

## HL 67: OLEDs and OFETs

Time: Wednesday 18:00–19:30

Location: FOE Anorg

HL 67.1 Wed 18:00 FOE Anorg

**Band bending and energy-level alignment in organic semiconductors** — ILJA LANGE<sup>1</sup>, JAMES BLAKESLEY<sup>1</sup>, JOHANNES FRISCH<sup>2</sup>, NORBERT KOCH<sup>2</sup>, and •DIETER NEHER<sup>1</sup> — <sup>1</sup>Universität Potsdam — <sup>2</sup>Humboldt Universität Berlin

Energy level alignment at organic semiconductor / electrode interfaces has been the subject of intensive debate in recent years. In particular, the existence of band bending in undoped organic semiconductors is disputed. It has been proposed that strong band bending should be present due to electronic states within the energy gap of a disordered material. It is also known that such states dominate some crucial properties of organic semiconductor devices, such as charge injection and charge transport. Thus the elucidation of the distribution of these tail states provides a key to understanding fundamental processes in such devices and hence to increasing device efficiency. Unfortunately, the densities of the relevant states are often so low that they are difficult to detect directly. We use a Kelvin probe (KP) to study the energy level alignment of four undoped conjugated polymers deposited on various electrodes. Band bending is observed in all polymers when the substrate work function exceeds certain critical values. Through modeling, we show that the band bending is caused by charge transfer into a low-density population of states that extends several hundred meV into the band gap. KP can therefore be used as a tool to study the energetic distribution of such states. The energetic spread of these states is correlated with charge transport properties, suggesting that these states also determine relevant device properties.

HL 67.2 Wed 18:15 FOE Anorg

**Optical Processes in OLEDs: Molecular Photonics** — •MICHAEL FLÄMMICH, DIRK MICHAELIS, and NORBERT DANZ — Fraunhofer Institute for Applied Optics and Precision Engineering, 07745 Jena, Germany

Following the OLED display market take-off, huge world wide efforts are spent to develop OLEDs towards competitive sources for general lighting applications. In this context, the light outcoupling problem is well known as the key parameter to improve OLED efficiency in order to tackle existing lighting schemes. From the optical point of view, the device performance is driven (i) by the architecture of the OLEDs layered system and (ii) by the internal features of the emissive material. Studies in recent years have shown that the latter attributes (which are the internal electroluminescence spectrum, the profile of the emission zone, the orientation of the transition dipole moments and the internal luminescence quantum efficiency  $\eta$ ) can be determined in situ by measurements of the far-field emission pattern generated by active OLEDs (i.e. in electrical operation) and corresponding optical reverse simulations. Starting from basic considerations of the dipole radiation characteristics, we elaborate specifically how the orientation distribution of the dipole transition moments in the layered system can be analyzed in situ, providing insight into the internal photo-physical processes on the molecular scale of the emitter.

HL 67.3 Wed 18:30 FOE Anorg

**Stability of Polarization in Organic Ferroelectric Metal-Insulator-Semiconductor (MIS) Structures** — •RENE KALBITZ<sup>1</sup>, PETER FRÜBING<sup>1</sup>, REIMUND GERHARD<sup>1</sup>, and MARTIN TAYLOR<sup>2</sup> — <sup>1</sup>Department of Physics and Astronomy, University of Potsdam, Karl-Liebknecht-Straße 24-25, 14476, Potsdam, Germany — <sup>2</sup>School of Electronic Engineering, Bangor University, Dean Street, Bangor Gwynedd, LL57 1UT, UK

Ferroelectric field effect transistors (FeFETs) offer the prospect of an organic-based memory device. Since the charge transport in such devices is confined to the interface between the insulator and the semiconductor, the focus of the present study was on the investigation of this region. Capacitance-voltage (C-V) measurements of all-organic MIS devices with poly(vinylidene fluoride- trifluoroethylene) (P(VDF-TrFE)) as gate insulator and poly(3-hexylthiophene)(P3HT) as semiconductor were carried out. When the structure was driven into depletion, a positive flat-band voltage shift was observed arising from the change in polarization state of the ferroelectric insulator. When driven into accumulation, the polarization was reversed. It is shown that both polarization states are stable. However, negative charge trapped at the interface during the depletion cycle masks the negative

shift in flat-band voltage expected during the sweep to accumulation voltages. Measurements on P(VDF-TrFE)/P3HT based FeFETs yield further evidence for fixed charges at the interface. Output characteristics suggest the injection of negative charges into the interface region when a depletion voltage is applied between source and gate contact.

