

HL 61 Organische Halbleiter

Zeit: Mittwoch 10:45–13:15

Raum: TU P270

HL 61.1 Mi 10:45 TU P270

Photoresponse of conjugated polymer/fullerene based Organic Field-Effect Transistors — ●NENAD MARJANOVIĆ, BIRENDRA SINGH, SERAP GÜNES, HELMUT NEUGEBAUER, and NIYAZI SERDAR SARICIFTCI — Linz Institute for Organic Solar Cells (LIOS), Physical Chemistry, Johannes Kepler University Linz, Austria

Results on photoresponsive organic field-effect transistors (photOFETs) fabricated on ITO glass substrates using conjugated polymer/fullerene bulk heterojunction and bilayer concepts will be presented. Measurements in the dark with LiF/Al source and drain top contacts show dominantly n-type transistor behaviour. Under AM1.5 illumination, an increase in drain-source current I_{ds} by five orders of magnitude is observed, whereas I_{ds} becomes independent on the gate voltage. The results suggest that a photodoping effect (creation of a large free carrier concentration from a photoinduced charge transfer at the conjugated polymer/fullerene heterojunction upon illumination) is strongly dominating over the gate effect.

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On the determination of the Transport Mechanism in Organic Semiconductors from the Field-Effect Mobility — ●GERNOT PAASCH, NABIN BARAN MANIK, and THOMAS LINDNER — IFW Dresden

The field-effect mobility is determined by the gate voltage dependence of the drain current for low drain voltage. Based on fitting analytical expressions to the measured dependencies on the gate voltage and on temperature, it has been claimed that there is a one-to-one correspondence to the transport mechanism: Either hopping in a Gaussian distribution of states, or in an exponential distribution (allegedly as an approximation for the first one in some energy interval), or transport of mobile carriers above a mobility edge in the presence of exponentially distributed traps below the edge (essentially the so-called a-Si model). A critical re-examination of these procedures shows that (i) the data used to prove the assumption of hopping in exponentially distributed states can be described also with the a-Si model. (ii) The respective models should not only describe the field-effect mobility but also the subthreshold and saturation currents. (iii) Full 2D numerical simulation with the a-Si model are reported and compared (for the small drain voltage limit) to the analytic approximation. (iv) Connections with the Einstein relation and with the transition from non-degenerate to degenerate statistics are clarified.

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Space Charge Layers in Organic Semiconductors with Gaussian or Exponential Density of States — ●SUSANNE SCHEINERT¹ and GERNOT PAASCH² — ¹TU Ilmenau — ²IFW Dresden

Space charge layers (SCL) in MOS structures are decisive for the operation of field effect transistors (FET). For many organic semiconductors, transport takes place as hopping in Gaussian or exponentially distributed states. However, existing theoretical descriptions of SCL suppose a density of states other than a Gaussian or an exponential. We present results of a simulation study for a thin semiconducting layer e.g. on a metal substrate and the MOS structure as the basic module of the FET. From the calculated distributions of concentration, field and potential, and the semiconductor capacitance as a function of either the surface potential or an applied gate voltage detailed, conclusions are drawn. Of special importance are: (i) the bulk Fermi energy and hence the flat band voltage depend strongly on the distribution, (ii) for broader distributions the accumulation layer becomes thinner, (iii) this can lead to an apparent contribution to a surface dipole, (iv) the total areal charge, which determines the FET current, is almost the same as that one of a delta shaped distribution if the flat band voltage shift is considered appropriately.

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Transport properties of ultra thin thiophene based thin film transistors — ●T. MUCK and V. WAGNER — School of Engineering and Science, International University Bremen, Campus Ring 8, D-28759 Bremen, Germany

