CPP 57: Hybrid, Organic and Perovskite Optoelectronics and Photovoltaics VIII

Time: Friday 11:30–13:00 Location: ZEU/LICH

CPP 57.1 Fri 11:30 ZEU/LICH

Novel n-Dopants for Improving Organic Solar Cells — •Yahya Asl Soleimani[1], Nora Engelmann[1], Stephanie Buchholtz[1], Jörn Vahland[2], Adrian Kishonti[2], Steffen Woltering[2], Karl Leo[1], and Johannes Benduhn[1] — [1]Institute of Applied Physics, Technische Universität Dresden, Nöthnitzer Straße 61, 01187 Dresden, Germany — [2]CREDOXYS GmbH, Liebigstraße 26, 01187, Dresden, Germany

Doping is a crucial concept in semiconductor technology, and it is no different for organic semiconductors. It increases conductivity and facilitates carrier injection and extraction. While substantial success has been achieved for organic molecular p-dopants, the same cannot be said for n-dopants. They suffer from an inherent disadvantage: the highest occupied molecular orbital (HOMO) of the n-dopant must be lower than the lowest unoccupied molecular orbital (LUMO) of the host, rendering them typically unstable under ambient conditions. Here, we report a new and efficient molecular n-dopant that can dope C_{60} to a conductivity of 20 S/cm. We investigate the origin of its efficacy and explore the doping mechanism using ultraviolet electron spectroscopy (UPS). Moreover, we incorporate the new n-dopant into organic solar cells, demonstrating its effectiveness by improving the power conversion efficiency of the reference devices.

CPP 57.2 Fri 11:45 ZEU/LICH

Computational Study of Electronic Trapping in TADF Host-Guest Systems — •Naomi Kinaret[1], Andrei Stankevych[2,3], Andriy Zugayevych[1], Rishabh Saxena[1], Alexander Vakhnin[3], Kun-Han Lin[1,4], Denis Andrienko[1], Heinz Bässler[2], Anna Köhler[2], and Andrey Kadashchuk[2,3] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]University of Bayreuth, Bayreuth, Germany — [3]National Academy of Sciences of Ukraine, Kyiv, Ukraine — [4]National Tsing Hua University, Hsinchu, Taiwan

Extrinsic traps created by dopants or impurities are ubiquitous in organic semiconductors and can critically influence charge transport [1]. Here we report a computational study of the trapping of charge carriers in amorphous host-guest systems of the thermally activated delayed fluorescence (TADF) emitter DMAC-TRZ in two different hosts, validated by low-temperature thermally- stimulated luminescence (TSL). In both hosts we find that DMAC-TRZ forms an additional Gaussian density of states (DOS), offset from the host DOS by a trap depth ϵ_t. In both systems trap depths and DOS widths, σ_{DOS}, agree with experimentally observed values over a range of compositions, showing that the nominal trap depth is concentration independent. In the case of deep traps, $\epsilon_t > 3\sigma_{DOS}$, we observe concurrent charge detrapping via guest-to-host and guest-to-guest pathways, with the latter dominating for $c_t > 5\%$. Guest-guest transfers are observed already at the low guest concentration of $c_t = 1\%$, attributed to local guest clustering and superexchange- mediated inter-cluster transfers.

[1] Kotadiya, N.B., et al., Nat. Mater. (2019).

CPP 57.3 Fri 12:00 ZEU/LICH

Interface Engineering toward High-Performance Subphthalocyanine-based Single-Component Organic Photodetectors — •Anncharlott Kusber[1], Ying Sun[2], Jakob Wolanksy[1,3], Fred Kretschmer[1], Conrad Winkler[1,3], Anna-Lena Hofmann[1], Ji-Seon Kim[2], Karl Leo[1], and Johannes Benduhn[1,3] — [1]Institute of Applied Physics, Technische Universität, Dresden, Germany — [2]Imperial College London, United Kingdom — [3]German Centre of Astrophysics, Görlitz, Germany

Organic photodetectors (OPDs) have attracted considerable attention due to their capability to convert light into electrical signals and enable high-quality imaging, while simultaneously offering the intrinsic benefits of organic materials. Single-component (SC) OPDs, using a single photoactive organic semiconductor material, have several advantages over the commonly used bulk heterojunction OPDs such as its simplified structure. The influence of several organic electron transport layers (ETLs) on energetic landscape at the immediate interface with organic layers has not yet been systematically reported. This is necessary to gain a deeper understanding of physics of organic interfaces, thereby enabling the further optimization of OPD performance. Sensitive measurement techniques were used to analyse the influence of different organic interfaces on the OPD performance.

