HL 41: Organic semiconductors

Time: Thursday 15:00–17:30 Location: ER 270

HL 41.1 Thu 15:00 ER 270

Charge transport in guanine crystals — •Frank Ortmann, Karsten Hannewald, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität, Jena, Germany

Charge-transport processes in organic molecular crystals exhibit similarities and differences to those in π-conjugated polymers. For both types of condensed matter the polaronic effects are of outstanding importance. These effects can cause a transition from band-like transport to thermally activated hopping.[1] While the hopping regime is prevalent for DNA polymers, it is not clear if the same holds also for crystaline guanine or if band transport dominates. Also the influence of the temperature is rarely discussed in literature. In our approach to the problem of charge-carrier transport in these systems [2,3], we discuss the temperature dependence of the polaron bandwidth and the mobility in guanine crystals [4].

[1] Hulea et al. Nat. Mater **5** , 982 (2006)
[2] Hannewald et al. PRB **69** , 075211 (2004)
[3] Hannewald et al. PRB **69** , 075212 (2004)
[4] Ortmann et al. J. Phys. Chem. B (to be published)

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Charge carrier mobility in organic bulk P3HT:PCBM solar cells with varied donor–acceptor ratio — •Andreas Baumann[1], Carsten Deibel[1], Jens Lorrmann[1], Maria Hammer[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, Am Hubland, D-97074 Würzburg — [2]ZAE Bayern, Div. Functional Materials for Energy Technology, Am Hubland, D-97074 Würzburg, Germany

The efficiency of organic solar cells has been increased to above 5 % in the last decade, promissing an interesting potential as a renewable energy source. For P3HT: PCBM heterojunction solar cells a ratio of 1:1 was found to yield the highest efficiencies. Concerning the donor–acceptor ratio, both an efficient charge transfer as well as a balanced mobility of the charge carriers are necessary to reach such high solar cell performances. We investigated the electron and hole mobilities in P3HT:PCBM heterojunction solar cells with different donor (P3HT)–acceptor (PCBM) ratio experimentally. For a deeper understanding, experimental results are discussed by comparing them with Monte Carlo simulations of hopping transport in a Gaussian density of states distribution.

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Polymer solar cell modules: first experimental results and their optimization — •Harald Hoppe[1], Burhan Mushin[1], Joachim Renz[1], Karl Heinz Drüe[2], Jonas Bachmann[3], Claudia Buerhop-Lutz[3], Ingo Riedel[4], Vladimir Dyakonov[4], and Gerhard Gobsch[1] — [1]Institute of Physics, Ilmenau University of Technology, Weimarer Str. 32, 98693 Ilmenau, Germany — [2]Electronic Technology, Institute of Micro- and Nanotechnologies, Ilmenau University of Technology, Gustav-Kirchhoff-Str. 7, 98693 Ilmenau, Germany — [3]ZAE BAYERN, Thermosensorik und Photovoltaik, Am Weichselgarten 7, 91058 Erlangen, Germany — [4]ZAE BAYERN, Funktionsmaterialien der Energietechnik, Am Hubland, 97074 Würzburg, Germany

Polymer solar cell modules based on the standard polymer-fullerene system of to-date, P3HT-PCBM, have been prepared and characterized. We have observed only a loss of ca. 20% when up scaling the active area of the solar cell by a factor somewhat larger than 10. A solar cell efficiency of 3% and a module efficiency of 1.9%, relating to the total area, are reported. The route for further optimization of module performance is discussed based on analysing the existing loss factors within this material system. We made thermographic measurements on the modules and identified parasitic shunts.

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Investigation of novel organic n-type semiconductors with respect to absorption, charge carrier generation and mobility — •Moritz Liedtke[1,2], Johannes Krantz[1], Andreas Sperrlich[1], Björn Titze[1], Maria Hammer[1], Carsten Deibel[1], Vladimir Dyakonov[1,2], and Martin Baumgarten[3] — [1]Experimental Physics VI, Physical Institute, Julius-Maximilians-University of Würzburg, Am Hubland, D-97074 Würzburg — [2]The Bavarian Center for Applied Energy Research (ZAE Bayern), Am Hubland, D-97074 Würzburg — [3]Max Planck Institute for Polymer Research, D-55128 Mainz

Novel organic n-type semiconductors as acceptors for applications in organic semiconducting devices such as solar cells are investigated. As reference materials, we used the donor poly(3-hexylthiophene) (P3HT) and the commonly used [6,6] phenyl-C61-butyric acid methyl ester (PCBM) as acceptor. We studied the materials and their composites in view of light absorption, photoluminescence quenching, electron spin resonance and field-effect mobillity measurements. Thus we obtained information on charge carrier generation, the spin state of excitations and the charge carrier mobility.

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How strain controls the exciton linewidth in single polyfluorene nanowires — •Enrico Da Como, Klaus Becker, and Jochen Feldmann — Photonics and Optoelectronics Group, Dep. of Phys. and CeNS, LMU, Munich

In this contribution, by low temperature single molecule fluorescence spectroscopy, we show a correlation between intramolecular order and the exciton linewidth in single chains of poly(9,9-dioctylfluorene) (PFO). According to the degree of planarization in the adjacent fluorene repeat units, PFO single chains can be distinguished between beta- (planar) or glassy (twisted) phase. By single molecule polarization anisotropy in excitation we have compared the overall shape of the chain in both phases. The results demonstrate that beta-phase chains are characterized by higher polarization values than the glassy ones, reflecting a structure comparable to a one-dimensional (1D) crystalline nanowire [1]. A detailed investigation of beta-phase chains shows a strong correlation between the exciton zero-phonon-linewidth and the polarization anisotropy of the emitting chromophore. While linewidth provides a lower limit for the exciton dephasing time, which reaches remarkable values up to 3 ps for straight chromophores, low anisotropy is symptomatic of the degree of strain which acts on the 1D structure. Bent chromophores show systematically larger linewidths suggesting an accelerated dephasing in the exciton wavefunction or an increased spectral diffusion. The results give a picture on how structure in a 1D organic semiconductor correlates with the electronic properties. [1] E. Da Como et al. Nano Lett. 7, 2993 (2007).

