HL 52: Organic semiconductors II

Time: Friday 10:15–12:30 Location: POT 51

HL 52.1 Fri 10:15 POT 51

Influence of electrical stress on hole transport in Poly(p-phenylenevinylene) — •Katja Stegmaier, Arne Fleissner, Christian Melzer, and Heinz von Seggern — Electronic Materials Department, Institute of Materials Science, TU Darmstadt, Petersenstraße 23, 64287 Darmstadt, Germany

One of the most prominent class of materials used as organic luminescent layer in large-area applications are derivatives of Poly(p-phenylenevinylene) (PPV). Organic light-emitting diodes (OLEDs) comprising such a polymeric semiconductor still disclose a degradation of the device performance under device operation limiting its applicability. Up to now, the processes taking place during this electrical fatigue are not fully understood. Different approaches to explain the increase of impedance and the loss of luminescence have been proposed.

For the first time the influence of electrical fatigue on the hole transport properties of different derivatives of PPV is investigated on bipolar PPV-based test structures similar to real OLED devices by the optical time-of-flight (TOF) technique. The utilized PPV layer thicknesses are in the order of microns and therewith considerably thicker than those of conventional OLEDs. TOF measurements on these structures before and after electrical treatment reveal a pronounced difference in hole transport. Due to electrical stressing under constant current hole transport becomes dispersive and hole mobility is reduced. The method of thermally stimulated currents (TSC) is employed to determine the trap structure in order to clarify the reasons for the variation in hole transport of the electrically fatigued OLEDs.

HL 52.2 Fri 10:30 POT 51

Growth and Morphology of Three Dimensional Rubrene Single Crystals — •Mira El Helou[1,2], Olaf Medenbach[3], and Gregor Witte[1,2] — [1]Molekulare Festkörperphysik, Philipps-Universität Marburg, Germany — [2]Physikalische Chemie I, Ruhr-Universität Bochum, Ger — [3]Institut für Geologie, Mineralogie und Geophysik, Ruhr-Universität Bochum, Germany

In the fast growing field of organic electronics, organic field effect transistors (OFETs) have become a focus of intense research due to their promising potential in flexible electronics, low-cost devices and large-area applications. Among organic semiconductors the highest room temperature charge carrier mobility has been reported for rubrene crystals (Sundar et al. 2004). So far essentially crystalline platelets of a few microns thickness and (001) orientation were grown (de Boer et al. 2004) while the growth of thicker single crystals became a challenge, due to the conformational change from gas into bulk phase but can be overcome by employing hot wall type deposition (Käfer et al. 2005). Here we report a detailed morphological characterization of bulk crystallites with lateral dimensions of up to 150*m. By using SEM and AFM the equilibrium structure and the topography including the step height of the differently oriented surfaces have been analyzed in detail. The availability of such oriented crystallites allows in particular a precise characterization of optoelectronic properties along different crystallographic directions. As a stating point the refractive indices of the three main crystallographic directions a, b and c at wavelength of 589 nm have been determined.

HL 52.3 Fri 10:45 POT 51

Electroluminescence from Single Molecules — •Maximilian Nothaft[1], Aurélien Nicolet[1], Fedor Jelezko[1], Jens Pflaum[2], and Jörg Wrachtrup[1] — [1]3. Phys. Inst., Univ. Stuttgart, D-70550 Stuttgart — [2]Exp. Phys. VI, Univ. Wuerzburg and ZAE Bayern, D-97074 Wuerzburg

Doping of organic host matrices by guest molecules is widely applied in organic light emitting devices to improve their efficiency. Especially in single molecule spectroscopy the individual guest molecules serve as a tool to investigate single quantum emitters for possible application in quantum cryptography.

In our contribution we discuss light emission properties of individual Dibenzoterrylene (DBT) dye molecules inserted into an Anthracene (AC) host crystal at relative concentrations in the order of 10^{-8} mol/mol driven by optical and electronic stimulation.

It will be shown that this system offers key requirements to observe electrically excited single molecules at room temperature such as the possibility to obtain balanced current densities of up to 100mA/cm^2 and single photon emission from the dye (DBT) using laser excitation of 710nm.

The electroluminescence signal was investigated using confocal microscopy and will be compared to images obtained using laser excitation. The detected light was spectrally resolved showing distinct emission peaks of the host and the dye. To quantify the respective emission behavior, photon correlation measurements under optical as well as electrical excitation will be presented.

HL 52.4 Fri 11:00 POT 51

The influence of field- and density- dependent mobility and contact properties on OFETs — •Susanne Scheinert[1] and Gernot Paasch[2] — [1]TU Ilmenau, Germany — [2]IFW Dresden, Germany

The current characteristics of organic field-effect transistors (OFET) show often a disadvantageous non-linearity at low drain voltages. We have already proved (J. Appl. Phys. 102, 054509 (2007)) that in top contact OFETs this effect can be caused by trap recharging, if the contacts are of Schottky type. For bottom contact OFETs, in spite of controversial discussions, the effect is repeatedly attributed to Schottky contacts. We show that such non-linearity does occur in bottom contact OFETs only in the special case with a Schottky contact with large ideality factor as drain and an Ohmic contact at source. However, if the dependence of the mobility on carrier concentration and field is taken into account, Schottky contacts at both source and drain can cause the non-linearity. The effect has been investigated by numerical 2D-simulations incorporating for the mobility the field dependent Pool/Frenkel model and two models, which in addition depend on the carrier concentration, the Limketai model and the Pasveer/Coehoorn model. Analysis of the simulated profiles of concentrations and fields allows us to clarify the mechanism causing the non-linearity, which is particularly effective for the Pasveer/Coehoorn model. Based on the achieved understanding of the mechanism, we discuss strategies to prevent the non-linearity.

