CPP 39: Organic Photovoltaics II

Time: Wednesday 9:30–10:45 Location: C 243

Invited Talk CPP 39.1 Wed 9:30 C 243

Charge generation and recombination in an organic BHJ solar cell with low energetic offsets — •Thuc-Quyen Nguyen — Department of Chemistry and Biochemistry, University of California, Santa Barbara

Organic bulk heterojunction (BHJ) solar cells require energetic offsets between the donor and acceptor to obtain high short-circuit currents and fill factors. However, it is necessary to reduce the energetic offsets to achieve high open-circuit voltages. Recently, reports have highlighted BHJ blends that are pushing at the accepted limits of energetic offsets necessary for high efficiency. How the energetic offset impacts the solar cell characteristics thus remains poorly understood. We attempt to characterize the losses in BHJ blends that achieves a high open-circuit voltages with very low energy losses from the energy of absorbed photons. Despite the low energetic offset, the system does not suffer from field dependent generation and instead it is characterized by very fast nongeminate recombination and the presence of shallow traps. The charge-carrier losses are attributed to suboptimal morphology due to high miscibility between a polymer donor and PC61 BM. These results hold promise that given the appropriate morphology, the device parameters such as short-circuit currents, open-circuit voltages and fill factors can all be improved, even with very low energetic offsets.

CPP 39.2 Wed 10:00 C 243

A Shockley-type polymer:fullerene solar cell — •Safa Shoaee[1], Ardalan Armin[2], Zhiming Chen[3], Yaocheng Jin[3], Kai Zhang[3], and Fei Huang[3] — [1]Optoelectronics of Organic Semiconductors, Institute for Physics and Astronomy, University of Potsdam, 14476 Potsdam-Golm, Germany — [2]Centre for Engineered Quantum Systems, School of Mathematics and Physics, The University of Queensland, St Lucia Campus, Brisbane 4072, Australia — [3]Institute of Polymer Optoelectronic Materials and Devices, State Key Laboratory of Luminescent Materials and Devices, South China University of Technology, Guangzhou 510640, P. R. China.

Despite the myriad of organic donor:acceptor materials, only few systems have emerged in the life of organic solar cells to exhibit considerable reduced bimolecular recombination. Charge extraction rate in such devices is typically slow due to their low charge carrier mobility. Herein, we investigate charge transport and recombination properties of a ~10% efficient polymer (NT812):fullerene blend which delivers ~9% power conversion efficiency even when the junction thickness is as large as 800 nm. Experimental results indicate that this material system exhibits exceptionally low bimolecular recombination constant, 800 times smaller than the diffusion-controlled electron and hole encounter rate with nearly ideal charge collection. This is the first realization of high efficiency Shockley-type organic solar cells with junction thicknesses suitable for scaling-up.

CPP 39.3 Wed 10:15 C 243

Does electron delocalization influence charge separation at donor- — •Anna Köhler[1], Frank-Julian Kahle[1], Christina Saller[1], Selina Olthof[2], Cheng Li[1], Eva Herzig[1,3], and Peter Strohriegl[1] — [1]Universität Bayreuth, Bayreuth, Germany — [2]Universität Köln, Köln, Germany — [3]TUM, München, Germany

Recent reports on organic solar cells have shown that efficiencies of up to 13% are possible using a polymeric donor and a small molecular acceptor. Yet, fundamental processes governing efficient dissociation, especially at the donor-acceptor interface are still not fully understood. In this work, we use bilayer devices with a series of three fullerene acceptors differing in order, intermolecular coupling and LUMO localization to systematically explore the influence of electron delocalization in the acceptor phase on the dissociation efficiency of charge transfer states. Structural information from GIWAXS measurements are combined with the results of optical and electrical characterization via photocurrent and photoemission spectroscopy, electroabsorption and electroluminescence as well as theoretical modelling. We find that stronger intermolecular coupling and higher order within the acceptor phase is correlated with lower CT binding energies implying a higher degree of electron delocalization. Theoretical modelling of experimental field dependent photocurrent measurements reveals that an enhancement in electron delocalization is directly coupled to an increase in CT dissociation efficiency. Therefore, our results substantiate the concept of delocalization of electrons taking an important and positive role in the charge separation process.

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Incoherent Pathways of Charge Separation in Organic and Hybrid Solar Cells — •Tobias Seewald, Alexander Grupp, Philipp Ehrenreich, Julian Kalb, Arne Budweg, Lukas Schmidt-Mende, and Daniele Brida — Department of Physics and Center for Applied Photonics, University of Konstanz, D-78457 Konstanz, Germany

In this work, we investigate the exciton dissociation dynamics occurring at the donor:acceptor interface in organic and hybrid blends employed in the realization of photovoltaic cells. Fundamental differences in the charge separation process are studied with the organic semiconductor polymer poly(3-hexylthiophene) (P3HT) and either [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) or titanium dioxide (TiO2) acting as the acceptor. By using ultrafast broad-band transient absorption spectroscopy with few-fs temporal resolution, we observe that in both cases the incoherent formation of free charges dominates the charge generation process. From the optical response of the polymer and by tracking the excited-state absorption, we extract pivotal similarities in the incoherent energy pathways that follow the impulsive excitation. On time scales shorter than 200 fs, we observe that the two acceptors display similar dynamics in the exciton delocalization. Significant differences arise only on longer time scales with only an impact on the overall photocarrier generation efficiency.