

HL 77: Joint Session: Organic Electronics and Photovoltaics III

Time: Thursday 14:00–16:00

Location: GER 38

HL 77.1 Thu 14:00 GER 38

Influence of the thickness dependent structural order on the electrical potential distribution in the channel of OFET's —

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Soluble organic semiconductors often exhibit a charge carrier dependent mobility and energetic disorder, which typically vary with layer thickness. In this study, organic field effect transistors (OFET) with different thicknesses of regio-regular P3HT as semiconductor and PMMA as gate-insulator on PET foils are investigated and analyzed statistically.

The mobility, which is very low for layers up to 10 nm, increases with the thickness over two orders of magnitude and saturates after 30 nm. This behavior is analyzed according to the Vissenberg-Matters model (VM) of the charge carrier density dependent mobility $\mu = \mu_0((V_{GS} - V_{th})/V_{aa})^\gamma$, where the disorder parameter γ decreases from 1.7 to 0.8 over the examined thicknesses proving the higher energetic disorder for thinner films. Increasing domain sizes in phase contrast AFM pictures confirm these findings.

The potential distribution within the channel, which has been measured by additional sense electrodes, is used to determine the potential steps at source and drain contact applying the VM model. The influence of the disorder parameter on the potential distribution is elucidated.

HL 77.2 Thu 14:15 GER 38

Local analysis on organic field effect transistors —•HARALD GRAAF¹, FRANZISKA LÜTTICH¹, DANIEL LEHMANN², DIETRICH R.T. ZAHN², and CHRISTIAN VON BORCZYKOWSKI¹ — ¹Optische Spektroskopie und Molekülphysik, Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz — ²Halbleiterphysik, Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz

Within the last decade the interest on organic electronics increased tremendously and reaches even industrial applications. Nevertheless, there are still a lot of open questions concerning e.g. the charge transport in the organic materials especially on a local scale. Here the focus is on the influence of trap states at interfaces and within the bulk provided e.g. by grain boundaries. By the combination of diverse measurement techniques a deeper insight and a better understanding of the local properties of the materials can be obtained.

We will present recent results on organic materials gained by electrical DC-measurements, Kelvin probe force microscopy on operating devices, optical and topographical investigations. By the results one obtain on the one hand information about the orientation and the coupling of the chromophoric systems (which is responsible also for the charge transport) within the film. On the other hand the electrical and electronical characterizations permit insight in the properties especially at the relevant interfaces (electrode/semiconductor and semiconductor/isolator) and on the local transport characteristics of the charges.

HL 77.3 Thu 14:30 GER 38

Dynamics of optically induced instabilities in P3HT field-effect transistors —

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The development of stable printed organic electronic circuits for everyday use remains a great challenge. Under ambient conditions electrical instabilities may be driven by external influences such as gases, humidity or light. Here, we report on a light induced instability of state of the art poly(3-hexylthiophene) field-effect transistors under ambient atmosphere. By illuminating p-type, top-gate poly(3-hexylthiophene) field-effect transistors in depletion mode with visible light a substantial shift of the threshold-voltage and an increase in the off-current by three orders of magnitudes has been observed. Both phenomena, the threshold-voltage shift and the increase of the off-current, require the presence of oxygen and are persistent for days at room temperature. The origin of this long lasting instability is attributed to traps which are induced in the semiconductor by oxygen incorporation and subsequent optical filling of these traps by electrons. This charge trapping shifts the threshold voltage and increases the doping level. The tempo-

ral evolution of the optically induced changes in the OFET characteristics under different thermal conditions will be highlighted. Such an instability is crucial for logic elements where OFETs are normally hold in the off-state, thus in depletion. Under these operational conditions light induces the aforementioned change in the OFET characteristics affecting the functionality of the employed logic circuit substantially.

HL 77.4 Thu 14:45 GER 38

Towards a biosensing device based on pentacene transistors —

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Organic semiconductors can be processed on flexible, biocompatible plastic substrates and offer a soft and non-toxic ambience to living cells (e.g. neurons). Therefore organic thin film transistors (OTFTs) are considered as promising candidates for the next generation of biosensing devices. However, most high mobility organic semiconductors have a limited lifetime in physiological aqueous conditions. For a stable device operation it is necessary to suppress redox reactions with the electrolyte and so called leakage currents.

For this purpose we recently used a thin alkane layer to passivate a pentacene thin film transistor, enabling the operation in an aquatic environment for many hours [1]. A transducer based on a capped OTFT should be sensitive to subtle changes of the charges at the interface to the electrolyte. Ongoing measurements indicate that it is possible to change the source-drain current of the transistor by changing the electrochemical potential of the electrolyte by a few mV. This suggests that the device should also be sensitive to the adsorption of charged molecules and the activity of cells. The sensing mechanism is discussed.