15 min. break

HL 52.5 Fri 11:30 POT 51

Ambipolar organic/inorganic field effect transistor — •Maria S Hammer[1], Daniel Rauh[2], Carsten Deibel[1], and Vladimir Dyakonov[1,2] — [1]Julius-Maximilians-University of Würzburg, Institute of Physics, Experimental Physics VI, D-97074 Würzburg — [2]Bavarian Centre for Applied Energy Research e.V. (ZAE Bayern), D-97074 Würzburg

In order to attain flexible electronic devices, the fabrication of complementary metal-oxide-semiconductor inverters based on soluble semiconductors offers an attractive potential for realizing printable logic circuits. One approach is an organic/inorganic bulk heterojunction system. Using an inorganic material offers the possibility of setting up its transport properties namely mobility, conductivity and charge carrier density via doping and adjusting it to an optimum for the combined performance with the organic material. Therefore we chose aluminium doped zinc oxide nanoparticles as the *n*-type and rr-poly(3-hexylthiophene) (P3HT) as the *p*-type component. Our field effect transistor measurements on the pristine and blended materials allow the determination of charge carrier mobility in dependence of the accumulated charge carrier densities and temperature. We survey the properties of the transport in disordered systems, organic and inorganic, with respect to the morphology of the film. We show that by doping zinc oxide nanoparticles it is possible to adjust a balanced electron and hole transport in the hybrid material which is indispensable for the performance of an ambipolar transistor.

HL 52.6 Fri 11:45 POT 51

Prediction of Dynamical Properties of Organic Field-Effect Transistors from DC Transistor Parameters — •Benedikt Gburek and Veit Wagner — Jacobs University Bremen, School of Engineering and Science, Campus Ring 1, 28759 Bremen, Germany

Dynamical properties of Organic Field-Effect Transistors (OFETs) are of crucial importance for almost any application. However, not direct AC data but DC measurements are usually used to optimize transistor performance. Here we present a systematic study to which extent DC parameters can actually be used to predict AC performance and AC

limits of transistors. The standard FET theory for long channel devices predicts a maximum device bandwidth of $\omega_B = \mu$ V / L^2. However, this holds only for ideal situations, e.g. without parasitic capacitances, and not too high frequencies. Furthermore, as was recently shown [1], contact resistances can pose severe additional high-frequency limits to the AC performance. To check the AC limit of a given transistor directly we perform a frequency scan up to the frequency where the gate current equals the drain current, which defines the true bandwidth of the device. The frequency-scanned AC voltage is applied at the gate while the drain contact is kept at a constant voltage. A model which defines a correction factor to the ideal μ V / L^2 behaviour is proposed in order to predict the measured bandwidth from DC transistor parameters correctly. The model takes into account contact resistances and parasitic capacitances among others.

[1] V. Wagner, P. Wöbkenberg, A. Hoppe, J. Seekamp, Appl. Phys. Lett. 89 (2006) 243515

HL 52.7 Fri 12:00 POT 51

Trapped-space-charge-limited currents: Evaluating analytical approximations by simulation — •Gernot Paasch[1] and Susanne Scheinert[2] — [1]IFW Dresden, Germany — [2]TU Ilmenau, Germany

The well-known analytical approximations for trapped-space-charge-limited currents are widely used in analyzing organic diodes. However, within these approximations, it is not possible to check the validity of the assumptions made in the derivation of the approximations. Besides the neglect of the diffusion current, this concerns especially the relations of the contact work function and of the layer thickness with the doping of the organic semiconductor, the position of the center of the trap distribution and its maximum value, and in the case of a Gaussian trap distribution the approximation for the density of the trapped charge. We present results of full numerical simulations (drift-diffusion model) for a wide range of parameter variation together with the application of the analytical approximations to fit the simulations. From this comparison one can set limits for the parameter ranges in which the approximations can be applied. This is important since other effects can also lead to similar power laws of the current voltage characteristics. In addition, further analytical approximations will be discussed for different combinations of trap distributions and distributions of hopping transport states.

HL 52.8 Fri 12:15 POT 51

Unified Theory of Charge Transport in Wide-Band and Narrow-Band Semiconductors — •Frank Ortmann, Friedhelm Bechstedt, and Karsten Hannewald — IFTO & ETSF, Friedrich-Schiller-Universität Jena, Jena, Germany

The charge carrier mobility is often calculated within one of the two limiting cases: wide bands or narrow bands. In the case of wide-band systems, usually pure band transport is assumed along with a calculated relaxation time. In contrast, for narrow-band materials, hopping is usually considered prevalent and the interaction with lattice vibrations is described within the polaron concept. In this talk, we will present a unified approach to the description of charge transport based upon the Kubo formalism applied to a Holstein Hamiltonian. As a result, we obtain an analytical formula for the temperature dependence and anisotropy of the mobility describing a seamless transition from band transport at low temperatures to hopping transport at high temperatures. The results are illustrated for naphthalene crystals and a comparison to previous approaches [1,2] is made. [1] V.M. Kenkre, Phys. Lett. A 305, 443 (2002) [2] K. Hannewald and P.A. Bobbert, Phys. Rev. B 69, 075212 (2004)