15 min. break

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Electron and hole transport in evaporated layers of copperphthalocyanine — •Michael Kraus, Andreas Opitz, and Wolfgang Brütting — Institute of Physics, University of Augsburg, Germany

The realisation of electron and hole transport in the same material will extend the probabilities of organic electronic circuits. An example is the field of complimentary logics where separated p- and n-type field-effect transistors are necessary. In this study copper(II)-phthalocyanine (CuPc) is investigated which is commonly used in organic field-effect transistors (OFETs) due to its stability in ambient air or in organic photovoltaic cells as a light absorber.

We fabricated bottom-gate top-contact OFETs with evaporated CuPc layers as active layer. The Si/SiO_2 substrates were treated with a thin layer of PMMA to achieve a trap free interface. It is possible to control the type of carrier transport by using various electrode materials differing in their work function. So both types of unipolar transport and also ambipolar transport are realised. The transfer-length-method is applied to calculate mobility and contact resistance separately. The field-effect mobility was found as an intrinsic property of the material which depends on the carrier type but not on the electrode material. Our results show an asymmetry between electron and hole transport since the hole mobility is one order of magnitude higher than the electron mobility.

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Influence of Dissociation and Recombination on the Photocurrent of Organic Bulk Heterojunction Solar Cells — •Carsten Deibel, Andreas Baumann, Thomas Strobel, and Vladimir Dyakonov — Experimental Physics VI, Julius-Maximilians-University of Würzburg, Am Hubland, D-97074 Würzburg

Despite the significant increase of performance of organic bulk heterojunction solar cells in recent years, the detailed knowledge of the relevant elementary processes remains under debate. Concerning charge carrier recombination, literature so far reports different mechanisms: monomolecular recombination or a combination of bimolecular recombination with thermalisation, or what is called dispersive recombination. In order to contribute to this discussion, we present investigations of the photocurrent of polymer:fullerene solar cells. We apply time-resolved as well as steady-state techniques such as photo-CELIV — charge carriers generated by a short laser pulse are extracted after a variable delay time — and current–voltage measurements, in dependence of temperature. In order to complement these experiments, we perform Monte Carlo simulations of polaron pair dissociation in disordered donor–acceptor systems, considering monomolecular and bimolecular recombination. Comparing the simulations to the experimental results, we discuss the impact of recombination mechanisms on the photocurrent.

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Optical Pumped Electrical Functional Organic Laser Device — •Bodo Wallikewitz, Matthias de la Rosa, Jonas Kremer, Dirk Hertel, and Klaus Meerholz — Universität zu Köln, Chemie Department, Luxemburgerstr. 116, 50939 Köln

The performance of organic light-emitting diodes (OLEDs) has made tremendous progress over the past decade, nevertheless, the realization of organic laser diodes remains a challenge. To achieve lasing optical gain manifested by amplified spontaneous emission (ASE) is mandatory. We have obtained low ASE thresholds (5 uJ/cm2) and high gain (50 cm-1) in oxetane-based photo-crosslinkable conjugated copolymers. Due to their photoresist properties, these materials can be structured by second-order DFB resonator through holographic exposure. Optically pumped single layer polymer lasers with the emitter and resonator made of the same material are investigated and the coupling mechanism is discussed. To realize an organic laser diode it is necessary to confine the waveguided mode in the active layer (gain medium) and to prevent losses induced by the metal contacts in the device. An electrical functional laser device and an ASE device with a threshold of 4.5 and 9 uJ/cm2 was enabled by using thick crosslinked hole transport layer (X-HTL) and non-crosslinked electron transport layer (ETL) cladding the functional emitter layer. OLEDs are characterized and the influence of thick multilayers on OLEDs performance is discussed. The efficiency decreases from 9 Cd/A for a standard 100nm "thin" OLED to 5 Cd/A for a 1 um "thick" multilayer OLED.

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Magnetoresistance effects in a PTCDI based ferromagnet/organic semiconductor hybrid structure — •Matthias Grünewald[1], Markus Michelfeit[1], Georg Schmidt[1], Rüdiger Schmidt[2], Frank Würthner[2], and Laurens W. Molenkamp[1] — [1]Experimentelle Physik 3, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]Organische Chemie 2, Universität Würzburg, Am Hubland, 97074 Würzburg

Organic semiconductors (OSC) are promising materials for spintronic devices because of their very long spin relaxation times. Already in 2004 a first OSC based spin valve has been demonstrated [Xiong et al, Nature 427, 2004]. Most of the experiments on OSC based spin valve like structures were carried out using low mobility OSC like Alq3. The low mobility, however, results in either low currents or high bias voltages, making the difference between true diffusive spin transport or tunnelling barely discernable. Here we present a spin valve structure based on LSMO (lanthanum strontium manganese oxide) and Co as electrode materials and a novel UHV deposited PTCDI based OSC. The Co contacts are deposited in-situ after OSC deposition. The device shows high field magnetoresistance (HFMR) at 4K superimposed by a spin valve like switching behaviour when a magnetic field is applied in plane of the sample. No magnetoresistance can be observed for fields perpendicular to the plane, excluding any influence of organic magnetoresistance (OMAR). The magnitude of the HFMR depends on the applied bias voltage with a maximum at about 1.5 V. This work is funded by the EU within the FP6 project OFSPIN.