[1] M. Göllner, M. Huth, B. Nickel, *Advanced Materials* 22, 4350-4354 (2010)

HL 77.5 Thu 15:00 GER 38

Electronic properties of spiro-compounds: A combined photoelectron spectroscopy and energy-loss spectroscopy study —•B. MAHNS¹, M. GROBOSCH¹, T. SARAGI², J. SALBECK², and M. KNUPFER¹ — ¹IFW Dresden, Helmholtzstrasse 20, 01069 Dresden, Germany — ²Macromolecular Chemistry and Molecular Materials, Institute of Chemistry, Department of Science and Center for Interdisciplinary Nanostructure Science and Technology (CINSA-T), University of Kassel, Heinrich-Plett-Strasse 40, 34132 Kassel, Germany

The electronic properties of three different spiro-compounds have been investigated using a combination of photoelectron spectroscopy and electron energy-loss spectroscopy. The compounds are characterized by parts with different electron affinity, and we demonstrate their variation in ionization potential and optical gap. Moreover, our data give a measure of the occupied density of states as well as the dielectric properties in a wide energy range.

HL 77.6 Thu 15:15 GER 38

Spatially resolved photoresponse of pentacene thin film transistors: slow component by trap release —

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Organic thin film transistors (OTFTs) have witnessed continuous improvement over the past years and become suited for widespread application. Small organic molecules, such as pentacene, are often used for OTFTs, since their ordered thin-film structures result in high charge carrier mobilities. Although pentacene has attracted high interest of research, the electronic transport and photoresponse mechanisms and their relation to the morphology and trap densities of the polycrystalline film are not well understood.

We perform spatially and time resolved photoresponse measurements of pentacene TFTs using a laser scanning setup for local illumination with varying laser frequencies and a photon energy of 1.96 eV. The excitation corresponds to the upper Davydov component of the S₁ state of pentacene. Besides the absorption in the 50 nm pentacene film, a significant fraction of the laser light is absorbed in the Si wafer upon reflection. Since the excitons in pentacene decay mostly radiationless, both contributions result in local heating. We argue that heat assisted detrapping results in the release of holes from trap states, thus

the effective charge carrier mobility increases locally. These bolometric effects are associated with a slow contribution to the photoresponse on a millisecond timescale and with an inhomogeneous structure presumably corresponding to the trap density distribution in pentacene.

HL 77.7 Thu 15:30 GER 38

Contact properties of organic PCBM field effect transistors analyzed by combined photoemission spectroscopy and electrical measurements — ●M. GROBOSCH¹, I. HÖRSELMANN², J. BARTSCH², S. SCHEINERT², M. KNUPFER¹, and G. PAASCH¹ — ¹IFW Dresden, D-01069 Dresden, Germany — ²Technical University Ilmenau, D-98684 Ilmenau, Germany

Source/drain contacts in OFETs based on a solution prepared modified PCBM were characterized by combined X-ray and ultra violet photoemission spectroscopy (XPS, UPS) and electrical measurements of the OFET. Thereby the sample preparation for the different measuring principles has been realized in parallel, differing only in the layer thickness of the polymer. By means of UPS a reduced work function could be demonstrated for differently prepared, sputtered, and as-received Au and Al contacts in agreement with previous publications [1]. On top of the Al contacts a natural AlO_x layer could be identified. For both the PCBM/Au and PCBM/Al systems from UPS a hole injection barrier of 1.8 eV has been determined. Considering the gap of 2.0 eV [2] the electron injection barrier would be the same of 0.2 eV. In contrast to these identical barriers as following from UPS, the OFET currents with Au and Al contacts differ by more than two orders of magnitude. A possible origin of this striking discrepancy

will be presented. [1] M. Grobosch et al., *Adv. Mater.* 19 (2007) 754. [2] Z.-L. Guan et al., *Organic Electronics* 11 (2010) 1779.

HL 77.8 Thu 15:45 GER 38

Dye directed changes in ZnO matrices in organic/inorganic photovoltaic systems — ●HARALD GRAAF¹, FRANZISKA LÜTTICH¹, MIRKO KEHR¹, CHRISTIAN DUNKEL², and TORSTEN OEKERMANN² — ¹Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz — ²Institut für Physikalische Chemie und Elektrochemie, Leibniz Universität Hannover, 30167 Hannover

Dye-sensitized photovoltaic cells with zinc oxide (ZnO) as the inorganic semiconductor and organic dye molecules as the sensitizer are well-known devices with high efficiency. Such cells are prepared by electrochemical deposition of an aqueous zinc salt solution including dye molecules. After deposition the dye is desorbed to obtain a porous ZnO network followed by re-adsorption of the dye as a sensitizer. The dye molecules influence the crystal orientation of the ZnO as they tend to physisorb on different crystal surfaces.

We will present recent results on as-deposited and desorbed dye/ZnO films obtained by different analytic methods: X-ray investigations, Scanning Electron Microscopy, Atomic and Kelvin probe force microscopy and optical spectroscopy. This allows a deep insight into the dye/semiconductor system, which is necessary to improve the efficiency of such devices. Here the focus is on crystal orientation, morphology and work function of the ZnO matrix. Also the arrangement of the dye molecules in as well as on top of the as-deposited films and the band edge of the zinc oxide is accessible.