

HL 8: Organic Electronics and Photovoltaics I (Joint Session with DS/CPP/O)

Time: Monday 10:15–12:30

Location: H8

HL 8.1 Mon 10:15 H8

Colour tuneable light-emitting transistor — ●EVA J. FELDMEIER, CHRISTIAN MELZER, and HEINZ VON SEGGERN — Electronic Materials Department, Institute of Materials Science Technische Universität Darmstadt, Petersenstraße 23, 64287 Darmstadt, Germany

In recent years the interest in ambipolar organic light-emitting field-effect transistors has increased steadily as the devices combine switching behaviour of transistors with light emission. Usually, small molecules and polymers with a band gap in the visible spectral range serve as semiconducting materials. Mandatory remain balanced injection and transport properties for both charge carrier types to provide full control of the spatial position of the recombination zone of electrons and holes in the transistor channel via the applied voltages. As will be presented here, the spatial control of the recombination zone opens new possibilities towards light-emitting devices with colour tuneable emission.

In our contribution an organic light-emitting field-effect transistors is presented whose emission colour can be changed by the applied voltages. The organic top-contact field-effect transistor is based on a parallel layer stack of acenes serving as organic transport and emission layers. The transistor displays ambipolar characteristics with a narrow recombination zone within the transistor channel. During operation the recombination zone can be moved by a proper change in the drain and gate bias from one organic semiconductor layer to another one inducing a change in the emission colour. In the presented example the emission maxima can be switched from 530 nm to 580 nm.

HL 8.2 Mon 10:30 H8

Improved transport properties of p-i-i small molecule solar cells deposited on heated substrates — ●STEFFEN PFUETZNER, KARL LEO, and MORITZ RIEDE — Institut für Angewandte Photophysik, Technische Universität Dresden

To achieve higher efficiencies in organic solar cells, ideally the open circuit voltage (V_{OC}), fill factor (FF) as well as the short current density (j_{SC}) have to be improved further. However, in bulk heterojunction (BHJ) solar cells j_{SC} and the FF are typically limited by charge carrier recombination due to transport problems (e.g. low mobility, dead ends) in the BHJ. A suitable way to modify the BHJ layer morphology and to improve solar cell parameters is substrate heating during bulk layer deposition. Furthermore, j_{SC} can be enhanced by replacing C_{60} by C_{70} . We show that substrate heating at 90°C leads to improved FF and j_{SC} for a C_{60} and ZnPc containing BHJ solar cell with the following stack structure: ITO/p-Di-NPD/ C_{60} :ZnPc/ C_{60} /BPhen/Al. However, in case of similar C_{70} :ZnPc solar cells, no significant improvements are observed. Using SEM we show that the preferential aggregation by heating is completely suppressed by the p-doped underlayer Di-NPD. To force aggregation of the heated C_{70} :ZnPc bulk, 5 nm intrinsic ZnPc layer is deposited on the p-Di-NPD layer and verified by SEM. J-V characteristics show a drop in FF and V_{oc} with the additional interlayer ZnPc. To overcome this problem probably caused by transport barriers to the neighboring layers, experiments with doped ZnPc are carried out.

HL 8.3 Mon 10:45 H8

Analysis of Chemical Degradation Mechanism of Phosphorescent Organic Light Emitting Devices by Laser-Desorption/Ionization Time-of-Flight Mass Spectrometry — ●INES RABELO DE MORAES, SEBASTIAN SCHOLZ, BJÖRN LÜSSEM, and KARL LEO — Institut für Angewandte Photophysik, Technische Universität Dresden, George-Bähr-Str. 1, 01062 Dresden, Germany

Phosphorescent Organic Light Emitting diodes (OLEDs) have attracted much interest for their potential application in full color flat-panel displays and as an alternative lighting source. However, low efficiency, and the short operation lifetime, in particular in the case of blue emitting devices, are the major limitations for the current OLEDs commercialization. In order to overcome these limitations, a deep knowledge about the aging and the degradation mechanism is required [1]. Our work focuses on the chemical degradation mechanism of different iridium based emitter materials like FIrpic (light blue) and Ir(ppy)₃ (green), commonly used in OLEDs. For this purpose, the devices were aged by electrical driving until the luminance reached

6% of the initial luminance. The laser-desorption/ionization time-of-flight mass spectrometry was used to determine specific degradation pathways.

