Organic Films and Devices
Room 318/319 - Session OF+EM-TuM

Molecular and Organic Films and Devices-Electronics

Moderator: A.R. Duggal, GE Global Research

8:20am **OF+EM-TuM1 Charge Transport and Charge Injection in Polymer Field Effect Transistors***, **H. Sirringhaus,*** University of Cambridge, UK **INVITED**

Conjugated polymer semiconductors have been intensely researched over the last 15 years as active layers in solution-processed semiconducting devices, such as field-effect transistors. Here we will disucss recent progress in understanding the charge transport physics of conjugated polymer semiconductors. Particular emphasis will be on polaronic relaxation effects, distinction between interchain and intrachain charge transport, and the physics of charge injection from a metal electrode into a polymer a semiconductor. Polymer field effect transistors offer new opportunities for the controlled manufacturing of active electronic circuits by a combination of solution processing and direct printing. Control over the morphology of the polymer semiconductor is obtained by making use of self-organisation mechanisms, such as liquid-crystalline phase behaviour. Techniques such as surface energy-assisted inkjet printing or embossing can be used to manufacture integrated polymer transistor circuits.

9:00am **OF+EM-TuM3 High Mobility Organic Field Effect Transistors***, **S.E. Sysoev,** V.V. Podzorov, E.M. Loginova, M.E. Gershenson,* Rutgers University

Both organic thin film transistors (OTFTs) and organic single crystal field effect transistors (OFETs) are of primary interest for the characterization of the transport properties of novel organic materials.@footnote 1@ At the present, a comparison between these two approaches shows that the mobility is low on the deposited thin films, which is attributed to interface and grain boundary phenomena.@footnote 2@ In the case of single crystal OFETs there are several key factors, which affect their performance (the mobility and on/off ration). We will report on optimization of the OFET fabrication process, which allowed to reproducibly obtain the values of μ ~ 10 cm@super 2@/Vs. To the best of our knowledge, this is the highest mobility reported for organic field-effect devices at room temperature. In addition, in contrast to the TFTs, our devices demonstrate the threshold-less operation, gate voltage in-dependent mobility and very small subthreshold slope. @FootnoteText@@footnote 1@D. Tsamouras et al. Appl. Phys. Lett. 80, 4528 (2002). @footnote 2@T. Komoda et al. Jpn. J. Appl. Phys., 41, 2767 (2002).

9:20am **OF+EM-TuM4 Growth Dynamics and Electrical Properties of Pentacene Ultra-thin Films***, **R. Ruiz,** A. Mayer, G. Malliaras,* Cornell University*; R.L. Headrick,* University of Vermont*; A.Y. Kazimirov, J.R. Engstrom,* Cornell University

Organic/inorganic interfaces play a crucial role in the rapidly growing field of molecular electronics. Even though huge progress has been achieved in the understanding of electronic transport in conjugated molecular materials, a complete study that relates the nucleation and growth mechanisms with charge transport properties in pentacene thin films is still missing, especially within the first few monolayers adjacent to the gate substrate where charge transport is believed to occur. Pentacene thin films were evaporated onto silicon oxide substrates and analyzed by in-situ synchrotron X-ray scattering and ex-situ atomic force microscopy (AFM). The evolution of the first monolayers was studied by monitoring the intensity of scattered X-rays at the anti-Bragg position. Layer coverages were then extracted from the X-ray intensities using a simple growth model and compared to AFM micrographs. Film evolution as a function of substrate temperature will also be discussed. Thin film transistors were also fabricated with these films for electrical characterization showing a field effect hole mobility of 0.1 cm@super 2@/V·sec.

9:40am **OF+EM-TuM5 Optical and Electronics Properties of Poly(o-Methoxyaniline) (POMA) for Organic FET Applications***, **R.P. Shrestha,** D.X. Yang, E.A. Irene,* University of North Carolina at Chapel Hill

The optical properties of spin coated thin films of poly(o-methoxyaniline) (POMA) was investigated using spectroscopic ellipsometry (SE) and optical absorption spectroscopy in the visibleâ€"near UV optical range. A Gaussian oscillator optical model was used to fit the data obtained from SE. Atomic force microscopy (AFM) was used to characterize film roughness and these results were also evaluated in the optical model. We have investigated the effect of different spin deposit conditions including spin rate, and concentration of solution and deposition ambient on the POMA film thickness, surface roughness, optical and electronic properties. Organic thin film field effect transistor fabrication was carried out using POMA on a gold line structure that formed the source and drain contacts and with SiO2 covered Si wafer as the gate dielectric and substrate, respectively. Device characteristics are presented.

