# CPP 26: Organic Electronics and Photovoltaics 2

Time: Wednesday 11:30–13:00 Location: H38

CPP 26.1 Wed 11:30 H38

**Large Area Semitransparent Near-Infrared Organic Photodetectors** — Yazhong Wang[1], •Tianyi Zhang[1], Louis Conrad Winkler[1], Donato Spoltore[2], Johannes Benduhn[1], and Karl Leo[1] — [1]Dresden Integrated Center for Applied Physics and Photonic Materials, Technische Universität Dresden, Dresden, Germany — [2]Department of Mathematical, Physical and Computer Sciences, University of Parma, V.le delle Scienze 7/A, 43124 Parma, Italy

Organic photodetector (OPD) is a promising technology for several sensing applications. With advances in material synthesis and device engineering, OPDs can rival their inorganic counterparts due to their tunable absorption, lightweight, facile fabrication, low cost, and comparable performance. Here, we demonstrate a semi-transparent large area (256 $mm^2$) near-infrared OPD. Through vacuum deposition and optimization of the thickness of the back metal contact layer, a promising average visible transmittance up to 34.6% is achieved while maintaining 36.0% of external quantum efficiency at 790 $nm$. Judicious design for combining wide-optical gap buffer layers with semi-transparent electrodes results in the remarkable specific detectivity of $1.4 \times 10^{13}$(6.44 $mm^2$) and $1.1 \times 10^{12}$(large area) Jones, respectively. Those performances are comparable with commercial silicon photodiodes. To the best of our knowledge, our device is the best see-through, large-area, near-infrared OPD, which enables a higher level of photon detection and integration into image sensors. The transparency and good stability of these OPDs make them excellent candidates for various biomedical sensing applications and the internet of things.

CPP 26.2 Wed 11:45 H38

**Exploring Highly Ordered Rubrene:$C_{60}$ Heterojunctions for Organic Photodetectors** — •Anna-Lena Hofmann[1], Lucy Winkler[1], Max Herzog[1], Eva Bittrich[2], Jakob Wolansky[1], Martin Kroll[1], Johannes Benduhn[1], and Karl Leo[1] — [1]Institute of Applied Physics, Technische Universität Dresden, Nöthnitzer Str. 61, 01187 Dresden, Germany — [2]Leibniz-Institut für Polymerforschung Dresden e.V., Dresden, Germany

Rubrene can form highly ordered phases, demonstrating an unusually high charge carrier mobility for holes ($> 10\,cm^2V^{-1}s^{-1}$) even in thin films. Therefore it is a promising material for high-performance organic photodetectors (OPDs). To study the impact on OPDs, crystalline triclinic rubrene is compared to amorphous rubrene. Planar heterojunctions (PHJs) and bulk heterojunctions (BHJs) are fabricated for both material systems. For the latter, rubrene is doped with 2, 5, and 10 wt% of $C_{60}$. Linearly polarized microscopy is used to get the first insight into the morphology, which is then completed by ellipsometry, atomic force microscopy (AFM), and x-ray diffraction (XRD). For the electrical characterization, the external quantum efficiency (EQE) and IV characteristics are obtained, where an additional crystalline sample with a neat $C_{60}$ layer is investigated. The neat layer of $C_{60}$ achieves an enormous improvement of the EQE. This makes the PHJ a more favourable device architecture. Even though triclinic rubrene reaches a higher EQE and has a broader spectral response, it does underperform in optimized OPDs concerning the specific detectivity since the dark current is three magnitudes higher than the amorphous counterpart.

CPP 26.3 Wed 12:00 H38

**Hybrid Energy Harvester based on Triboelectric Nanogenerator and PbS Quantum Dot Solar Cell** — •Tianxiao Xiao[1], Wei Chen[1], Wei Cao[1], and Peter Müller-Buschbaum[1,2] — [1]Physik-Department, LS Funktionelle Materialien, 85748 Garching — [2]MLZ, TU München, 85748 Garching

Developing clean energy lies in the heart of the sustainable development of human society. Triboelectric nanogenerators (TENGs) originating from Maxwell's displacement current is a new type of energy harvester for harnessing ambient mechanical energy based on the coupling of triboelectrification and electrostatic induction effect. Compared with other counterparts, owing to the light-weight, low-cost, and easy fabrication TENGs become one of the most promising candidates in the replacement of conventional fossil fuels and attract worldwide attention in the past years. However, to further increase the energy harvesting efficiency and broaden application fields, integrating the TENG with other kinds of energy harvesters in one device is a possible way to meet these needs. In the present work, a TENG based hybrid energy harvester is designed and fabricated on the flexible polyethylene terephthalate (PET) substrate. This hybrid device consists of a single-electrode mode TENG component and a PbS quantum dot (QD) based solar cell component, which can harness both mechanical and solar energy from ambient environment to directly generate electricity.

