**HL 38**: Organic electronics and photovoltaics II (DS, jointly with CPP, HL, O)

**Time**: Tuesday 9:30–12:45

**Location**: H32

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**HL 38.1** Tue 9:30 H32

**Influence of triplet excitons on the lifetime of polymer based organic light emitting diodes**

- **Antti Piekola**, **Andrea Gassmann**, **Christian Melzer**, and **Heinz von Seggern** — Electronic Materials Division, Institute of Materials Science, Technische Universität Darmstadt, Petersenstr. 3, 64287 Darmstadt, Germany

Despite the promising development of polymer based organic light emitting diodes (PLEDs), device lifetime and stability are still among the most critical issues. One of the lifetime-related factors investigated to a large extent is the influence of the triplet density on the decay of the lifetime. The presence of triplet excitons could be responsible for local heating or act as traps for charge carriers, leading to a degradation of the device.

This study utilizes PLEDs based on poly(p-phenylene vinylene) (PPV) derivatives to understand the influence of triplet excitons on the fatigue by increasing their amount in the PPV film. This increase is achieved by blending different concentrations of the triplet sensitizers platinum (II) octaethylporphyrine ketone (PtOEPK) into the PPV matrix in order to convert PPV single excitons to triplets. One observes that in PLEDs both the 500 and 190 lifetimes are drastically shortened in the presence of PtOEPK. To rule out a possible influence of the solvate presence of PtOEPK on charge carrier transport, single carrier devices with different sensitizer contents were prepared. In these devices, no fatigue is observed regardless of the sensitizer concentration, suggesting that the decrease in the lifetimes of the bipolar diodes is indeed caused by the increased triplet population in the diodes with sensitized polymer films and not by the sensitizer additive as such.

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**HL 38.2** Tue 9:45 H32

**Homogeneity of thin ZnTPP-films on silicon measured with reflectance anisotropy spectroscopy and Raman spectroscopy**

- **Stephan Peter Katz**, **Simona Pop**, **Jörg Rappich** — Leibniz-Institut für Analytische Wissenschaften - ISAS - e.V., Albert-Einstein Str. 9, 12489 Berlin, Germany

**Kekulestraße 5, Berlin, 12489, Germany**

- **Karsten Hinrichs** — Inorganic Materials Division, Institute of Materials Science, Technische Universität Darmstadt, Darmstadt, Germany

Homogeneity of thin ZnTPP-films on silicon measured with reflectance anisotropy spectroscopy (RAS) and Raman spectroscopy is useful to investigate the homogeneity of structure and homogeneity of thin films is of crucial importance. In this study we demonstrate that Reflectance Anisotropy Spectroscopy (RAS) and Raman spectroscopy are useful to investigate the homogeneity of thin films of ZnTPP on silicon substrates. The RAS spectra of the thin films show an optical anisotropy in the visible spectral range. Analyzing the anisotropy, conclusions about the homogeneity of the thin films can be drawn. The vibrational modes of the molecules seen with resonant Raman spectroscopy are sensitive to the film structure. A pyrrole-bending mode at 1760 cm⁻¹ serves as a marker for the film homogeneity. The RAS and Raman results are correlated with AFM measurements.

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**HL 38.3** Tue 10:00 H32

**Morphology evolution of diblock copolymer based ZnO nanostructures upon solvent vapor treatment**

- **Kubring Sarker**, **Christoph Schaffer**, **Anna Naumann**, **Daniel Moesge Gonzalez**, and **Peter Müller-Buschbaum** — TU München, Physik Department, LS Funktionelle Materialien, James-Franck-Str. 1, 85748 Garching, Germany

Nanostructured inorganic metal oxides with tunable morphologies are desirable for optimizing many potential applications in the field of gas-chemical sensing, catalysis and energy storage. Zinc oxide (ZnO) is of great interest due to its present study owing to its optoelectrical properties. Different ZnO nanostructures are synthesized using a suitable diblock copolymer template via sol-gel chemistry. Zinc acetate dihydrate is used as the suitable commercial precursor for ZnO. There are several possibilities to tune the morphology of most of the diblock copolymers respond to the external fields such as temperature and solvent vapor. Hence, tetrahydrofuran solvent vapor treatment has been employed to the as-prepared thin films corresponding a grid-like morphology for different annealing times. Grazing incidence small angle X-ray scattering (GISAXS) has been performed to probe the structural order over the entire film volume. Evolution of the morphology has been followed by GISAXS studies as a function of different solvent treatment times. The annealed films are subsequently calcined at a higher temperature in order to understand the preservation of the required thin films after removal of the diblock copolymer.