[1] Hany Aziz, and Zoran D. Popovic, Chem. Mater. 16, 4522 (2004).

HL 8.4 Mon 11:00 H8

Spatially resolved, polarization dependent absorption and photocurrent measurements of pentacene based OFETs — ●CHRISTIAN WESTERMEIER, MATTHIAS FIEBIG, and BERT NICKEL — Department für Physik and CeNS, Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, 80539 München

Pentacene is a promising candidate for organic electronics and optoelectronic applications due to its high charge carrier mobility and strong absorption properties. Forming a triclinic herringbone structure, its optical properties are highly anisotropic [1]. Pentacene films show a thin-film-phase texture. The grains inducing the texture should absorb linear polarised light depending on their orientation with respect to the direction of polarisation.

Here we use local illumination of the transistor channel in a confocal laser scanning setup with a spatial resolution in the submicron regime [2]. The pentacene grains in the channel of our OFETs exhibit a size of a few microns in diameter. The absorption of separate grains is found to be strongly dependent on the polarisation of the incident light, as expected. Thus, the scanning technique allows for imaging of grain orientation with a submicron resolution over large areas.

Absorption being the initialising step to generate excitons is important for optoelectronic devices like solar cells and the photoresponse of transistors. The influence of polarisation on the spatially resolved photocurrent of pentacene OFETs will be discussed.

[1] M. Dressel, et al., Opt. Express 16, 19770-19778 (2008)

[2] M. Fiebig, et al., Appl. Phys. A 95, 1, 113-117 (2009)

HL 8.5 Mon 11:15 H8

In-situ Analysis of Charge Carrier Mobility in Field Effect Transistors During Organic Semiconductor Deposition — ●CHRISTOPHER KEIL, DOMINIK KLAUS, JAN HARTEL, and DERCK SCHLETTWEIN — Institute of Applied Physics, Justus-Liebig-University Giessen, Germany. email:schlettwein@uni-giessen.de

Films of $F_{16}PcCu$ prepared by physical vapour deposition under high vacuum conditions were characterized in situ during the growth from the monolayer range up to about 100 nm. The charge carrier mobility in the linear and saturation region as well as the threshold voltage were investigated in real time at deliberate film thickness by help of a real time analysis software routine. The organic films were deposited on thermally grown silicon oxide which also acts as gate dielectric. The underlying Si wafer served as a bottom gate electrode and structured inter-digital metal source-drain contacts were prepared by photolithography. Different channel lengths and widths as well as different metal contacts were used to determine the influence of semiconductor/metal contacts on the characteristics of the field effect transistors.

HL 8.6 Mon 11:30 H8

Investigation of contact properties of organic field effect transistors — ●M. GROBOSCH¹, I. HÖRSELMANN², 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 P3HT were characterized by combined X-ray and ultra violet photoemission spectroscopy (XPS, UPS) and electrical measurements of the OFET whereas the sample preparation for the different measuring principles has been realized in parallel differing in the layer thickness of the polymer. By means of UPS a reduced work function could be demonstrated for different prepared, sputtered, and as-received Au contacts in agreement with previous publications. Furthermore the chemistry and the electronic structure of the interfaces between Au metal deposited onto thin films of solution prepared modified P3HT on sputtered Au contacts have been studied. From the observed well defined molecular orbitals we have found an interface dipole of +1.5 eV and a hole injection barrier of about 0.6 eV. However, one cannot expect such a high barrier from the measured characteristics of

the OFET because the currents are not contact limited. Clarifying the reason for such a discrepancy we have carried out two-dimensional simulations. These results confirm clearly for a barrier of 0.6 eV strongly reduced drain currents would be measured. The difference in the layer thickness can be the reason for the measured difference but further investigations are necessary to explain more in detail this phenomenon.