10:00am **OF+EM-TuM6 An Optical and Electronic Properties Study of a Stable n-Type Organic Semiconductor: N,N'-bis(3-phenoxy-3-phenoxy-phenoxy)-1,4,5,8-naphthalenetetracarboxydiimide***, **D.X. Yang,** R.P. Shrestha,* University of North Carolina at Chapel Hill*; T.J. Dingemans,* Delft University of Technology, The Netherlands*; E.T. Samulski, E.A. Irene,* University of North Carolina at Chapel Hill

The use of organic semiconductors in the electronic devices typically requires stable and reliable n and p-type semiconductors. Stable p-type organic semiconductors are well known, but useful n-type organic semiconductors are rare mainly due to their relative reactivity. In this study, a novel n-type organic semiconductor: N,N'-bis(3-phenoxy-3-phenoxy-phenoxy)-1,4,5,8-naphthalenetetracarboxydiimide (NDA-n2) is investigated. NDA-n2 is stable up to 200 °C in air and shows excellent solubility in THF and CH@sub 2@Cl@sub 2@. Also, its co-planar packing structure could yield high electronic mobility. NDA-n2 film was spin-cast onto SiO@sub 2@ coated Si wafer substrate. The optical properties were determined using spectroscopic ellipsometry (SE) and optical absorption spectroscopy in the visible near UV optical range. The optical properties were obtained from the experimental data using a Gaussian oscillator model and regression analyses. The results show four absorption peaks around 4.60 eV, 3.87 eV, 3.68 eV and 3.48 eV. Atomic force microscopy (AFM) was used to obtain surface roughness which was included in the optical model using the Bruggeman effective medium approximation. Electrical properties were determined from simple structures and correlated with film deposition parameters. PN junctions were formed and evaluated.

10:20am **OF+EM-TuM7 Organic Semiconducting Materials for Plastic Electronics***, **Z. Bao,*** Bell Labs, Lucent Technologies **INVITED**

Organic electroactive materials are now being considered as the active materials in displays, electronic circuits, solar cells, chemical and biological sensors, actuators, lasers, memory elements, and fuel cells. The flexibility of their molecular design and synthesis makes it possible to fine-tune the physical properties and material structure of organic solids to meet the requirements of technologically significant applications. In this talk, the performance of several new organic semiconducing materials will be presented. These materials are designed for high performance, long-term stability, and ease of fabrication.

11:00am **OF+EM-TuM9 Localized Deposition of Thin Films of Conducting Polyaniline on Microhotplates for Chemical Sensing***, **G. Li,** S. Semancik,* National Institute of Standards and Technology

A procedure for directly processing thin films of conducting polyaniline on MEMs microhotplates is described. The method allows the fabrication of conductometric gas microsensors within microarray platforms. It combines alternating electrochemical and electroless surface polymerization steps along with the localized heating capability of microhotplates to selectively deposit strongly adhering, smooth and compact films on the hybrid (metal/SiO@sub 2@) surfaces of microhotplate sensing elements. The polyaniline films within the arrays can be deposited using different processing parameters and then further fuctionalized electrochemically. In this way, both the film thickness and film conductance can be efficiently fine-tuned to desirable values. Film thickness varies in the sub-micron range and the film conductivities range from insulating up to the order of magnitude 10@super 2@ S.cm@super -1@. In addition, we describe the effect of these film characteristics on the temperature programmed sensing performance of the microsensors to various gases (methanol, H@sub 2@O, CO and NH@sub 3@ etc at 1-1000 ppm concentrations in air).

11:20am **OF+EM-TuM10 Polymeric Aperture Masks for High Performance Organic Integrated Circuits***, **D.V. Muyres,** T.W. Kelley, P.F. Baude, S. Theiss, M. Haase, P. Fleming,* 3M

We present here the use of polymeric aperture masks to fabricate high performance pentacene-based integrated circuits. The aperture masks are fabricated using a laser ablation process with capabilities of generating 10 micron features. A mask set consisting of 4 to 6 aligned layers has been fabricated and has been used to demonstrate functional rf-powered integrated circuits with 20 micron gate lengths. Devices consisted of shadow-mask patterned layers of gold, alumina and pentacene. TFT mobilities greater than 2 cm2/Vs were measured and propagation delays from 7-stage ring oscillators of less than 5 microseconds were observed. This all-additive, dry patterning method has been extended to the production of samples as large as 6 â€œ x 6 â€œ. Larger aperture masks are under investigation and continuing efforts are focused on automation of the alignment process.

11:40am **OF+EM-TuM11 Conducting Nanofibers Integrated with Surface Micromachined Structures**, *D. Czaplewski, **H. Liu**, J. Kameoka, R. Mathers, G. Coates, H.G. Craighead,* Cornell University

We present a non-lithographic approach to the formation of oriented polymer nanowires on patterned surfaces. We utilized MEMS structures to deposit conducting nanofibers integrated with patterned electrodes on the surface of a silicon chip. The MEMS structures, used as scanned electrospray sources, are bulk micromachined silicon tips fabricated using microfabrication techniques. A 5 kV potential was applied between the MEMS tip and a rotating counter electrode, which was used to control the orientation of the fibers on the silicon chip containing the measurement electrodes. The nanofibers would form from the extraction of a liquid jet from the silicon tip under an applied electric field. The fibers would dry in transit to the counter electrode, thus depositing single cylindrical fibers. We deposited nanofibers made from a mixture of poly(ethylene oxide) and polyaniline on surface patterned electrodes. Fibers, with diameters ranging from 600 nm to 20 micrometers, were deposited on a set of 4 electrodes, used in a 4 point probe configuration. We measured the conductivity of the fibers, which is consistent with previous reports. We have deposited poly(ethylene oxide) fibers suspended over trenches with diameters as small as 50nm. Additionally, we have used this method to deposit fiber arrays, forming polymer junctions. This method can be used to deposit polymers of various compositions integrated with topographical and surface features.

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