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**HL 38.4** Tue 10:15 H32

**Correlation of morphology and electronic properties of MoO₃-doped CBP layers I: CBP and electrical properties**

- **Daniela Donhauser**¹,², **Levin Dietterle**¹,², **Paul Heimel**³,², **Tobias Glaser**¹,², **Maybritt Köhn**¹,², **Mustapha Al-Helwi**³,², **Rasmus R. Schröder**⁶, **Eric Mankel**¹,², **Michael Kröger**¹,², and **Wolfgang Kowalsky**¹,² — Institut für Hochfrequenztechnik, TU Braunschweig, Braunschweig — InnovationLab GmbH, Heidelberg

In this study we demonstrate that Reflectance Anisotropy Spectroscopy (RAS) and Raman spectroscopy are useful to investigate the homogeneity of thin films of ZnO. There are several possibilities to tune the morphology as most of the diblock copolymers respond to the external fields such as temperature and solvent vapor. Hence, tetrahydrofuran solvent vapor treatment has been employed to the as-prepared thin films corresponding a grid-like morphology for different annealing times. Grazing incidence small angle X-ray scattering (GISAXS) has been performed to probe the structural order over the entire film volume. Evolution of the morphology has been followed by GISAXS studies as a function of different solvent treatment times. The annealed films are subsequently calcined at a higher temperature in order to understand the preservation of the required thin films after removal of the diblock copolymer.

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**HL 38.5** Tue 10:30 H32

**Correlation of morphology and electronic properties of MoO₃-doped CBP layers II: IR spectroscopic study**

- **Tobias Glaser**¹,², **Sébastien Beck**¹,², **Daniela Donhauser**²,³, **Maybritt Köhn**³,², **Bernd Lunkemeier**⁴,⁵, **Andreas Köhn**³,², **Eric Mankel**¹,², and **Annemarie Pucci**³,² — Universität Heidelberg, Kirchhoff-Institut für Physik — Technische Universität Braunschweig, Institut für Hochfrequenztechnik — Technische Universität Darmstadt, Fachbereich Materialwissenschaft, Fachgebiet Oberflächenforschung — Universität Mainz, Institut für Physikalische Chemie — InnovationLab GmbH, Heidelberg

In order to obtain a further understanding on the charge transfer process in p-type doping using transition metal oxides, we performed in situ FTIR-spectroscopy on thin layers of 4,4’-Bis(N-carbazolyl)-1,1’-biphenyl (CBP) doped with MoO₃. In the doped layers, charge transfer complexes (CTCs) are formed, that exhibit a broad electronic excitation in the near IR region. These CTCs are located at the interface of the MoO₃ agglomerates and the organic layer, inducing an interface dipole. The intensity of this electronic excitation in the spectra of layers with various dopant concentrations indicates a linear increase of the agglomerates' surface area with MoO₃ concentration. The vibrational changes in the spectra of the doped layers indicate a charge transfer of Z=1e within the CTCs. By cooling the substrate during the deposition process, the agglomeration of the dopants can be suppressed.

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

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**HL 38.6** Tue 10:45 H32

**Correlation of morphology and electronic properties of MoO₃-doped CBP layers III: XPS and UPS study**

- **Maybritt Köhn**¹,², **Eric Mankel**¹,², **Daniela Donhauser**²,³, **Tobias Glaser**¹,², **Thomas Mayer**³,², and **Wolfram Jägermann**³,² — Technische Universität Darmstadt, Fachgebiet Materialwissenschaft — Technische Universität Braunschweig, Institut für Hochfrequenztechnik — Universität Heidelberg, Kirchhoff-Institut für Physik — InnovationLab GmbH, Heidelberg

Electrochemical doping is a prerequisite to improve efficiency and conductivity of organic OLED materials. Here the p-type doping behavior of MoO₃ is analyzed using photoelectron spectroscopy (XPS/UPS). The doped CBP layers were evaporated and analyzed under UHV con-
Concentration of 45 mol%. The electron transfer from CBP to MoO
strong and finally saturating at a maximum shift of 1 eV at a doping
conditions. Concerning the Fermi level shift two different regimes can
can be distinguished: At low doping concentrations (< 9 mol%) a rapid
shift towards the HOMO level of CBP can be observed, becoming less
strong and finally saturating at a maximum shift of 1 eV at a doping
concentration of 45 mol%. The electron transfer from CBP to MoO

of these species we get information of the surface to volume ratio of
the MoO₃ clusters in dependence of the doping concentration. Also
here three different regimes can be distinguished. The morphology and
Fermi level shift regimes will be correlated discussing the dopant mor-
phology as shown in Talk I. Finally the amount of transferred charges
is calculated regarding the reduced MoO₃ species and is compared with
the number of cations determined by IR-spectroscopy (Talk II).

