

DS 15: Organic semiconductors: Transistors and OLEDs (Jointly with HL, CPP)

Time: Tuesday 14:00–15:45

Location: POT 081

DS 15.1 Tue 14:00 POT 081

Solution-gated organic field effect transistors: small-molecule versus polymeric materials — ●HANNAH SCHAMONI¹, ROSSELLA PORRAZZO^{1,2}, JOSE A. GARRIDO¹, and MARIA ROSA ANTOGNAZZA² — ¹Walter Schottky Institut, Technische Universität München, Deutschland — ²Center for Nanoscience Technology (CNST) of IIT@Polimi, via Pascoli 70/3, 20133 Milano, Italy

Solution-gated organic field effect transistors (SGOFETs) are promising devices for biosensing applications featuring, amongst others, low production costs. For the organic semiconductor, two different kinds of materials are typically used, namely polymers like poly(2,5-bis(3-hexadecylthiophen-2-yl)thieno[3,2-b]thiophene) (pBTTT) and small molecules like α -sexithiophene (6T). In this work, we have investigated devices of both types regarding their performance, stability, and pH and ion sensitivity. A comparison of the two approaches is presented, taking also into account the differences in processing: While polymers can be spin-coated onto the substrate, small molecules are grown using organic molecular beam deposition. Finally, we will discuss the potential of SGOFETs as light sensors to stimulate nerve cells, which can pave the way towards the development of a new generation of retinal implants.

DS 15.2 Tue 14:15 POT 081

Light-induced switching mechanism of porphyrin-coated Si nanowire field effect transistors — ●EUNHYE BAEK¹, SEBASTIAN PREGL^{1,2}, MEHRDAD SHAYGAN³, LOTTA RÖHMILDT¹, DMITRY RYNDYK^{1,2}, LARYSA BARABAN¹, and GIANAURELIO CUNIBERTI^{1,2} —

¹Institute for Materials Science and Max Bergmann Center of Biomaterials, TU Dresden, Germany — ²Center for Advancing Electronics Dresden, TU Dresden, Germany — ³Division of IT Convergence Engineering, Pohang University of Science and Technology, Pohang, Korea

We present light-induced switching mechanism of porphyrin-coated Si nanowire field effect transistors (Si NW FETs). Si NW FETs were fabricated by bottom-up methods and show ambipolar characteristics due to thermally annealed Schottky barrier on the contact between the electrode and NW channel. Si NW FETs are functionalized by porphyrin, a key dye molecule in photosynthetic process, to have photo-sensitive operation. Porphyrin-coated devices show clear current switching under light illumination that is not shown in bare devices. Switching time and switching current ratio depend on the concentration of porphyrin. Under light irradiation, electrical properties of molecular layer are changed; increased mobile charges by photo-excitation screen electrical field from the applied bias. In addition, molecules are polarized by charge separation that build vertical field towards the NWs. The electrical charge of porphyrin layer modifies the total applied field in NW, which induces current switching according to the concentration of porphyrin.

DS 15.3 Tue 14:30 POT 081

Lithographically processed vertical organic thin-film transistors (VOTFTs) — ●ALRUN ALINE GÜNTHER¹, HANS KLEEMANN², BJÖRN LÜSSEM³, DANIEL KASEMANN¹, and KARL LEO¹ — ¹Institut für Angewandte Photophysik, TU Dresden, George-Bähr-Str. 1, 01069 Dresden Germany — ²Novalad AG, Tatzberg 49, 01307Dresden, Germany — ³Department of Physics, Kent State University, Kent, OH 44242, USA

Vertical organic transistors are a novel type of organic semiconductor devices, the first of such devices having been presented by Ma et al. in 2004[1]. The idea of this novel device concept is to overcome the limitations often faced in conventional organic thin-film transistors (OTFTs), where performance parameters (e.g. cut-off frequency or transconductance) are limited by the channel length of the OTFT. The VOTFT concept developed at IAPP[2] allows for downscaling of this channel length to the order of nanometres, while using a novel photolithography approach[3] to achieve patterning of the source electrode. In the present work, the effects of semiconductor film morphology and addition of dopant molecules are investigated for pentacene VOTFTs. It is expected that knowledge of such effects will give a more detailed insight into the fundamental functional principles of the device, as these are not yet well understood.