The aim of this study was to determine the properties of thin organic layers within a field-effect transistor geometry. Transport properties of standard OFETs are known to be crucially influenced by the first monolayer (ML). Deposition of the active material was performed by organic

molecular beam deposition in ultra high vacuum. As organic semiconductor various thiophene derivatives, e.g. dihexylquaterthiophene (DH4T) were analyzed. These DH4T films were prepared at elevated temperatures (90 °C) to achieve a growth in the smectic phase of DH4T. Electrical measurements were performed on these growing liquid crystal films. By characterizing the organic transistors at different film thicknesses in the monolayer range we observe a step-like behavior of the charge mobility. Charge transport starts at approx. 0.6 ML and the field-effect mobility shows a quadratic increase for increasing coverage due to percolation of DH4T monolayers. Saturation is observed while completing the first ML. We interpret this behavior with the growth mode of DH4T analyzed by AFM imaging and compare this with Monte-Carlo simulations. The deposition of the second monolayer influences the mobility first by worsening due to non-percolated islands and a subsequent improvement while closing the second monolayer. Additional monolayers do not increase the performance. These data allow the determination of the transport layer thickness, which is given mainly by the first two monolayers.

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Electronic Properties of a Metal/Organic/GaAs Heterostructure — ●HENRY MÉNDEZ, ILJA THURZO, MIHAELA GORGOI, CRISTIAN IACOVITA, GIANINA GAVRILA, and DIETRICH R.T. ZAHN — Institut für Physik, Reichenheiner Str.70 D-09107 Chemnitz, Germany

Devices based on a metal/organic/GaAs heterostructure were prepared under UHV conditions and their electrical properties studied *in situ*. Hydrogen plasma treated GaAs(100) (H⁺GaAs) and the perylene derivative dimethyl-3,4,9,10-perylenetetracarboxylic diimide (DiMe-PTCDI) were used as inorganic substrate and organic material, respectively. Silver contacts were then deposited through a shadow mask. The electronic transport properties were investigated by UPS, IV, CV and QTS techniques. A barrier height of (0.83 ± 0.05) eV for the reference Ag/H⁺GaAs diode was deduced from IV characteristics. Organic modification of the reference diode with DiMe-PTCDI leads to a decrease in the effective barrier height with increasing thickness of the molecular film. The electrical measurements show that at the interface LUMO of DiMe-PTCDI lies below the CBM of GaAs(100). This is confirmed by IPES measurements on a DiMe-PTCDI layer deposited on H⁺GaAs. The transport mechanism through the device is discussed considering the Fermi level alignment at the organic/inorganic interface and the role of interfacial and bulk trap levels. All the information is taken into account when simulating IV characteristics of the organic modified device.

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Optimisation of contacts for downscaling of organic thin-film transistors — ●M. LEUFGEN¹, U. BASS¹, M. MICHELFERT¹, T. BORZENKO¹, G. SCHMIDT¹, J. GEURTS¹, L. W. MOLENKAMP¹, and P. MACKIE² — ¹Universität Würzburg, Physikalisches Institut (EPIII), Am Hubland, D-97074 Würzburg, Germany — ²Avecia Ltd., PO Box 42, Hexagon House, Blackley, Manchester M9 8SZ, UK

When downscaling the channel length of organic thin-film transistors (OTFTs), the conductance is increasingly governed by the electrical contact resistance. We verified this behaviour for DH4T-based bottom-contact OTFTs with different contact metals (Au/Ti, Pd). The electrical behaviour of the Au contacts was hampered by the Ti adhesion layer, while the Pd contacts, although electrically superior, suffered from insufficient mechanical stability.

We report two alternative strategies to overcome these drawbacks: (i) For Au/Ti, we developed a two-layer resist technique for UV lithography. The resulting undercut guarantees smooth and homogeneous metal contact edges, confirmed by SEM, and an improved Au/DH4T-contact. (ii) Sputtered Pt contacts have the necessary adhesion on SiO₂ and a good contact to the organic layer. In this context we optimised an e-beam lithography process, resulting in an undercut in the resist combined with a sub-100 nm resolution for large area structures (channel width of several 100 μm). Operating devices were fabricated both by vacuum deposition of DH4T and by spin cast deposition of diluted semiconducting polymers.

