

Organic Electronic Materials Topical Conference Room 616/617 - Session OE+EM+FP-MoA

Transport and Nanostructures in Organic Films

Moderator: E. Umbach, Universität Würzburg, Germany

2:00pm **OE+EM+FP-MoA1 Generation and Transport of Charge Carriers in Conjugated Polymers**, V.I. Arkhipov, H. Baessler, S. Barth, C. Im, D. Hertel, B. Schweitzer, Philipps Universität, Germany **INVITED**

Upon photoexcitation of conjugated polymers, such as ladder-type polyphenylene (LPPP) and substituted PPVs, both geminately bound electron-hole pairs and free charge carriers are generated. Evidence for geminate pair production in LPPP comes from electric field assisted delayed fluorescence. Intrinsic free charge carrier generation occurs via on-chain dissociation of vibrationally hot singlet excitations. Motion of positive charge carriers has been studied involving time of flight experiments. From the hole mobility in a series of substituted PPV as a function of temperature and electric field it will be concluded that transport is disorder controlled as it is in molecularly doped polymers. An exception of this rule is hole transport in LPPP. The question of intra versus inter chain transport will briefly be addressed. This work was supported by the Deutsche Forschungsgemeinschaft (Sonderforschungsbereich 383) and the Stiftung Volkswagenwerk.

2:40pm **OE+EM+FP-MoA3 Resistance of Individual Molecular Semiconductor Grains Measured by Conducting Probe Atomic Force Microscopy**, T.W. Kelley, C.D. Frisbie, University of Minnesota

Continued interest in organic electronics has underscored the need for better understanding of transport mechanisms in polycrystalline films of organic semiconductors. We are employing conducting probe atomic force microscopy (CP-AFM) to measure the electrical resistances associated with individual grains and grain boundaries in thin films of α -sexithiophene (6T). These measurements focus on single 6T grains that are several microns in length and width and 1 - 6 molecular layers (2-14 nm) in thickness. The 6T grains are vacuum deposited onto insulating substrates with lithographically patterned gold electrodes. A Au-coated AFM probe is used to image each grain, including any crystal defects, and to subsequently make point-contact electrical measurements at particular positions on the grain. Current-voltage (I-V) curves are recorded at each position as a function of probe-electrode separation. From these data, we estimate tip-grain contact resistance and conductivity of each grain. In general, we show that CP-AFM is a powerful approach to exploring the effects of microstructure on conductivity in organic semiconductor films.

3:00pm **OE+EM+FP-MoA4 Self-Assembled, Template-Based Nanolithography**, S.R. Cohen, R. Maoz, E. Frydman, J. Sagiv, Weizmann Institute of Science, Israel

The versatility of our recently developed technique¹ for scanning probe microscope (SPM)-based, non-destructive nanolithography on an organized organic monolayer template is demonstrated here. By building on, rather than destroying the organic "resist", consisting of an ordered self assembled monolayer (SAM), it is possible to construct complex 3 dimensional structures which can ultimately lead to device formation. In the first step, applying a bias voltage between a conductive SPM tip and a silver thiolate-based monolayer surface site leads to "activation" of that site by the tip. The second step, deposition of metal (silver) from solution by interaction with an enhancing solution which specifically deposits silver on these sites, leads to in-situ formation of metallic features with sub-micron resolution. These features are chemically bound to the surface-altered monolayer, and comprise a three-dimensional structure of surface-bound silver. The fabrication of conducting nanowires is demonstrated, which could be extended to device or nanocircuit formation. The formation of complex, three-dimensional structures with order determined by the underlying monolayer has been demonstrated. Considering that the surface template exhibits molecular order, this technique has the potential of creating molecular-scale devices, using standard ambient application of SPM, and solution chemistry. ¹FootnoteText@ ¹Footnote 1@ R. Maoz, S.R. Cohen, and J. Sagiv, Adv. Mater. 11, 55 - 61 (1999).

3:20pm **OE+EM+FP-MoA5 Fabrication of Organic Microstructures Using Soft Lithography**, G. Whitesides, Harvard University **INVITED**

Chemistry, with stimulus from biology, is beginning to develop a range of new concepts for fabrication of microsystems: these include self-assembly,