CPP 26.4 Wed 12:15 H38

***In Situ* and *In Operando* KPFM Studies on OFET Based on Hexadecafluoro-Copper-Phthalocyanine ($F_{16}PcCu$) to Access Energy Level Alignment and Electrical Contact Resistance** — •Pascal Schweitzer, Clemens Geis, and Derck Schlettwein — Justus-Liebig-Universität Gießen, Institut für Angewandte Physik

Contact resistances are considered a show-stopper for organic field effect transistors (OFET). Perfluorinated copper-phthalocyanine ($F_{16}PcCu$) is a promising chemically stable n-conductor to build complementary logical circuits with established p-conductors. A reasonably high charge carrier mobility $\mu_{ext} \approx 2 \times 10^{-3}cm^2/Vs$ was estimated from device performance affected, however, by neglected contact resistances. In this work, we used *in operando* Kelvin probe force microscopy under high vacuum to study the influence of contact resistances at the source and drain electrodes on the OFET performance. Non-contact potentiometry at different applied external voltages revealed relevant voltage drops at the electrode interface and in the adjacent contact region. Based on these voltage drops and measured device currents significant contact resistances were calculated. Correcting for such parasitic voltage drops, contact-free $\mu_{ch}$ was obtained, substantially higher than $\mu_{ext}$. The growth mode of $F_{16}PcCu$ on application-relevant polycrystalline gold substrates and shifts of the energy levels were studied by *in situ* KPFM and an injection barrier was confirmed. From these results, we conclude that the model of thermionic emission, often used for contact resistances, is not completely sufficient to describe the present case.

CPP 26.5 Wed 12:30 H38

**Thin films of electron donor-acceptor complexes: characterisation of mixed-crystalline phases and implications for electrical doping** — •Andreas Opitz[1], Giuliano Duva[2], Marius Gebhardt[3], Hongwon Kim[3], Eduard Meister[3], Tino Meisel[1], Paul Beyer[1], Valentina Belova[2], Christian Kasper[4], Jens Pflaum[4], Linus Pithan[4,5], Alexander Hinderhofer[2], Frank Schreiber[2], and Wolfgang Brütting[3] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Germany — [2]Institut für Angewandte Physik, Universität Tübingen, Germany — [3]Institut für Physik, Universität Augsburg, Germany — [4]Experimentelle Physik VI, Julius-Maximilians-Universität Würzburg, Germany — [5]European Synchrotron Radiation Facility, Grenoble Cedex 9, France

Electron donor-acceptor (EDA) complexes are of interest as low-band gap molecular semiconductors and as dopants for molecular semiconducting matrices. Our recent work establishes a link between optical, structural and vibrational properties of EDA complexes as well as the electrical doping by them. [1] Here, we report on optical and electrical properties of EDA complexes. All studied donor:acceptor systems form mixed crystalline structures and the EDA complex is characterised by the complex-related absorption, which cross the neutral-to-ionic boundary. Our measurements reveal an exponential relation between electrical conductivity and activation energy of transport for all complex-doped systems related to the separation of Coulombically bound charges.

[1] A. Opitz *et al.*, *Mater. Adv.* **3** (2022). DOI: 10.1039/D1MA00578B

CPP 26.6 Wed 12:45 H38

**Effect of phenylation vs. functionalization for tetracene-based electron transport materials** — •Maryke Kouyate, Sebastian Hutsch, and Frank Ortmann — Technical University of Munich, Munich, Germany

In analogy to the tetracene/rubrene system, new electron transport materials (ETMs) are designed by modifying the outer benzene rings of tetracene with electron-withdrawing groups and attaching four phenyl groups to the modified backbone. Subsequent crystal structure prediction and charge transport calculations provided further insights in the structural effect of tetra-phenylation on tetracene based systems and the impact on charge transport properties. A strong effect of core-end

modification on the molecular packing and charge transport properties for molecules without phenylation is revealed. These structures differ significantly from the known crystal structure of tetracene. Tetraphenylation, on the other hand, reduces the impact of core-end modification and crystal structures close to the high-mobility orthorhombic rubrene structure are obtained, suggesting a considerable steric effect of the bulky phenyl-groups. We finally compare the charge-transport properties between the tetracene/rubrene reference systems and ETMs with and without phenyl functionalization.