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Structural properties of thin P3HT/PCBM-films for organic solar cells — •TOBIAS ERB¹, ULADZIMIR ZHOKHAVETS¹, GERHARD GOBSCH¹, SOFIYA RALEVA², BERND STÜHN², PAVEL SCHILINSKY³, CHRISTOPH WALDAUF³, and CHRISTOPH BRABEC³ — ¹Institute of Physics, Ilmenau Technical University, 98684 Ilmenau, Germany — ²Institute of Solid Physics, Darmstadt Technical University, 64289 Darmstadt, Germany — ³Konarka Technologies GmbH, Paul-Gossen-Str. 100, 91052 Erlangen, Germany

We have investigated thin P3HT/PCBM - (poly[3-hexylthiophene 2,5-diyl]/[6,6]-phenyl C61 butyric acid methyl ester) films, which are widely used as an active layer in plastic solar cells. Their structural properties were studied by X-ray diffraction in grazing incidence geometry. The size and the orientation of crystalline P3HT-nanodomains within the films were determined. Contrarily, PCBM crystallites were not detected in thin films. Upon annealing, the P3HT-crystallinity is increased, whereas PCBM crystallites were not found.

With these results the raise of the optical absorption and spectral photocurrent in low photon energy region can be explained. In addition, the efficiency of P3HT/PCBM solar cells is also significantly increased upon annealing.

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Ultrafast transient absorption spectroscopy of perylene derivatives — •E. ENGEL¹, K. SCHMIDT², D. BELJONNE², J.-L. BRÉDAS², K. LEO¹, and M. HOFFMANN¹ — ¹Institut für Angewandte Photophysik, TU Dresden, 01062 Dresden, Germany, www.iapp.de — ²School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332-0400, USA

The perylene derivatives N,N'-dimethylperylene-3,4,9,10-dicarboximide (MePTCDI) and 3,4,9,10-perylene-tetracarboxylic dianhydride (PTCDA) are paradigmatic and widely investigated organic semiconductors. Quantitative statements about excitonic relaxation processes require a thorough understanding of the optical transitions involved in time-resolved experiments.

We investigated matrix (SiO₂) isolated molecules and thin films of MePTCDI and PTCDA by means of ultrafast pump-probe spectroscopy. A broad femtosecond white-light continuum was used to record high resolution transient absorption spectra between 1.2 eV and 2.7 eV above the lowest excited state energy. Excited state contributions below the onset of linear absorption exhibit two pronounced peaks. The observed peaks in the monomer (around 1.85 eV and 1.3 eV, respectively) can be clearly correlated to numerical spectra obtained by a highly correlated quantum chemical MRD-CI calculation technique.

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COMPARATIVE ELECTROABSORPTION STUDIES ON ORGANIC SEMICONDUCTOR DEVICES WITH VARIOUS INTERFACIAL LAYERS — •CHRISTOPH LUNGENSCHMIED¹, MARKUS SCHARBER², HELMUT NEUGEBAUER¹, and SERDAR SARICIFTCI¹ — ¹Linz Institute for Organic Solar Cells (LIOS), Johannes Kepler University Linz, Altenbergerstr. 69, 4040 Linz, Austria — ²Konarka Austria, Gruberstr. 40-42, 4020 Linz, Austria

Electroabsorption spectroscopy in reflection geometry was used to probe the electric field induced changes in the transmission of thin organic semiconducting films sandwiched between asymmetric contacts. The photoactive layer of the investigated devices consisted of a soluble polyphenylene vinylene derivative, namely MDMO-PPV, spin cast on ITO coated glass substrates and covered with an Al layer as top electrode. The change in the transmission (ΔT) due to the Stark effect was monitored using a modulation technique at various applied DC voltages (VDC). It is observed, that $|\Delta T|$ goes to zero at positive VDC (ITO is +), indicating that the internal electric field is cancelled by the externally applied field.

This VDC was found to change by introducing interfacial layers. When using the same device setups in photovoltaic studies the maximum open circuit voltage (VOC) qualitatively follows the same trend. A possible correlation of the internal electric field with photovoltaic device param-

eters will be described.

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Fullerene/Silicon Hybrid Heterojunction diodes — •G. J. MATT¹, T. FROMHERZ², and N.S. SARICIFTCI¹ — ¹Linz Institute for Organic Solar Cells (LIOS), Johannes Kepler University Linz, Austria — ²Institute for Semiconductor and Solid State Physics, Johannes Kepler University, Austria

Fullerene based diodes on p-Si substrates are presented. Rectification up to 10⁵ at $\pm 1V$ is observed with broad spectral resolved photo-current in UV-Vis. Device parameter as the ideality factor and the nature of the electronic structure at the Fullerene/Silicon heterojunction are discussed.