Coffee break (15 min)

HL 38.7 Tue 11:15 H32

Semiconductor devices on fibre shaped structures for
smart textile applications. — Tobias Köβner-Toth, Andrea
Gasemann, and Heinz von Seggern — Electronic Materials Depart-
ment, Institute of Materials Science, Technische Universität Darm-
stadt, Petersenstraße 23, 64287 Darmstadt, Germany

In the development of smart textiles already realized prototypes utilize embedded LEDs, displays or interactive communication devices based on inorganic semiconductor technology. Yet, these wearable smart tex-
tiles are not always comfortable since inorganic devices are still rigid.

On the other hand, organic electronic devices can be realized on flexible substrates employing very thin active layers of only about 100 nm thickness. The aim of the present work is to process organic semiconductor based devices directly on fibre surfaces. This task is challenging as manufacturing related problems due to the cylindrical shape of the fibre substrates and their small diameter of about 200 nm have to be overcome. Here, we present our findings on functional OLEDs on fibre substrates. Also the choice of proper fibre materials, ways to acquire smooth fibre surfaces and the structuring and encapsu-
lation of fibre-shaped devices will be discussed. Additionally, methods to characterize the functionality of the devices, like angle dependence emission, will be presented.

HL 38.8 Tue 11:30 H32

Doping of organic semiconductors in case of dopant precipi-
tation: the internal interface charge transfer doping model —
Thomas Mayer, Eric MankeI, Corinna HeinI, and Wolfram JägermannI,II — Technische Universität Darmstadt, Institute of Materials Science, Science Surface Science Division — Innovation Lab Heidelberg

Doping of organic semiconductors is of paramount interest for de-
vice optimization as in addition to improved conductivity, engineering of space charge regions at interfaces e.g. of donor acceptor hetero-

junction solar cells is achieved. Photoemission data taken at the syn-
chrotron BESSY on co-sublimed and bilayer films of prototypical or-
ganic semiconductors as CuPc and spiro-MesTAD and prototypical p-
type organic and inorganic dopants as TCNQ and WO3 show similar
electronic trends, which can be explained assuming phase separation of the dopants within the matrix material. For metal oxides the precipita-
tion is directly observed using TEM. For the doping induced variations of the matrix Fermi level in such semiconductor-dopant composites we propose the internal interface charge transfer doping model. According to this model the doping limit can be predicted from pristine matrix and pristine dopant electronic band diagrams. The model also admits of deriving measures that can be taken to improve doping efficiency.

HL 38.9 Tue 11:45 H32

Molecular orientation at heterojunctions for organic photovoltaics studied by NEXAFS — Andreas Optitz, Norbert Koch, Ulrich Hörmann, Wolfgang Brütting, Christoph Lorch, Alexander Hinderhofer, Frank Schreiber, and Ellen Morgen — Inst. f. Physik, Humboldt-Universität zu Berlin, Germany — 2Inst. of Physics, University of Augsburg, Germany — 3Inst. of Applied Physics, University of Tübingen, Germany — 4Dept. of Physics and Electrical Engineering, Karlstad University, Sweden

Organic/organic heterojunctions are widely used in organic photo-
voltaic cells. The morphology at the interface, where the charge carrier separation takes place, plays an important role. In this contribution the interfaces between sexithiophene (6T) as donor and the acceptor materials fullerene (C₆₀) and diindenoperylene (DIP) [1] were anal-

ized by angle resolved near-edge X-ray absorption fine structure spec-
troscopy and the results were compared to X-ray scattering data.