These investigations lead to SubNc SC OPD devices, which achieves an EQE of 56 % at 0 V, an ultra-low J_D of $2.5 \cdot 10^{-11}\,\mathrm{A} \cdot \mathrm{cm}^{-2}$ at -0.5 V and D* of $3.8 \cdot 10^{14}$ Jones at 0 V (based on calculated shot noise).

CPP 57.4 Fri 12:15 ZEU/LICH

Impact of additive on the morphology and electronic states of PPDT2FBT:PCBM organic solar cells — Md Moidul Islam[1,2], Hassan Ismail[1,2], Saib Qazi[1,2], Ulrich S. Schubert[1,2], and •Harald Hoppe[1,2] — [1]Laboratory of Organic and Macromolecular Chemistry (IOMC), Friedrich Schiller University Jena, Humboldtstrasse 10, 07743 Jena, Germany — [2]Center for Energy and Environmental Chemistry Jena (CEEC Jena), Friedrich Schiller University Jena, Philosophenweg 7a, 07743 Jena, Germany

Among organic solar cells using PCBM as an acceptor, the donor PPDT2FBT yields one of the highest power conversion efficiencies (PCE) of nearly 10%. It has been demonstrated that the processing additive diphenyl ether (DPE) contributes to that success essentially. However, the exact mechanism responsible for the performance improvement has so far not been revealed. Therefore, we undertook a systematic study for comparing PPDT2FBT:PCBM solar cells, under variation of annealing temperatures and use of DPE. A combination of optical, electrochemical, microscopic, and further characterization methods enabled the decoding of the impact of DPE on the blend morphology. In addition, the limitation in device stability by extended morphological degradation has been revealed and strategies to overcome those are being discussed.

CPP 57.5 Fri 12:30 ZEU/LICH

Photo-physics of symmetric and asymmetric ITIC-2F non-fullerene acceptors in organic solar cells — •Shahidul Alam[1,2], Nisreen Alshehri[2], Michael Bulgakov[3], Zerui Li[4], Khawla Alkhezaim[2], Maryam Alqurashi[2], Oleksandr Matiash[2], Vojtech Nadazdy[5], Martin Hager[6], Ulrich S Schubert[6], Vladimir Dyakonov[3], Harald Hoppe[6], Peter Müller-Buschbaum[4], Andreas Sperlich[3], and Frédéric Laquai[1,2] — [1]LMU Munich — [2]KAUST, Saudi Arabia — [3]University of Wurzburg — [4]TU Munich — [5]Slovak Academy of Sciences, Slovak Republic — [6]FSU Jena

Fluorination is an effective strategy to tune the electronic and structural properties of organic semiconductors by lowering frontier orbital energies, enhancing intermolecular interactions, and improving stability. We investigated ITIC and its fluorinated derivatives, sITIC-2F and aITIC-2F, in blends with PBDB-T and its halogenated analogue PM6 to elucidate the effects of fluorination on molecular packing and energetics. Optically detected magnetic resonance reveals triplet excitons in all pristine materials and blends, with their donor-acceptor distribution governed by fluorination. These results demonstrate that fluorination effectively modulates molecular organization and excited-state dynamics, leading to improved structure-property-performance relationships in organic solar cells.

CPP 57.6 Fri 12:45 ZEU/LICH

Single-Component Vacuum-Deposited Organic Photodetectors Achieving NIR Detection — •Jakob Wolansky[1,4], Jacob Hille[1], Cedric Hoffmann[2], Michel Panhans[3], Frank Ortmann[3], Natalie Banerji[2], Karl Leo[1], and Johannes Benduhn[1,4] — [1]IAPP, TU Dresden, Germany — [2]DCBP, University Bern, Switzerland — [3]NAT-School, TU Munich, Germany — [4]DZA, Görlitz, Germany

Efficient charge separation in organic semiconductor devices typically relies on an energetic offset at the donor-acceptor interface to dissociate photogenerated electron-hole pairs. While such an offset facilitates charge generation, it can limit the maximum open-circuit voltage. Additionally, interfacial traps generate charge carriers in the dark. To address these limitations, significant research is exploring single-component (SC) architectures that minimize interfacial losses.

In this work, we investigate SC organic photodetectors in which a newly developed small molecule serves as the active layer. By chemically tuning the molecular structure, extended near-infrared absorption up to 900nm is achieved, while maintaining devices with a large linear dynamic range of 160dB, a -3dB cutoff frequency of 50kHz, and an external quantum efficiency of 20% at zero bias. Comparison with the widely studied small molecule DCV2-5T allows the extraction of structure-property relationships that serve as a basis for future molecular design. Furthermore, an in-depth analysis of the charge generation process in DCV2-5T provides new insights into the pathways governing efficient photogeneration in SC organic systems.