

CPP 18: Organic semiconductors I

Time: Wednesday 9:30–11:00

Location: C 130

CPP 18.1 Wed 9:30 C 130

Solvent induced morphology in polymer-based systems for organic photovoltaics — MATTHIAS A. RUDERER¹, SHUAI GUO¹, ROBERT MEIER¹, HSIN-YING CHIANG¹, VOLKER KÖRSTGENS¹, JAN PERLICH², STEPHAN V. ROTH², and •PETER MÜLLER-BUSCHBAUM¹ — ¹TU München, Physik-Department, LS Funktionelle Materialien, James-Frank-Str. 1, 85748 Garching, Germany — ²HASYLAB at DESY, Notkestr. 85, 22603 Hamburg, Germany

In this investigation we probe the influence of the used solvent on the morphology formation of polymer-based bulk heterojunction systems for photovoltaic applications. Films are spin coated from different solvents. We chose the bulk heterojunction system consisting of the conjugated polymer P3HT (poly(3-hexylthiophene-2,5-diyl)) and the methano fullerene PCBM. Both components fit very well concerning their electronic behaviors and this combination is probably the best investigated system in organic photovoltaics so far. Besides imaging methods such as atomic force microscopy (AFM), the advanced scattering techniques X-ray reflectivity and grazing incidence small and wide angle X-ray scattering (GISAXS and GIWAXS) reveal a full understanding of the inner film structure on molecular to mesoscopic length scales. In combination with topography imaging we are able to reconstruct schematic morphologies from the scattering experiments for the films made from the different solvents. Depending on the solvent, enrichment layers at the interfaces as well as varying structural length scales inside the active layer are found [Adv. Funct. Mater. 21, 3382-3391 (2011)].

CPP 18.2 Wed 9:45 C 130

Influence of aggregation on the performance of all-polymer solar cells containing low-bandgap naphthalenediimide-copolymers. — •MARCEL SCHUBERT¹, DANIEL DOLFEN², JOHANNES FRISCH³, STEFFEN ROLAND¹, ROBERT STEYRLLEUTHNER¹, BURKHARD STILLER¹, ZHIHUA CHEN⁴, ULLRICH SCHERF², NORBERT KOCH³, ANTONIO FACCHETTI⁴, and DIETER NEHER¹ — ¹University of Potsdam, Germany — ²University of Wuppertal, Germany — ³Humboldt University Berlin, Germany — ⁴Polyera Corporation, USA

Naphthalene-diimide (NDI) or perylene-diimide (PDI) containing copolymers are promising alternatives for replacing fullerenes as the electron-accepting phase in organic solar cells. So far, the power conversion efficiencies (PCEs) of all-polymer solar cells comprising NDI/PDI-based copolymers and regio-regular poly(3-hexylthiophene) (P3HT) remained below 1%. It was proposed that the NDI/PDI-copolymers exhibit a strong tendency to aggregate, which promotes long range phase separation and unfavourable nanomorphologies.

Our studies of the optical properties of such copolymers in different solvents reveal a strong tendency to pre-aggregate. This pre-aggregation could be fully suppressed by adding suitable high boiling point solvents. Solar cells prepared from these solvent mixtures showed PCEs of up to 1.4% and high fill factors of up to 70%, which are among the highest reported values for polymer-polymer blends. Finally, SNOM and AFM measurements in combination with optical absorption studies reveal a surprising anticorrelation between the degree of chain aggregation and the photovoltaic device performance.

CPP 18.3 Wed 10:00 C 130

Does conjugation help exciton dissociation? A study on poly(p-phenylene)s in planar heterojunctions with C₆₀ or TNF — •CHRISTIAN SCHWARZ¹, HEINZ BÄSSLER¹, IRENE BAUER¹, JAN-MORITZ KOENEN², EDUARD PREIS², ULLRICH SCHERF², and ANNA KÖHLER¹ — ¹Experimental Physics II, University of Bayreuth — ²Macromolecular Chemistry, Bergische Universität Wuppertal

We report the field-assisted photocurrent generation in organic bilayer diodes with different poly(p-phenylene)s as donors and C₆₀ or TNF as acceptor. The polymers differ regarding their torsional degree of freedom and concomitantly regarding their conjugation length and energetic disorder. We find the photocurrent yield to saturate around 100% at fields between $5 \cdot 10^4 \frac{V}{cm}$ to $10^6 \frac{V}{cm}$. The saturation field required scales with the optical gap, implying that conjugation and energetic order is of crucial importance for the yield. We conclude that the rate limiting step for photogeneration is the formation of a loosely bound electron-hole pair that can either be collected by a moderate field or relax back to a tightly bound electron-hole pair.

