CPP 3: Organic Electronics and Photovoltaics I

Time: Monday 9:30–11:15 Location: H38

CPP 3.1 Mon 9:30 H38

Demonstration of flexible organic solar cells in space — ●Lukas V. Spanier[1], Lennart K. Reb[2], Michael Böhmer[3], Zerui Li[1], Christoph Dreissigacker[4], Thomas Voigtmann[4], and Peter Müller-Buschbaum[1] — [1]TUM School of Natural Sciences, Chair for Functional Materials, Garching, Germany — [2]TUM School of Natural Sciences, Zentrales Technologielabor, Garching, Germany — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — [4]DLR Institut für Materialphysik im Weltraum, Köln, Germany

The deployment of flexible organic solar cells (OSCs) in space presents a transformative opportunity for exceptionally lightweight power generation on satellites and deep space research probes, promising record-breaking gravimetric power densities. In this study, we report the successfull launch, operation and recovery of flexible PEN-based OSCs on a suborbital rocket launch, assessing their performance in the harsh conditions of space. Flexible OSC modules were integrated into the payload and exposed to vacuum, microgravity, and cosmic radiation during the flight. Post-flight analysis of the recovered cells further confirmed the cells' operational viability. The experiment demonstrates the potential of OSCs for reducing launch mass and enabling novel satellite architectures, paving the way for their adoption in future space missions.

CPP 3.2 Mon 9:45 H38

Evaluate the energy losses in non-fullerene based organic photovoltaic — ●Maryam Alqurashi[1], Shahidul Alam[2], Jose Jurado[1], Julien Gorenflot[1], and Frederic Laquai[1,2] — [1]Division of Physical Sciences and Engineering, King Abdullah University of Science and Technology, Thuwal 23955-6900, Saudi Arabia — [2]Physical Chemistry and Spectroscopy of Energy Materials, Department of Chemistry, Ludwig Maximilian University of Munich, D-81377 Munich, Germany

Organic photovoltaics that use non-fullerene acceptors are gaining popularity because they can potentially increase power conversion efficiency. However, they suffer from significantly higher total energy losses than inorganic photovoltaics, primarily due to non-radiative recombination, a process in which electron-hole pairs recombine without generating current. Electroluminescence spectroscopy helps evaluate charge transfer state energy, which is crucial in charge recombination. This study focused on three systems: PM6:Y6, PM6:IT-4F, and PM6:ITIC. The PM6:Y6-based device showed higher radiative recombination, while the PM6:IT-4F system exhibited the highest order of non-radiative recombination. The total open circuit voltage losses were 0.64 eV, 0.67 eV, and 0.56 eV for PM6:Y6, PM6:IT-4F, and PM6:ITIC, respectively. Despite PM6:Y6 achieving a higher power conversion efficiency, its open circuit voltage losses were comparable to that of the other two systems.

CPP 3.3 Mon 10:00 H38

Towards printing of organic solar cells out of green solvents — ●Peter Müller-Buschbaum — TUM School of Natural Sciences, Chair for Functional Materials, 85748 Garching, Germany

Despite big achievements in terms of power conversion efficiencies in the last years, with champion efficiencies above the 20% limit, it remains an unresolved challenge to fabricate large-area organic solar cells without sacrificing efficiencies. Large-area deposition of the conjugated polymer donor and small molecule acceptor blends via printing is key in the device upscaling. Another issue calling the attention is the fabrication of environmentally friendly organic solar cells. To become environmental-friendly, the used solvents are a key factor. Today, still the most used solvents are harmful and can cause environmental pollution during the device fabrication process and waste solvent treatment. Accordingly, we investigate the printing of donor-acceptor blend films out of different solvents for use as active layers in organic solar cells with advanced in-situ scattering methods. We use grazing incidence small and wide-angle X-ray scattering (GISAXS and GIWAXS) in-situ during printing to gain a fundamental understanding of the underlying film formation processes. Different examples of polymer donors and small molecule acceptors are presented, and the resulting morphologies are correlated with solar cell device performance. A special emphasis is put on the shift towards more environmentally friendly solvents, which will also be a prerequisite to promote the large-scale production of organic solar cells.

CPP 3.4 Mon 10:15 H38

The Role of Oxygen Insertion on Performance of A-D-A-type Non-Fullerene Acceptors (NFA) in Organic Solar Cells — ●Wejdan Althobaiti[1], Yakun He[1], Julien Gorenflot[1], Wisnu Hadmojo[1], Sandeep Sharma[1], Filip Aniés[1], Weimin Zhang[1], Shahidul Alam[1], George Harrison[1], Anirudh Sharma[1], Shadi Fatayer[1], Derya Baran[1], Iain McCulloch[2], Thomas Anthopoulos[1], Martin Heeney[1], and Frédéric Laquai[1] — [1]King Abdullah University of Science and Technology (KAUST), Saudi Arabia — [2]University of Oxford, UK

Charge transfer in OSCs can occur through two pathways: photo-induced electron transfer from the donor to the acceptor, controlled by the electron affinity (EA) offset, and photo-induced hole transfer from the acceptor to the donor, governed by the ionization energy (IE) offset. Here, we report the synthesis of a novel NFA coded TPTI-BT, whose properties were first predicted by computational chemistry before the material was synthesized. Despite the favorable properties for high device performance, TPTI-BT exhibited moderate device performance, in particular when compared with the structurally-related and efficient acceptor O-IDTBCN. In fact, the chemical structure of TPTI-BT is very similar to that of O-IDTBCN, it contains only two additional oxygen atoms in the donor core of the A-D-A-type acceptor backbone structure. Interestingly, this causes TPTI-BT to exhibit overall lower device performance. We present a comparative study of these two NFAs and elucidate the origin of the lower performance of the TPTI-BT caused by two additional oxygen atoms.