References [1] L. Ma et al, Appl. Phys. Lett. 85, 21 (2004) [2] H. Kleemann et al, Small, Epub ahead of print (2013) [3] H. Kleemann et

al, Org. Elec. 13, 3 (2012)

DS 15.4 Tue 14:45 POT 081

Controlling morphology of a Vertical Organic Transistor for enhanced current gain and very low operation voltages — ●FELIX KASCHURA, AXEL FISCHER, BJÖRN LÜSSEM, DANIEL KASEMANN, and KARL LEO — Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden

Vertical Organic Triodes represent a novel transistor technology enabling high current densities without the need for expensive structuring techniques. These devices require a permeable base for highly efficient operation. Therefore, we place a morphology modifying gold layer underneath the organic semiconductor, which enhances charge carrier transmission and thus the current gain. We have further studied a geometry optimization of the device structure allowing to tune the built-in field of the device. This results in an increased transmission as the built-in field at the collector actively gathers charge carriers, as well as a very low minimum operation voltage - both desirable characteristics for practical applications.

DS 15.5 Tue 15:00 POT 081

Contact Resistance Adjustment in Top-Contact Organic Field Effect Transistors by Localized Doping — ●JI-LING HOU, BJÖRN LÜSSEM, DANIEL KASEMANN, and KARL LEO — Institut für Angewandte Photophysik, Technische Universität Dresden, George-Bähr-Str. 1, 01069 Dresden, Germany

The contact resistance between metal and organic interface is a key challenge for Organic Field-Effect Transistors (OFETs) when short channel lengths are used to achieve low-cost and high-frequency. In this study, bottom-gate top-contact organic field effect transistors (OFETs) with different thickness of the p-dopant 2,2-(perfluoronaphthalene-2,6-diylidene) (F6-TCNNQ) under Au electrodes were fabricated by orthogonal photolithography to further investigate their impact on contact resistance. Extracted by the transmission line method (TLM), contact resistance was found to be significantly reduced from 50 kOhm*cm to 10 kOhm*cm by adding a 1nm thin dopant layer. Doping leads to an improved injection at low gate voltages, while the contact resistance is also reduced in the undoped reference device due to the applied field at higher gate voltages. Finally, we conducted temperature dependent I-V measurement to study the change of contact resistance at lower temperature. The result shows an abrupt transition in the linear region between 220K and 240K, which gives a direct evidence and link between contact resistance and doping effect.

DS 15.6 Tue 15:15 POT 081

IR spectroscopic investigation of charge transfer in organic semiconductors I: Doped layers — ●TOBIAS GLASER^{1,2}, SEBASTIAN BECK^{1,2}, DAVID GERBERT^{1,2}, JOHANNES ZIMMERMANN^{1,2}, and ANNEMARIE PUCCI^{1,2,3} — ¹Kirchhoff-Institut für Physik, Universität Heidelberg — ²InnovationLab GmbH, Heidelberg — ³Centre for Advanced Materials, Universität Heidelberg

Electrochemical doping of amorphous organic semiconductors is a frequently used technique in order to increase the amount of free charge carriers and thereby the conductivity of the doped layers. But for organic semiconductors, in general very low doping efficiencies in the range of only a few percent have been reported.

We performed infrared (IR) spectroscopy under ultrahigh vacuum conditions in order to investigate the process of charge transfer in various p-doped material systems. The charge transfer in doped layers can be determined with IR spectroscopy, as the new electronic structure of the charged molecules leads to a change in bond length and bond strength within the charged molecules that therefore exhibit a different vibrational spectrum compared to the neutral molecules. The appearance of broad electronic excitations in these systems shows the formation of new electronic states due to hybridization. We investigated the behavior of these electronic states after annealing as well as after degradation of the doped layers.

Financial support from the BMBF via the MESOMERIE Project (FKZ 13N10724) is gratefully acknowledged.

DS 15.7 Tue 15:30 POT 081

IR spectroscopic investigation of charge transfer in or-

ganic semiconductors II: Interfaces — •SEBASTIAN BECK^{1,2}, DAVID GERBERT^{1,2}, TOBIAS GLASER^{1,2}, and ANNEMARIE PUCCI^{1,2,3} — ¹Kirchhoff-Institut für Physik, Universität Heidelberg — ²InnovationLab GmbH, Heidelberg — ³Centre for Advanced Materials, Universität Heidelberg

In organic semiconductors charge transfer (CT) is crucial for all kinds of applications but its basic mechanisms are still under severe discussion. Especially a better knowledge of CT at organic/organic and inorganic/organic interfaces is essential for the design of new electronic devices with improved performance.

In this study we want to introduce a new approach to investigate CT at interfaces by means of in situ infrared (IR) spectroscopy. We investigated the system 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP)/MoO₃, as a prototypical example, and spectroscopically identified charged and non-charged species of CBP molecules, that were deposited onto MoO₃. Both species can be distinguished by their specific vibrational modes in the mid IR range. The inverted layer structure with MoO₃ deposited onto CBP shows a significantly different behavior that is attributed to the diffusion of MoO₃ into the organic film.

Financial support by BMBF (project MESOMERIE) is gratefully acknowledged.