non-covalent synthesis, microprinting, micromolding, microfluidic patterning, microelectrochemistry, and related techniques designed to make it possible to design complicated structures having electrical, optical, biological or magnetic functionality and to replicate these systems efficiently. These concepts suggest approaches to fabrication that are substantially different from photolithography in their areas of application. The phrase "soft lithography" encompasses one core set of techniques for replication. The techniques included in soft lithography include the formation of self-assembled monolayers, the patterning of these monolayers using microcontact printing, the fabrication of structures inside small channels using microfluidic methods, and the fabrication of small (< 50 nm) polymer structures using transfer molding and replica molding. The adjective "soft" in the phrase "soft lithography" refers to the elastomeric stamps or molds that are important in many of these techniques, and to the properties of organic materials in general. These techniques may use photolithography, but normally primarily during the step that fabricates the master. This talk will outline progress in this area: from homogeneous self-assembled monolayers (SAMs) to transistors, and from molecular self-assembly to the self-assembly of macro-scale objects. Areas of application in which soft lithography is promising include 3-D fabrication and pattern transfer to non-planar surfaces, large-area patterning, low-cost additive fabrication, rapid prototyping (especially of microanalytical and microfluidic systems), fabrication of systems where control of surface chemistry is crucial (e.g., cell biology) and fabrication of MEMS. Key problems are defect densities, distortions in the elastomeric masks/stamps/molds, and fabrication requiring multiple registered levels of fabrication. Reviews: "Soft Lithography" Xia, Y. and Whitesides, G. M., Angew. Chem. Intern. Ed. Engl. 1998, 37, 550-575. "Soft Lithography" Xia, Y. and Whitesides, G. M., Annu. Rev. Mater. Sci. 1998, 28, 153-184.

4:00pm **OE+EM+FP-MoA7 Electron Beam Patterning of Amine-Functionalized Self-Assembled Monolayers**, C.K. Harnett, K.M. Satyalakshmi, M.G. Metzler, Cornell University; D.R. Medeiros, IBM T.J. Watson Research Center; H.G. Craighead, Cornell University

Amine-functionalized self-assembled monolayers form a hydrophilic surface that can strongly attach other materials. Examples of materials that have been selectively deposited on patterned amine monolayers include nanoparticles,¹ metals, fluorescent molecules, and biological cells.² Nanopatterning of reactive monolayers is therefore of great practical interest. We have studied electron-beam patterning of 3-aminopropyltriethoxysilane (APTS) and other self-assembled monolayers. Submicron features that are difficult to achieve with UV lithography or microcontact printing are accessible with electron beams. Exposed patterns are examined with lateral-force microscopy (LFM) to determine pattern quality vs. electron dose. At 20 kV, a dose of 300 $\mu\text{C}/\text{cm}^2$ ² is required to produce continuous 1-micron lines. Results from several electron energies will be presented, with the goal of using these monolayers in a low-energy (1-2 kV) electron-beam lithography system. Exposed areas are analyzed with grazing angle IR spectroscopy to determine possible exposure mechanisms. Subsequent deposition of metals, and use of protection-group chemistry to produce a tone-reversed pattern, will also be discussed. ¹FootnoteText@ ¹Footnote 1@ T. Vossmeier, S. Jia, E. Delonno, M. R. Diehl, S.-H. Kim, X. Peng, A. P. Alivisatos, J. R. Heath, Journal of Applied Physics 84, 3664-3670 (1998) ²Footnote 2@ C. S. Dulcey, J. H. Georger, V. Krauthammer, D. A. Stenger, T. L. Fare, J. M. Calvert, Science 252, 551-554 (1991).

4:20pm **OE+EM+FP-MoA8 Liquid Crystal Imprinting: A New Method for Preparing Uniformly Oriented Thin Films**, D.L. Patrick, Western Washington University

A new synthetic strategy is presented for preparing nanostructured thin films possessing macroscopically-uniform organization. The method is based on the use of a thermotropic nematic liquid crystal (LC) solvent, which serves a growth medium for deposition of material onto a suitable substrate. Application of a magnetic field results in the formation of an oriented film whose directionality can be controlled externally. The method has been used to prepare several organic monolayer systems in which the orientation of the films' molecular constituents is highly controlled. We show that orientational order at the solid-fluid interface originates during film nucleation, and that the alignment mechanism is based on anisotropic anchoring interactions between surface adsorbates and the LC solvent. Details of the relationship between molecular-scale surface structure and bulk LC ordering were studied by combining scanning tunneling microscopy and polarized optical measurements of uniformly oriented cells. LC fluids exhibit anisotropic anchoring interactions with most crystalline surfaces, indicating that the method may be applicable to the synthesis of films and

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layered materials using a wide range of molecular and supramolecular building blocks.

4:40pm **OE+EM+FP-MoA9 Electro-Patterning of Conjugated Polymer Films on Conducting Surfaces Using the Precursor Polymer Approach**, *R.C. Advincula*, University of Alabama at Birmingham, US; *S. Inaoka*, University of Alabama at Birmingham; *D. Roitman*, Hewlett-Packard Laboratories

Recently, a novel method of depositing ultrathin films of conjugated polymers on conducting surfaces has been investigated by the UAB and HP groups. We report the formation and patterning of conjugated polymer films by novel electro-deposition of materials on specific sites of substrates and sequences. We have investigated a range of feature sizes using this method with features below micron size. We have also investigated the formation of unique blend film structures, with emphasis on light emitting materials. Previous attempts in using electrodeposition resulted in 'brittle' and defective (pinholes) film surfaces. Our results indicate that the overall optical, mechanical quality and physical integrity of the films are superior compared to previously reported systems.

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