

## CPP 31: Organic Electronics and Photovoltaics II - Non-Fullerene Organic Solar Cells

Time: Wednesday 9:30–11:00

Location: H18

CPP 31.1 Wed 9:30 H18

**Loss Processes in Non-fullerene Acceptor Bulk Heterojunction Solar Cells** — ●FRÉDÉRIC LAQUAI — King Abdullah University of Science and Technology, KAUST Solar Center, Thuwal, Saudi Arabia

Organic solar cells that use non-fullerene acceptors (NFA) are now outperforming their fullerene-based counterparts with efficiencies exceeding 14%. While the photophysics of fullerene-based systems have been studied quite intensively, the complex interplay between structure, morphology, photophysics, and efficiency of non-fullerene acceptor devices remains less well understood; yet, understanding the structure-property relations is an important prerequisite for a guided material design and further efficiency enhancements. In this contribution, I will discuss what currently limits the quantum efficiency in blends of common donor polymers and novel non-fullerene acceptors. By using steady-state and transient spectroscopy techniques and advanced data analysis tools, we are able to distinguish the spectral contributions and dynamics of singlet excitons, charge carriers, and triplet states and to quantify their concentration across a wide dynamic range relevant to the solar cell performance. Furthermore, we investigate how the CT-state energy, radiative, and non-radiative losses in non-fullerene acceptor blends influence the open-circuit voltage and we address the origin of low fill factors sometimes observed in NFA systems. This allows us to develop a precise picture of the efficiency-limiting processes in solar cells that use novel non-fullerene acceptors.

CPP 31.2 Wed 9:45 H18

**Analysing geminate and non-geminate losses in high performance non-fullerene blends** — ●LORENA PERDIGÓN-TORO<sup>1</sup>, HUOTIAN ZHANG<sup>2</sup>, SAFA SHOAEI<sup>1</sup>, FENG GAO<sup>2</sup>, and DIETER NEHER<sup>1</sup> — <sup>1</sup>University of Potsdam, Institute of Physics and Astronomy, Germany — <sup>2</sup>Linköping University, Department of Physics, Chemistry and Biology (IFM), Sweden

Organic solar cells consist of blends of two or more semiconductors with different electronic structures, namely organic electron donors and acceptors. Recently, interest has increased towards non-fullerenes (NF) as the small-molecule acceptor. Organic cells benefit from the NF long wavelength absorption, which provides the blend with a broader coverage of the sun spectrum and thus, higher short-circuit currents. Moreover, devices containing NFs show high open-circuit voltages meaning that charge separation occurs efficiently even with small driving forces. In this work we study charge generation and recombination in a set of NF devices with efficiencies up to 13%. While all blends exhibit similar low voltage losses, the fill factors (FF) of the solar cells differ greatly, pointing to significant differences in geminate and/or non-geminate recombination. Time delayed collection field (TDCF) and bias assisted charge extraction (BACE) were used to disentangle these processes. Indeed, the devices with lower FF suffer from field-dependence of charge generation and faster bimolecular recombination. Altogether, the obtained recombination coefficients together with SCLC-measured mobilities allow reconstructing the FF, clearly pointing to these parameters as those to address for higher overall performance.

CPP 31.3 Wed 10:00 H18

**Triplet Excitons in Non-Fullerene Acceptor-Polymer Blends and Organic Solar Cells?** — ●MARIA KOTOVA, JOHANNES JUNKER, ANDREAS BAUMANN, KRISTOFER TVINGSTEDT, ANDREAS SPERLICH, and VLADIMIR DYAKONOV — Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg

In the past, most organic solar cells (OSCs) employed fullerenes as electron acceptors. Recently, the synthesis of novel non-fullerene acceptors (NFA) resulted in significantly higher power conversion efficiencies (PCE) of over 13%. It has been shown, that in fullerene-based OSCs the formation of triplet excitons (TE) opens an additional recombination pathway. In this work, the formation of TEs in NFA-based OSCs is investigated. We studied optical, electrical and spin properties of the polymer donor PBDB-T and the NFA acceptor ITIC in pristine films, in blend films and OSCs based on the blend. OSCs show a PCE of 9.8% and external quantum yield of up to 73%. Low temperature spin-sensitive photoluminescence measurements reveal the formation of highly localized TEs in pristine films of the donor (D) and acceptor (A), as well as in the blend films. This can occur either via inter-

system crossing (ISC) or electron back transfer (EBT). ISC is likely for low mobility singlet excitons that cannot reach D-A interfaces and cannot dissociate into CT states. The EBT forms TE from the CT states. However, no TE signal was observed in solar cells under working conditions, thus no significant ISC or EBT occurs and the triplet formation loss channel is not very efficient. The lack of TEs matches well with the high PCE of NFA-based OSCs and their stability.

