SYSA 3: Organic Devices I

Time: Tuesday 14:30–16:15 Location: H 2013

Invited Talk SYSA 3.1 Tue 14:30 H 2013

Charge transport and contact effects in organic semiconductors — •Alberto Salleo[1], Leslie Jimison[1], Jonathan Rivnay[1], Ludwig Goris[1], and Michael Toney[2] — [1]Materials Science Department, Stanford University, Stanford CA 94305 — [2]Stanford Synchrotron Radiation Laboratory, Menlo Park CA

The long-standing promise of organic electronics, i.e. the ability to design molecular materials at will, is complicated by the fact that one needs to predict the microstructure of the semiconductor from the molecular structure. Thus, in order to truly design novel semiconductors, one must understand how microstructure and transport are related. In polymeric semicrystalline semiconductors, mobility is well described by a multiple trapping and release model. The beneficial effect of annealing in poly(thiophenes) for instance can be understood as a tightening of the trap energy distribution. Regio-regularity on the other hand does not affect crystalline texture (i.e. intergrain coupling) or tail state distributions but only the crystalline mobility. Finally, the microstructure of the polymeric semiconductor plays a role in other device non-idealities. For instance, we will show that tailoring the microstructure of the polymer allows to eliminate a well-known non-ideality of short-channel TFTs (L<10 um) due to ambipolar injection at the drain contact.

SYSA 3.2 Tue 15:00 H 2013

Integrated circuits based on low cost polymer electronics — •Klaus Schmidt, Andreas Ullmann, Markus Böhm, Jürgen Krumm, Robert Blache, Alexander Knobloch, Dietmar Zipperer, and Walter Fix — PolyIC GmbH & Co. KG, Fürth, Germany

It is expected that low-cost organic electronics will open a new mass market besides the already existing market for conventional and more expensive Si-based technology. We have fabricated different multi-bit RFID-Transponder based on polymer electronics. Polymer rectifiers working at 13.56 MHz and fast integrated organic circuits up to 0.6 MHz are demonstrated. A 64-bit transponder operating at a supply voltage of about 14V was realized based on poly-(3-hexylthiophene) as p-type semiconductor material with charge carrier mobility of about 0.02 cm2/Vs. The polymeric devices are very stable and exhibit high electrical performance and lifetime. Since the polymeric materials used for our devices are all soluble, it is possible to fabricate our electronic circuits by a cost efficient roll to roll printing process. Thus, completely high speed printed and low cost polymer electronics can be realized.

SYSA 3.3 Tue 15:15 H 2013

Peculiarities of OFET performance due to hopping transport near the gate insulator interface — •Susanne Scheinert[1] and Gernot Paasch[2] — [1]TU Ilmenau — [2]IFW Dresden

The operation of thin film field-effect transistors is determined by the channel at the interface to the gate oxide. There the carrier concentration can be changed from depletion to accumulation and the electric field increases from source to drain. For variable range hopping in disordered organic semiconductors as the active layer, the mobility depends on both the carrier concentration and the field. Our numerical simulation study shows that besides the known dependency of the field-effect mobility on the gate voltage there occur in addition (i) a strong modification of the saturation current, (ii) a shift of the threshold voltage, and (iii) an increase of the inverse threshold slope. In addition, (iv) the influence of the dependency on the mobility is critically determined by the transistor channel length. The origin of all these peculiarities is clarified by analyzing the internal profiles of concentrations and fields. Conclusions are drawn on the possibilities of parameter extraction from measured current characteristics.

SYSA 3.4 Tue 15:30 H 2013

High resolution mapping of the electrostatic potential in organic thin film transistors by phase electrostatic force microscopy — •Paolo Annibale, Cristiano Albonetti, Pablo Stoliar, and Fabio Biscarini — CNR-Institute for the Study of Nanostructured Materials (ISMN), Bologna, Italy

We investigate by a scanning probe technique termed phase-electrostatic force microscopy the local electrostatic potential and its correlation to the morphology of the organic semiconductor layer in operating ultra-thin film pentacene field effect transistors.

In order to address experimentally the role of defects in the device performance it is necessary to map the local electrostatic potential in the semiconductor layer with a resolution comparable with that of the morphological features associated to them.

This technique yields a lateral resolution of about 60 nm, allowing us to visualize that the voltage drop across the transistor channel is step-wise. Spatially localized voltage drops, adding up to about $\frac{3}{4}$ of the potential difference between source and drain, are clearly correlated to the morphological domain boundaries in the pentacene film.

This strongly supports and gives a direct evidence that in pentacene ultra-thin film transistors charge transport inside the channel is ultimately governed by domain boundaries.

SYSA 3.5 Tue 15:45 H 2013

Observation of charge injection and trapping in depleted channels of organic field effect transistors — •Christopher Siol, Christian Melzer, and Heinz von Seggern — Electronic Materials Division, Institute of Materials Science, Technische Universität Darmstadt, Petersenstr. 23, 64287 Darmstadt, Germany

The measurement of I-V characteristics is the standard means of transistor investigation. However, it gives limited information about the electronic processes that determine the transistor operation. Kelvin probe force microscopy (KPFM), however, gives the opportunity to resolve the surface potential locally. This allows one to separate the injection phenomena from the charge transport in the channel.

Here the surface potential in the channel of n- and p-type pentacene OFETs with poly(methyl methacrylate) dielectrics has been measured during operation. In the on state the conducting accumulation layer links surface potential of the channels to the contact electrodes. However, driving the device into the off state causes depletion of the channel from mobile charge carriers. Then, the surface potential depends on the gate potential but might be altered due to the presence of trapped charges in the channel. Depending on the device history, such trapped charges are observed. Additionally, by applying high gate fields to the already depleted transistor an injection of complementary charge carriers has been observed even for high injection barriers.

SYSA 3.6 Tue 16:00 H 2013

Influence of gap states on the electrical stability of pentacene Thin Film Transistors — •Amare Benor, Arne Hoppe, Veit Wagner, Rahul Dewan, and Dietmar Knipp — Jacobs University Bremen, School of Engineering and Science, 28759 Bremen, Germany

Despite the realization of polycrystalline pentacene transistors with high mobility, the creation of gap states and the influence of gap states on the charge transport and the device stability is still under investigation. In order to study the creation of electronic defects and the influence of these defects on the device stability electrical in-situ measurements of pentacene TFTs were carried out. The TFTs were prepared by Organic Molecular Beam Deposition with hole mobilities ranging from $0.2-0.5cm^2/Vs$. The devices were exposed to oxygen to study the influence on the device characteristics. Unexposed devices are stable, whereas devices exposed to dry oxygen exhibit a shift of the threshold voltage upon prolonged device operation. Stressing the transistor in the on-state (negative bias) leads to a shift of the threshold voltage towards negative gate voltages, whereas prolonged bias stress in the off-state causes a shift of the threshold voltage in the opposite direction. The gap states are formed 0.18 eV (acceptor-like states) and 0.62 eV (donor-like states) above the valence band maxima. The shift of the threshold voltage due to bias stress is determined by the ratio of acceptor-like and donor-like states in the pentacene film. The charge carrier mobility and the on/off ratio of the transistor are not affected by the gap states. A simple density-of-states model will be presented, which allows for the explanation of the experimental results.