HL 67.4 Wed 18:45 FOE Anorg

**Ambipolar organic field-effect devices using an aliphatic passivation layer** — MICHAEL KRAUS, MATTHIAS HORLET, SIMON HAUG, STEFAN RICHLER, WOLFGANG BRÜTTING, and •ANDREAS OPITZ — Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

In recent years electron and hole transport has been found to be an intrinsic feature for many organic semiconductors. The charge carrier type depends thereby on the injecting electrodes and the presence of interface traps.

In this contribution we demonstrate the application of the insulating long-chain alkane C<sub>44</sub>H<sub>90</sub> tetratetracontane (TTC) as passivation layer, which has been shown to be highly suitable for the elimination of electron traps [1]. The analysis of its growth behaviour on silicon dioxide and of the subsequently deposited organic semiconductor will be shown for different molecular semiconductors like copper-phthalocyanine and diindenoperylene. The charge carrier transport in these semiconductor layers was analysed using top contact organic field-effect transistors. Thereby an asymmetry between electron and hole mobilities was found with diindenoperylene showing the better electron transport whereas copper-phthalocyanine has balanced mobilities at room temperature. The growth of the phthalocyanine gives crystalline needles up to 500 nm in length which improves the transport properties.

[1] M. Kraus et al., J. Appl. Phys. 107, 094503 (2010).

HL 67.5 Wed 19:00 FOE Anorg

**Electrolyte-gated organic thin-film transistors for sensing applications** — •FELIX BUTH, DEEPU KUMAR, MARTIN STUTZMANN, and JOSÉ ANTONIO GARRIDO — Walter Schottky Institut, Technische Universität München, Garching, Germany

Organic thin films can potentially be used in low-cost, disposable devices for chemical or bio-sensing. However, operating organic sensor devices in an aqueous environment raises difficulties when it comes to necessary operation voltages or device stability. One approach to reduce the gate voltage is increasing the capacitance of the gate dielectric. Electrolytic gates offer extraordinarily large capacitances, up to several  $\mu\text{F}/\text{cm}^2$  at low frequencies. This high capacitance, which is the result of the formation of an electrical double layer at the electrolyte/semiconductor interface makes low-voltage operation possible, without high production costs. In this contribution, we investigate the behavior of polycrystalline  $\alpha$ -sexithiophene ( $\alpha$ 6T) thin-film transistors with an aqueous electrolyte gate. Electrochemical impedance spectroscopy and CV measurements indicate a nearly perfectly polarizable interface with negligible parasitic Faradaic currents. For gate voltages below 1 V, a conductive channel is induced at the  $\alpha$ 6T/electrolyte interface via an electrical field effect. The transistor is stable for several hours and sensitive to changes in the pH or the ionic strength of the solution. The pH sensitivity arises from a shift in the threshold voltage of the transistor, and is not due to changes of the carrier mobility. The pH-dependent threshold voltage shift, in the range of 10 mV/pH, is caused by a change in the surface charge of the thin film.

HL 67.6 Wed 19:15 FOE Anorg

**the origin of the short channel effect in organic field effect transistor.** — •ALI VEYSEL TUNC<sup>1</sup>, ELIZABETH VON HAUFF<sup>1</sup>, AHMET LÜTFİ UĞUR<sup>2</sup>, ALI ERDOĞMUS<sup>2</sup>, and JURGEN PARISI<sup>1</sup> — <sup>1</sup>University of Oldenburg, Department of Physics, Energy and Semiconductor Research Laboratory (EHF) Carl-von-Ossietzky Str.9-11, 26129 Oldenburg, Germany — <sup>2</sup>Yıldız Technical University, Department of Chemistry, Davutpasa Campus, 34210 Esenler, Istanbul, Turkey

The origin of the short channel effect in polymer-based field effect transistors (FETs) was investigated. Here, we employed three different molecular weight poly [2-methoxy,5-(3',7'-dimethyl-octyloxy)]-p-phenylene vinylene (MDMO-PPV) and in blends with different ratios

of 1-(3-methoxycarbonyl) propyl-1-phenyl[6,6]C61 (PCBM). In this work we demonstrate that the short channel effect is not only influenced by the device geometry but there is also a correlation between intrinsic material properties, the hole current, field effect mobility, contact resistance and short channel behavior in PPV based OFETs. Intrinsic properties, mobility or molecular weight, of the semiconductor influence the onset of the short channel effect. We observed that increasing the PCBM content in the blend leads to an increase in the

hole current and field effect mobility, a decrease in the contact resistance, as well as a deviation from the saturation behavior of the output characteristics of the FET. This effect is attributed to a change in the polymer chain ordering in the source channel which in turn influences the charge transport properties in the polymer film.