CPP 31.4 Wed 10:15 H18

**Fullerene-free bulk heterojunction blends for photovoltaic applications - a morphological study** — ●SEBASTIAN GROTT<sup>1</sup>, LORENZ BIESSMANN<sup>1</sup>, NITIN SAXENA<sup>1</sup>, WEI CAO<sup>1</sup>, SIGRID BERNSTORFF<sup>2</sup>, and PETER MÜLLER-BUSCHBAUM<sup>1</sup> — <sup>1</sup>TU München, Physik-Department, LS funktionelle Materialien, 85748 Garching — <sup>2</sup>Eletra-Sincrotrone Trieste, 34149 Basovizza, Italy

In the last decades, organic electronics have been in the focus of research due to their advantageous properties, such as versatility, flexibility, low-cost manufacturing processes, like roll-to-roll printing or spray casting, and the tunable characteristics. These properties open up a wide range of applications and represent a promising alternative for the conventional inorganic photovoltaics. Even though the power conversion efficiency is lower than the ones of conventional devices, values of over 11% have been reported. Thereby, systems using low-band gap polymers and non-fullerene small molecules have received increasing attention. We study the inner morphology of such a bulk heterojunction blend, namely PBDB-T and ITIC of different compositions with grazing-incidence small-angle X-ray scattering (GISAXS). The obtained structural information are correlated with current density-voltage characteristics and the absorbance of the active layer in order to improve the efficiency.

CPP 31.5 Wed 10:30 H18

**Long term UV stable organic solar cells by utilizing a stable donor-acceptor-additive combination** — ●THOMAS HEUMÜLLER, ANDREJ CLASSEN, YAKUN HE, LUKAS EINSIEDLER, JOHANNES GERNER, NING LI, and CHRISTOPH BRABEC — Friedrich-Alexander-Universität Erlangen-Nürnberg

With the advent of non-fullerene acceptors (NFA), current state of the art organic solar cells (OSC) reach efficiencies around 14 % and an efficiency of 10 % is surpassed for plenty of systems. However, little is known about the stability and lifetime of current NFA based OSCs. Here we present a detailed degradation analysis of OSCs based on a polymer (PBQ-QF) which exhibits a good performance when blended with two different NFAs (ITIC and o-IDTBR) as well as PC70BM. In order to separate effects from several different degradation mechanisms that usually occur at the same time, we perform tests under controlled environmental conditions to avoid photo-oxidation and we focus on the degradation in dependence of UV light. Under full AM 1.5G light spectrum (1000 h continuous illumination) we observe an intense degradation of PBQ-QF:PC70BM while PBQ-QF:ITIC exhibits a moderate stability and PBQ-QF:o-IDTBR is highly stable. Interestingly we find, that the strong degradation of PBQ-QF:PC70BM can be lifted when UV cut-off filters are applied. The in-depth analysis reveals that the UV instability originates from a UV instability of PC70BM towards the processing additive 1,8 diiodooctane.

CPP 31.6 Wed 10:45 H18

**Enthalpy of Charge Transfer Energetics for Organic Photovoltaics based on anthracene-containing PPE-PPVs and ITIC** — ●SHAHIDUL ALAM<sup>1,2</sup>, CHRISTIAN FRIEBE<sup>1,2</sup>, JOHANNES AHNER<sup>2</sup>, MARTIN HAGER<sup>1,2</sup>, DANIEL A. M. EGBE<sup>3</sup>, TOMAS VARY<sup>4</sup>, VOJTECH NÁDAŽDY<sup>4</sup>, ULRICH S. SCHUBERT<sup>1,2</sup>, and HARALD HOPPE<sup>1,2</sup> — <sup>1</sup>FSU Jena, Germany — <sup>2</sup>IOMC, Jena, Germany — <sup>3</sup>JKU, Linz, Austria — <sup>4</sup>SUT, Bratislava, Slovak Republic

Lately, NFAs have received increasing attention for use in polymer-based bulk-heterojunction OPVs, as they have demonstrated improved PV performances over classical polymer-fullerene blends. Part of the success of these materials has to be attributed to a considerable contribution to the overall absorption of the solar cells, thanks to relatively low bandgaps in these materials. In this study a systematic comparison between two acceptor materials, the classical fullerene-derivative PCBM and the NFA ITIC was performed in combination with AnE-

PVstat. The photo-induced charge transfer occurring at the D-A interface within an organic semiconductor (bulk) heterojunction is considered to be driven by the energy level offset between the corresponding LUMO of the same. Commonly, these energy offsets between LUMO levels of D-A are taken from CV characterization of organic semicon-

ductors in film or solution. While the such derived energy levels seem to suggest successful charge transfer from the polymer to the ITIC, blend films and PV studies show the opposite. Literature, various spectroscopic, morphological and structural characterization methods have been used for finding an explanation.