

## HL 38: Organic semiconductors

Time: Thursday 9:30–11:15

Location: H33

HL 38.1 Thu 9:30 H33

**Quantitative Analysis of the Density of Trap States in Organic Semiconductors by Electrical Transport Measurements on Low-Voltage Thin-Film Transistors** — ●MICHAEL GEIGER<sup>1</sup>, LUKAS SCHWARZ<sup>1</sup>, THOMAS FERSCHKE<sup>2</sup>, UTE ZSCHIESCHANG<sup>1</sup>, DIRK MANSKE<sup>1</sup>, JENS PFLAUM<sup>2,3</sup>, JÜRGEN WEIS<sup>1</sup>, HAGEN KLAUK<sup>1</sup>, and RALF THOMAS WEITZ<sup>4,5</sup> — <sup>1</sup>Max Planck Institute for Solid State Research, Stuttgart, Germany — <sup>2</sup>Experimental Physics VI, Julius-Maximilian University, Würzburg, Germany — <sup>3</sup>ZAE Bayern, Würzburg, Germany — <sup>4</sup>Faculty of Physics, Ludwig Maximilians University, München, Germany — <sup>5</sup>NanoSystems Initiative Munich (NIM) and Center for NanoScience (CeNS), Ludwig Maximilians University, München, Germany

We present an extension to an existing method to convert a measured transfer curve of a field-effect transistor to the underlying density-of-trap-states (trap DOS) function [1]. A comparison between thin-film transistors (TFTs) with high- and low-voltage operation confirms the validity of the original method for high-voltage transistors, but also the need for the extended method for the reliable extraction of the trap DOS in low-voltage transistors. Furthermore, we developed a method to systematically control the surface roughness of the gate dielectric in our TFTs and then used our extended method to investigate the correlation between the surface roughness of the gate dielectric and the trap DOS in the organic semiconductor layer and the implications of the surface roughness for the TFT performance.

[1] M. Grünwald et al., Phys. Stat. Sol. B 100, K139 (1980).

HL 38.2 Thu 9:45 H33

**Fabrication and electrical properties of Rubrene/F6-TCNNQ charge transfer interfaces** — ●BIPASHA DEBNATH, DANIEL WAAS, MARTIN KNUPFER, BERND BÜCHNER, and YULIA KRUPSKAYA — Leibniz Institute for Solid State and Materials Research Dresden, 01069 Dresden Germany

Although charge-transfer interfaces are widely used in organic electronics, the mechanism of the charge transfer remains unexplored. One of the very promising approaches to study the charge transfer is organic single-crystal based interfaces, where an enhanced electrical conductivity at the interface of two initially insulating materials can be observed [1]. In this research work, we build a charge-transfer interface based on high quality Rubrene single crystals as a donor material. As an acceptor, we choose F6-TCNNQ -a molecule with very high electron affinity (EA = 5.6 eV) [2]. Rubrene single crystals are grown using physical vapor transport (PVT) and characterized with the optical and atomic force microscopy. Additionally, field-effect transistor (FET) measurements are performed to ensure the highest quality of the crystals. To fabricate the charge-transfer interface, F6-TCNNQ is evaporated on top of the Rubrene crystals. Strongly increased electrical conductivity along the interface is observed by electrical measurement. The acquired results well complement the previous studies of Rubrene/Fx-TCNQ interfaces [1] and widen the possibility for further systematic investigations of the charge transfer mechanisms. Financial support: DFG KR 4364/4-1. [1] Y. Krupskaya et al., Adv. Funct. Mater. 26, 2334 (2016) [2] A. Kahn et al., Adv. Funct. Mater. 28, 1703780 (2018)

HL 38.3 Thu 10:00 H33

**Charge transport properties of highly ordered solution processed films of C8-BTBT** — ●MICHAEL BRETSCHNEIDER<sup>1</sup>, KATHERINA HAASE<sup>2</sup>, STEFAN C.B. MANNSFELD<sup>2</sup>, BERND BÜCHNER<sup>1</sup>, and YULIA KRUPSKAYA<sup>1</sup> — <sup>1</sup>IFW Dresden, Germany — <sup>2</sup>CFAD, TU Dresden, Germany

In the field of organic electronics one has to improve device sizes and structures and find new, more efficient materials. On the other hand it is intended to enhance the device performance. For all of these tasks one needs to understand the specific material properties of organic semiconductors. In terms of device performance it is important to investigate the charge carrier mobility and find a way to increase its value. The family of [1]Benzothieno[3,2-b]benzothiophene (BTBT) is a new type of high hole mobility organic semiconductor. In this family C8-BTBT is investigated the most in the past years. Solution based fabrication methods like shear coating allow for a large area growth of highly ordered films of C8-BTBT. Recently a new record value of mobility in field-effect transistors based on that method was published

(1). Beside that there are still open questions concerning charge carrier properties. For further improvement one has to understand the transport mechanisms in these organic semiconductor devices. Here we present our results based on temperature dependent field-effect and Hall-effect measurements. These measurements allow to get a closer look into the transport behaviors of solution processed C8-BTBT films.

(1)K. Haase, C. Teixeira da Rocha, C. Hauenstein, Y. Zheng, M. Hamsch, S. C. B. Mannsfeld, Adv. Electron. Mater. 2018, 4, 1800076.