Different orientations are observed for molecules in the bulk, at free surfaces and at buried interfaces. Here, the orientation at the free surfaces depends on the substrate temperature during deposition for 6T but not for DIP. Furthermore, the acceptor molecules influence the orien-
tation of the underlying 6T molecules. An improved crystalization and pronounced upright standing of the molecules in the underlying 6T film was observed upon deposition of C₆₀. In contrast the depo-
osition of DIP on top of 6T leads to an orientational relaxation of the 6T molecules to the bulk inclination angle.


HL 38.10 Tue 12:00 H32

Electronic interface properties of PCBM using photoelectron

The electronic interface properties of wet processed organic materials are of current interest as many fabrication techniques for organic electronic devices are based on inks. Photoelectron spectroscopy (PES) has proven to be a powerful method to investigate the electronic struct-
ure under doping conditions. Due to the low vacuum in conventional PES, the interface is generally prepared step by step in UHV. For films deposited from solution we integrated a newly developed ultrasonic nebulizer unit to the UHV cluster-tool of the analytic competence center at the InnovationLab, Heidelberg. Dilute solutions of Phenyl-
C₆₁-butyric acid methyl ester (PCBM) in Chlorobenzene were used to fabricate a multilayer of CNT, reduced graphene oxide and gold to investigate the contact behavior of PCBM. With the nebulizer method layer thicknesses in the range of 10-20 Å can be achieved while repeated exposure to the nebulae increased step by step the emission intensities of the PCBM. Furthermore drop-casting of thicker layers has been performed allowing in combination the thickness dependent determination of the electronic properties. In case of PCBM on ozone treated ITO the HOMO spectra shift 0.4 eV to higher binding energy with increasing thickness, indicating the formation of a space charge region in PCBM due to electron transfer from ozone treated ITO.

HL 38.11 Tue 12:15 H32

Carbon Nanotubes and Organic Solar Cells — Gerhard
Lackner, Richard Boucher, Vladimir Shvartsman, Viktor Bezugly, Ingolf Endle, Mario Kruc, Frank Meissner, Martin Mkandawire, and Doru C. Lupascu — 1Universität Duisburg-Essen, Essen, Germany — 2Technische Universität Dresden, Dresden, Germany — 3Fraunhofer-Institut für Keramische Technolo-
gie und Systeme IKTS, Dresden, Germany — 4Verschueren Centre for Sustainability in Energy and the Environment, Cape Breton University, Canada

Materials like carbon nanotubes (CNT) attracted much attention by researchers all around the world due to their exceptional electrical, mechanical and chemical properties. Especially single-wall carbon nanotubes (SW-CNT) offer great opportunities in the field of new electrical devices, for instance field effect transistors based on their semiconductor properties. CNT are also used in organic photovoltaics (OPV) as acceptor material, to enhance charge carrier transport within organic layers or as transparent electrodes. The application of CNT as acceptor material and for charge carrier enhancement is the main topic of this work. Therefore, we studied the photovoltaic device performance of different material combinations of CNT with aromatic organic systems. Poly(3-Hexylthiophen-2,5-diyl) (rr-P3HT), Phenyl-C₆₁-butyric acid methyl ester (PCBM) and copper phthalocyanine (CuPc). Furthermore, different device architectures were investigated and compared with each other.

HL 38.12 Tue 12:30 H32

n-channel percolation in a pentacene-C₆₀ ambipolar organic
thin film transistor — Simon Noever, Stefan Fischer, and Bert Nickel — Ludwig-Maximilians-Universität, Fakultät für Physik & CENS, München, D

We present [1] a well balanced ambipolar organic field effect transis-
tor with high hole and electron saturation mobilities of 0.28 cm²/Vs and 0.36 cm²/Vs, respectively. The structure and morphology of the respective films are analyzed using AFM and GIIXS methods. Fur-
thermore, we track the formation of a pentacene-C₆₀ heterojunction by in-situ measurements during deposition of C₆₀. Upon percolation
of the n-channel, the heterojunction charges, acting as an additional top gate for the hole conducting channel. The fact that the p-channel threshold does not shift before the n-channel develops highlights two interesting findings for bilayer ambipolar TFTs. Apparently, before the C60 film percolates, the fullerene islands are electronically floating and the charging of the interface is confined to the pentacene-C60 contact area. Secondly, the threshold voltage shift of the p-channel upon fullerene percolation implicates the generation of a second hole conducting channel at the pentacene top surface. The introduced method demonstrates a way to evaluate the electrostatic situation in operating organic heterojunction devices. [1] S. Noever, S. Fischer, B. Nickel, Advanced Materials (in press)