CPP 18.4 Wed 10:15 C 130

Charge Transfer in Polymer:PC₆₀BM:PC₇₀BM triple Blends: Which Fullerene gets the Electron? — •ANDREAS SPERLICH¹, JOHANNES RÖMER¹, HANNES KRAUS¹, CARSTEN DEIBEL¹, and VLADIMIR DYAKONOV^{1,2} — ¹Experimental Physics VI, Julius Maximilian University of Würzburg, D-97074 Würzburg, Germany — ²ZAE Bayern, D-97074 Würzburg, Germany

The highest efficiencies reported for organic solar cells are for devices incorporating blends of conjugated polymers and C₇₀-derivatives, due to their higher optical absorption compared to C₆₀. Yet the costly purification of higher fullerenes might hinder a widespread adoption of this promising material. However recent results showed that polymers blended with a PC₆₀BM/PC₇₀BM mixture without further purification yield solar cells with comparable performance. This is surprising, because from absorption and photoluminescence spectra, different energy levels for both fullerenes are expected. If there were a noticeable difference in electron affinity, one of the two fullerenes would act as an electron trap in a mixed phase, hence hindering transport and limiting device performance. This raises the question, on which fullerene derivate the electron is residing after light induced charge transfer from the polymer? Using Light-induced Electron Spin Resonance (LESR) we can distinguish between holes on the polymer and electrons on either C₆₀ or C₇₀, since their ESR spectra are slightly shifted against each other. Our results demonstrate that there is no strong preference for either fullerene. Thus from an economic point of view “unpurified” fullerenes might be a viable option for large scale production.

CPP 18.5 Wed 10:30 C 130

Exciton and Charge Dynamics in PCPDTBT:PCBM Blends Probed by Broadband VIS-NIR Transient Absorption Spectroscopy — •FABIAN ETZOLD, IAN A. HOWARD, DON CHO, MICHAEL MEISTER, RALF MAUER, KLAUS MÜLLEN, and FRÉDÉRIC LAQUAI — MPI für Polymerforschung Mainz

The efficiency of PCPDTBT:PCBM bulk heterojunction solar cells depends very much on the film preparation conditions, like the use of cosolvents, for reasons still not well understood. In this contribution we present the exciton and charge carrier dynamics in pristine PCPDTBT films and in photovoltaic blends with PCBM studied by VIS-NIR broadband transient absorption spectroscopy. In particular we monitor the previously unobserved, but for low-bandgap polymers essential spectral region between 1000-2000 nm, where we can clearly identify the individual contributions and dynamics of singlet excitons, charge-transfer excitons as well as free and trapped polarons. This not only allows a qualitative assessment of the effect of cosolvents on the photophysics, but also the extraction of the most relevant recombination parameters that finally determine the device efficiency. Our experiments show that cosolvents promote the generation of mobile charge carriers that can be extracted as photocurrent.

[1] F. Etzold et al., manuscript in preparation.

CPP 18.6 Wed 10:45 C 130

Origin of Sub-Bandgap Absorption in P3HT:PCBM Solar Cells — MARTIN PRESSELT, •FELIX HERRMANN, MARCO SEELAND, MAIK BÄRENKLAU, ROLAND RÖSCH, WICHARD J. D. BEENKEN, ERICH RUNGE, SVIATOSLAV SHOKHOVETS, HARALD HOPPE, and GERHARD GOBSCH — TU Ilmenau, Ilmenau, Germany

To explain the origin of sub-bandgap (SBG) absorption contributing to the photocurrent in bulk-heterojunctions (BHJ) made of poly(3-hexylthiophene-2,5-diyl) (P3HT) and [6,6]-phenylC₆₁-butyric acid methyl ester (PCBM) at least four different models are discussed in the literature. In an earlier work we have shown that an exponential in addition to a Gaussian function is needed to reproduce SBG external quantum efficiency (EQE) spectra. There, the exponential function was assigned to a disorder related absorption tail, while the SBG EQE Gaussian was not assigned unambiguously. In the present work, the SBG EQE Gaussian is assigned to a hole-polaron transition at P3HT rather than to a direct charge transfer transition from the P3HT HOMO to the PCBM LUMO or absorption of molecularly dispersed PCBM as concluded from temperature dependent EQE measurements.