HL 38.4 Thu 10:15 H33

**Optical and Electrical Investigations of an Organic Microcavity** — ●STEFAN MEISTER, ROBERT BRÜCKNER, MARKAS SUDZIUS, HARTMUT FRÖB, and KARL LEO — IAPP, TU Dresden, Dresden, Germany

Organic materials are widely used in opto-electronic devices such as the OLED or the organic solar cell. The properties are also very interesting for laser applications. Whereas different types of laser, with an organic active medium, were presented optically pumped, so far, it is not possible to realize an electrically driven organic solid-state laser. There are several obstacles, e.g. potentially high current densities or accumulation of triplet states, which need to be addressed before the more convenient electrical pump process can be realized.

We investigated different kinds of electrically active structures and their potential for laser applications. The results are compared to optically pumped devices to better rate and understand the device performance.

Due to expected current densities in the range of kA/cm<sup>2</sup>, the use of metal contacts seems to be inevitable. Therefore, optimizing the contacts plays a key role to prevent a decrease in device functionality due to the metals. We realized metal contacts which did not increase the optical lasing threshold and still supply a conductivity of 1.9x10<sup>5</sup> (Ωcm)<sup>-1</sup>.

HL 38.5 Thu 10:30 H33

**Electron paramagnetic resonance detected in a metal-free fluorescence-phosphorescence dual-emitter OLED** — ●TOBIAS GRÜNBAUM, WOLFRAM RATZKE, SEBASTIAN MILSTER, SEBASTIAN BANGE, and JOHN M. LUPTON — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstraße 31, 93053 Regensburg, Germany

Organic light-emitting diodes (OLEDs) constitute an ideal model system for investigating spin-dependent phenomena in condensed matter physics. A tool for direct access to the spin symmetry of charge carrier pairs in OLEDs is electron paramagnetic resonance (EPR) [1].

We performed EPR measurements on OLEDs comprising the dual emitting host-guest system CBP:DMDB-PZ [2]. This allows us to simultaneously detect the effect of both static as well as high frequency magnetic fields on the ratio of singlet and triplet charge-carrier pairs. We find the anticipated anti-correlation of singlet and triplet light emission in magneto-electroluminescence as well as under EPR. Due to the precise control of molecular design, spin-orbit as well as hyperfine interaction can be selectively tuned and investigated. We anticipate that the EPR technique can be applied to identify the region of the device where formation of charge-carrier pairs takes place, since differing distributions of the hyperfine fields are expected in different molecular scaffolds.

[1]: Baker, W. J. et al., Nat. Commun. 3, 898 (2012)

[2]: Ratzke, W. et al., Phys. Rev. Appl. 9, 054038 (2018)

HL 38.6 Thu 10:45 H33

**Photoemission Spectroscopy Studies of Charge Transfer Interfaces** — ●ROBERT KUHR, MARTIN HANTUSCH, MARTIN KNUPFER, and BERND BÜCHNER — IFW Dresden, Helmholtzstraße 20, 01069 Dresden

Charge transfer plays an important role in the field of organic molecular materials. Prominent examples are so-called two dimensional metals and superconductors as well as the doping of organic semiconductors that are used in devices like solar cells, OLEDs and organic transistors. Charge transfer at the interface of two organic semiconductors can lead to electronic properties that differ significantly from those of the individual materials which makes a deeper understanding of this

process a matter of scientific interest. In principle, charge transfer is expected at interfaces where the ionization potential of one material is located in the same region as the electron affinity of the other material.

In this contribution we present a photoemission spectroscopy (PES) study of interfaces between the acceptor molecule hexafluorotetracyanonaphthoquinodimethane (F<sub>6</sub>TCNNQ) and the donor molecules pentacene and di-benzo-pentacene. The electronic states in the valence band region are probed with ultraviolet photoemission spectroscopy (UPS) and an x-ray source (XPS) is used to measure the core levels. It is revealed that the highest occupied molecular orbitals of the donor molecules are shifted when they are in contact with the F<sub>6</sub>TCNNQ-molecules. Also, the identification of additional nitrogen and carbon species indicate the presence of reduced F<sub>6</sub>TCNNQ molecules and therefore a full localized charge transfer at the interface.

HL 38.7 Thu 11:00 H33

**Electronic excitations in phthalocyanine mixed films** —

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This contribution will present optical and electron spectroscopy experiments on mixed films of phthalocyanines. Phthalocyanines (PC's) are organic semiconductors which are well suited for fundamental studies as well as applications. Band structure tuning, such as size and position of the bandgap, is common in inorganic semiconductors. In organic semiconductors it was first reported in 2016 for mixtures of ZnPC with fluorinated ZnPC (M. Schwarze et al, Science, 2016). We investigate mixed films of ZnPC and its fluorinated partner F<sub>8</sub>ZnPC with a particular focus on the electronic excitations. In different ratios they are evaporated in thin films on a KBr substrate. These films are measured by optical spectroscopy (UV,IR, VIS) and with electron energy loss spectroscopy (EELS), a method where the energy-loss of the transmitted electrons through the film can be measured momentum dependently. This unique technique allows us to measure the exciton dispersion of the materials and to see how the mixed films' dispersion is just a superposition of the pure molecules or if they are building new properties by being stacked next to each other. This is supported by the DFG (KN393/25, KN293/26).