CPP 3.5 Mon 10:30 H38

Revealing the effect of solvent additive selectivity on morphology and formation kinetics in printed non-fullerene organic solar cells at ambient conditions — ●Jinsheng Zhang and Peter Müller-Buschbaum — TUM School of Natural Sciences, Chair for Functional Materials, 85748 Garching, Germany

Solvent additives have received tremendous attention in organic solar cells as an effective way to optimize morphology and phase separation. However, most research primarily focuses on solvent additives with superior solvation for non-fullerene acceptors (NFA) over polymer donors, such as the 1-chloronaphthalen (1-CN) and 1, 8-diiodooctane (1,8-DIO). Few researches are related to solvent additives characterized by better solubility for polymer donors than NFA. Furthermore, the impact of solvent additives is mainly investigated through spin coating rather than slot-die coating, which exhibits distinct kinetics in film formation. Hence, the influence of solvent additive selectivity on the kinetics of active layer formation in the printed active layer remains unknown. In this study, we use PBDB-T-2F as the donor and BTP-C3-4F as the acceptor and introduce two distinct solvent additives one with superior solubility for PBDB-T-2F compared to BTP-C3-4F, and the other with inferior solubility for PBDB-T-2F. The drying process of the slot die coated active layers with different solvent additives is studied by in situ UV-vis absorption spectra and in situ grazing incidence wide angle X-Ray scattering (GIWAXS).

CPP 3.6 Mon 10:45 H38

Locally Resolved Thermally Induced Degradation on PM6:Y6-based Organic Solar Cells — ●Shahidul Alam[1,2], José P. Jurado[2], Biwajit Pal[2], Zhuo Xu[3,4], Aurelien D. Sokeng[3,4], Harald Hoppe[3,4], and Frédéric Laquai[1,2] — [1]Physical Chemistry and Spectroscopy of Energy Materials, Department of Chemistry, LMU Munich, Germany — [2]King Abdullah University of Science and Technology (KAUST), KAUST Solar Center (KSC), Kingdom of Saudi Arabia — [3]Laboratory of Organic and Macromolecular Chemistry (IOMC), FSU Jena, Germany — [4]Center for Energy and Environmental Chemistry Jena (CEEC Jena), FSU Jena, Germany

The commercialization of new photovoltaic technology is impeded by the degradation of organic photovoltaic devices caused by thermal factors. Therefore, it is crucial to have an in-depth awareness of the underlying causes of thermal device instability and to develop effective approaches to reduce its negative impacts. This study examines the thermal degradation of PM6:Y6 bulk heterojunction solar cells, which are currently considered at the forefront of organic solar cell technology. The investigation focuses on the effects of varying temperatures on the performance and locally resolved thermally induced impact of these solar cells. We report a comprehensive study probing the influence of thermal annealing of solar cells by the use of several advanced optoelectrical and imaging characterization techniques.

CPP 3.7 Mon 11:00 H38

Thermal degradation behavior of BTP-4F-12 based green-solvent organic solar cells — •Zerui Li[1], Jinsheng Zhang[1], Simon Wegener[1], Yingying Yan[1], Xiongzhuo Jiang[1], Kun Sun[1], Matthias Schwartzkopf[2], Sarathlal Koyiloth Vayalil[2,3], and Peter Müller-Buschbaum[1] — [1]TUM School of Natural Sciences, Chair for Functional Materials, 85748 Garching, Germany — [2]Deutsches Elektronen-Synchrotron DESY, 22607, Hamburg, Germany — [3]Applied Sciences Cluster, University of Petroleum and Energy Studies UPES, Dehradun, Uttarakhand, 248007, India

Thermal degradation is inevitable for organic solar cells in real application conditions. The common research of thermal stability could only observe ex-situ conditions before and after heating and the device behavior during heating is missing, which is insufficient to the understanding of degradation mechanisms. Herein, a new observation aspect is realized to analyze the thermal degradation of BTP-4F-12 based green-solvent organic solar cells with the application of operando GIWAXS/GISAXS, which provides a deep learning of thermal degradation. The OSC devices show a harsh Voc loss with temperature increase, which would recover mostly after getting cooled down to low temperature, while the loss of FF and Jsc during aging is irreversible. Thus, polymer donors play a crucial role in the device performance as well as thermal behavior. In addition, such thermal degradation is driven by the evolution of the molecular stacking and aggregation and thermal expansion/contraction during aging.