, and MORITZ RIEDE — Institut für Angewandte Photophysik, George-Bähr-Str. 1, 01069 Dresden

In addition to high efficiency and low cost, a long device lifetime is a crucially important factor for the commercialisation of small molecule organic solar cells. Previous results mostly covered unencapsulated devices and showed low lifetimes under 1000 hours even without permanent illumination.

Here, we present results on improving the intrinsic stability of glass-glass-encapsulated p-i-n solar cells containing small molecules. Zinc-Phthalocyanine and the fullerene C₆₀ are used as photoactive materials. Doped layers of wide gap materials and C₆₀ are used as hole and electron transport layer, respectively. All devices are illuminated with monochromatic or white LEDs and IV characteristics are automatically recorded during the entire measuring period.

In contrast to polymer solar cells, we do not observe an influence of different types of top contact materials on the lifetime. All variations of Gold, Silver and Aluminium lead to stable cells for about 1500 hours of continued illumination.

However, by changing the type and even the thickness of the hole transport material we are able to enhance the extrapolated lifetime (t₈₀) from about 1100 hours with 30nm PV-TPD up to more than 5000 hours with 60nm Di-NPB. These results are achieved with encapsulated devices and illumination intensities up to 840 mW/cm² from high-power white LEDs at controlled temperatures of 50°C.

CPP 21.11 Wed 12:15 H37

Self organized molecular electronic junctions using two phase liquid structures in microfluidic channels — ●SHASHI THUTUPALLI¹, MARK ELBING², MATTHIAS FISCHER², DAVID MUÑOZ³, RALF SEEMANN^{1,4}, MARCEL MAYOR^{2,3}, and STEPHAN HERMINGHAUS¹ — ¹MPI for Dynamics and Self Organization, Göttingen, Germany — ²Forschungszentrum Karlsruhe GmbH, Institute for Nanotechnology, Karlsruhe, Germany — ³University of Basel, Department of Chemistry, Basel, Switzerland — ⁴Experimental Physics, Saarland University, Saarbrücken, Germany

Using a combination of microfluidics and molecular design, we demonstrate self assembled, reconfigurable molecular electronic junctions. To construct metal-molecule-metal junctions, we employ liquid mercury as the electrode contact in crossed microfluidic channels. Self assembled monolayers (SAM's) of conducting molecular rods are created on the surface of the mercury, which are then bridged to the other mercury electrode via microfluidic control. By precise flow control, we create rectifying molecular junctions using asymmetric molecules. We report on the electrical properties of these microfluidic metal-molecule-metal junctions. Also, we use surfactant stabilized foam-like water-in-oil emulsions to form variable molecular junctions. Here, molecules synthesized with hydrophobic conducting cores and hydrophilic ends self-insert into the lamellae between aqueous droplets. Using the aqueous droplets then as the molecular contacts, we report on the conducting properties of the inserted molecules and demonstrate the possibility of reconfigurable circuits using topological droplet rearrangements.

CPP 21.12 Wed 12:30 H37

DNA Based Molecular Electronics Using Mercury Droplets in Microfluidic Channels — ●SHUANG HOU, SHASHI THUTUPALLI, and STEPHAN HERMINGHAUS — Max Planck Institute for Dynamics and Self Organization, D-37073, Göttingen, Germany

Mercury droplets in microfluidic channels are used as electrodes to investigate the electronic properties of single strand DNA (ssDNA) molecules. In this system, a self assembled monolayer (SAM) of thiolated DNA oligomers (~ 5 nm length) of specific base sequences is formed on the surface of mercury droplets. Two such droplets are

then brought together by microfluidic manipulation to form a mercury-ssDNA-mercury electrical junction. We identified single SAMs of ssDNA oligos, double SAMs of ssDNA oligos of the same composition, and complementary binding DNA composed junctions. Here, we re-

port the influence of base pair type and DNA sequence length to the electronic characteristics. On the basis of these results, the design of DNA based molecular electronic elements (such as diodes) seems possible.