HL 8.7 Mon 11:45 H8

Improving the mobility of the CuPc OFETs by varying the substrate preparation — •IULIA G. KORODI¹, DANIEL LEHMANN¹, MICHAEL HIETSCHOLD², and DIETRICH R. T. ZAHN¹ — ¹Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — ²Solid Surfaces Analysis Group, Chemnitz University of Technology, D-09107 Chemnitz, Germany

Top-contact organic field-effect transistors (OFETs) using Copper Phthalocyanine (CuPc) as active layer were produced under high vacuum conditions ($p \leq 5 \times 10^{-7}$ mbar). 20 nm thick organic films were deposited by Organic Molecular Beam Deposition on highly p-doped Si(100) substrates with 100 nm SiO₂ as the gate dielectric. Source and drain electrodes of gold were deposited through a shadow mask on top of the organic layer with the substrate cooled by liquid nitrogen.

The performance of the OFETs was tested in vacuum as well as in atmosphere. The highest mobility of CuPc OFETs was found to be $\mu_{vacuum} = (1.5 \pm 0.6) 10^{-3} \text{ cm}^2/\text{Vs}$. When the substrate was modified by applying an elevated temperature (130 °C) during deposition of the CuPc film the mobility of the OFETs increased by a factor of ≈ 6 . The threshold voltage was also improved from a value of $V_{Th} = -(15.0 \pm 0.3) \text{ V}$ to $V_{Th} = -(9.6 \pm 1.4) \text{ V}$ for deposition at room and elevated substrate temperatures, respectively. A similar effect on the electrical characteristics was found after modifying the gate dielectric with a self-assembled monolayer of n-octadecyltrichlorosilane. The improved OFET performance with the variation of the substrate conditions will be discussed.

HL 8.8 Mon 12:00 H8

Electrical characterization of operating OFETs using Kelvin Probe Force Microscopy — •FRANZISKA LÜTTICH, HARALD GRAAF, IULIA G. KORODI, DANIEL LEHMANN, DIETRICH R. T. ZAHN, and CHRISTIAN VON BORCZYKOWSKI — Center for nanostructured Materials and Analytics, Chemnitz University of Technology, Germany
We present recent results on n-type organic field effect transistors

(OFETs) using Atomic Force Microscopy (AFM) and Kelvin Probe Force Microscopy (KPFM). These studies allow the local potential in the channel of OFETs during operation to be determined. The transistor structures investigated differ in gate insulator treatment and substrate temperature during evaporation of the organic material.

All investigated top-contact OFETs were fabricated under high-vacuum conditions ($p < 4 \cdot 10^{-7}$ mbar) by evaporating PDI8-CN₂ on top of a p-doped silicon substrate covered by a SiO₂ layer. Gold-electrodes were evaporated through a shadow mask on top of the organic layer. The gate insulator modification was implemented prior to the substrate transfer into the vacuum chamber. For this purpose monolayers of N-octadecyltrichlorosilane (OTS) resulting in hydrophobic surfaces were employed. In the case of deposition at elevated temperature the substrate was kept at 130 °C.

These variations of preparation influence the structural and electronic properties of the OFET and result in changes of the charge carrier mobility. The effects observed indicate tuning possibilities for organic devices leading to increased charge carrier mobility.

HL 8.9 Mon 12:15 H8

Experimental study and time dependent modeling of OFETs with solid electrolyte gate dielectrics — •KATHARINA SCHÄTZLER¹, KLAUS SCHMIDT¹, WALTER FIX¹, GOTTFRIED DÖHLER¹, and HEIKO WEBER² — ¹PolyIC GmbH & Co. KG, Fürth — ²Lehrstuhl für Angewandte Physik, Friedrich-Alexander-Universität, Erlangen

We successfully investigated and simulated organic field effect transistors (OFETs) with a solid organic insulator containing ionic salt. It is already well known that electrolytes as gate dielectrics in OFETs offer low operating voltages by means of a high capacitance. Hence, the charge carrier density is increased in the channel region of the semiconductor. However, the drain-source current I_{ds} shows a strong time dependency because of the limited mobility of the ions. Consequently we developed a time dependent model for the spatial distribution of the ionic current within the insulator matrix. The ionic current of both cations and anions splits in a diffusion and a drift process. The model very precisely reproduces the time as well as the ion concentration dependency of I_{ds} . Parameters like ion and semiconductor mobility are extracted and are in good agreement with parameters extracted from experimental OFET and capacitance characteristics.