Monday Evening Poster Sessions, November 2, 1998

Organic Electronic Materials Topical Conference Room Hall A - Session OE-MoP

Organic Electronic Materials Poster Session

OE-MoP1 Photoelectron Spectroscopic Studies of Interfaces Between Metals and CBP, I.G. Hill, A. Kahn, Princeton University

A mixture of Mg and Ag is traditionally used as a low work function electron injecting contact in small molecule organic light emitting devices (OLEDs). Thin cathode interface layers of aromatic diamines, such as 4,4'-N,N'-dicarbazolyl-biphenyl (CBP), have recently been shown to increase the electron injection efficiency of Ag cathodes.@footnote 1@ The resulting devices are more stable than traditional structures utilizing reactive MgAg cathodes, and have comparable efficiencies. The role of the aromatic diamine interface layer is unclear. We have investigated the interfaces between CBP and Mg, Ag and Au using ultraviolet photoemission spectroscopy. Each interface was studied by depositing the organic on the metal, and by depositing the metal on the organic. The two methods produced inequivalent interfaces, except in the case of Au/CBP. We have measured the Fermi level/HOMO offset, and estimated the electron injecting barriers at each of these interfaces. The electron injection barrier was 0.5 eV for Mg, 0.6 eV for Ag and 1.2 eV for Au. This variation with the metal work function is quite strong, when compared to PTCDA and Alg@sub 3@.@footnote 2@ The discontinuity of the vacuum level at the interface, caused by the formation of an interface dipole layer, was also measured. The barriers to electron injection from Mg and Ag are comparable in magnitude, and surprisingly large, considering the performance of devices using these contacts. The evolution of the UPS spectral shape with overlayer thickness indicates a rough morphology in the cases of Ag and Mg on CBP. This qualitatively supports the suggestion that a rough interface may lower the barrier to electron injection and improve contact efficiencies.@footnote 3@ @FootnoteText@ @footnote 1@H. Kanai, S. Ichinosawa and Y. Sato, Synthetic Metals, 91, (1997) 195. @footnote 2@I. G. Hill, A. Rajagopal, A. Kahn and Y. Hu, Submitted to Appl. Phys. Lett. @footnote 3@Y. Yang, E. Westerweele, E. Zhang, P. Smith and A. J. Heeger, J. Appl. Phys., 77, (1995) 694.

OE-MOP2 Ultraviolet and X-ray Photoemission Spectroscopy Characterization of Base and Acid Treated Indium Tin Oxide for Organic Device Applications, F.A. Nüesch, E.W. Forsythe, Y. Gao, University of Rochester

Because of its transparency and high conductivity, indium tin oxide (ITO) electrodes are ideal for optoelectronic device applications. Its ability to inject charges into organic solids, however, depends strongly on the interface properties. The effective ITO workfunction can be modified by a surface treatment such as plasma cleaning and chemical treatments. Here, we report the ultraviolet and X-ray photoemission spectroscopy (UPS, XPS) of chemically modified ITO using acids and bases. The UPS results confirm the presence of a dipole layer at the base treated ITO surface, with a vacuum level decrease of more than 1 eV. Current-voltage characteristics of tris-(8-hydroxyginoline) aluminum (Alg) films sandwiched between the treated oxide electrode and a metallic counter electrode are in agreement with the workfunction shifts obtained by the UPS measurements. From XPS results, we will report the surface composition of the ITO films. In addition to base treatments, we will report UPS and XPS results for acid treated ITO and correlate these results with device transport measurements. The construction of thin dipole layers on the ITO substrate is a promising technique to modify the effective work function of ITO and improve the overall organic LED performance.

OE-MOP3 Investigation of the Growth Mode of Phenyldiamine (NPB) on Indium Tin Oxide, *F.M. Avendano*, *E.W. Forsythe*, *Y. Gao*, University of Rochester; *C.W. Tang*, Eastman Kodak Company

Since the first report on Organic Light Emitting Devices (OLED)@footnote 1@ there has been much interest for their potential applications as flat panel displays. In these devices charge carriers are injected into the organic layers across the interfaces and the electrode/organic interface characteristics have a strong effect on the device efficiency. Among these characteristics, the morphology of the anode(Indium Tin Oxide) strongly affects the device stability@footnote 2@ as revealed by the presence of microshorts in I-V curves. We study the growth mode of N,N-bis-(1-naphthyl)-N,N-diphenyl-1,1-biphenyl-4,4-diamine (NPB) on Indium Tin Oxide (ITO)/Glass substrates using Atomic Force Microscopy (AFM) and Lateral Force Microscopy (LFM). The addition of LFM to AFM allows us to

clearly distinguish the features due to NPB or ITO. The study was performed as a function of the ITO morphology and NPB thickness. In order to modify the ITO surface morphology a series of processing steps were applied reducing the roughness more than three times as compared to the as received ITO. Next, NPB was deposited with thickness of 5, 15, 30 and 150Å onto the flat and as received ITO. At 5Å of NPB on the flat ITO, AFM/LFM pictures reveal the formation of NPB islands. These islands start to coalesce at a thickness of 15Å. At 30Å of NPB on flat ITO the film exhibits some pinholes which are no longer present at 150Å of NPB on flat ITO. The NPB films grown onto as received ITO show ITO features at the thickness of 5, 15, and 30 Å of NPB and the roughness of the NPB film is an order of magnitude bigger as compared to the NPB grown onto flat ITO. These ITO features present in the NPB film grown onto as received ITO may have detrimental effects on device performance as a consequence of microshorts. @FootnoteText@ @footnote 1@C. W. Tang and S. A. Van Slyke, Appl. Phys. Lett. 51, 913 (1987) @footnote 2@F. M. Avendano, E. W. Forsythe and Yongli Gao. The American Physical Society, March 1998.

OE-MoP4 Second-Harmonic-Generation Spectroscopy and Hyper-Rayleigh Scattering in Langmuir Films of C60 and its Derivatives, E.D. Mishina, T.V. Misuryaev, A.A. Nikulin, Moscow State University, Russia; V.R. Novak, Institute of Physical Problems, Russia; Th. Rasing, University of Nijmegen, The Netherlands; O.A. Aktsipetrov, Moscow State University, Russia

We report here the results of experimental studies by second-harmonicgeneration (SHG) spectroscopy and hyper-Rayleigh scattering (HRS) of thin Langmuir films of C60 and C60-derivatives: C60-tetracyanoethylene oxide derivative (C60[CN]) and C60-indopane derivative (C60[-ind]). Langmuir technique allows to fabricate thin films with controlled thickness with monolayer resolution and ordering the molecules within the layer, while the SHG probe provides a reliable diagnostic tool for such films. For the SHG measurements the output of a Ti:Sapphire laser in the range of the fundamental wavelength of 710-800 nm is used. SHG spectroscopic studies showed that, depending on the nature of organic group, the modification of C60 molecules can either increase (for C60[CN]) or decrease (for C60[ind]) the SHG intensity in thin fullerene films, while the general character of the spectra remains unchanged. The obtained results can be interpreted as due to the following two mechanisms: nonuniform broadening of resonances due to fluctuations, that is also revealed in absorbtion spectra; breaking of the inversion symmetry of C60 molecules by the organic "grafts" resulting in appearence of dipole hyperpolarizability and its interference with the quadrupole hyperpolarizability of C60 "cage". Hyper-Rayleigh scattering allowed us to get information about the structural and statistical properties of these systems. In particular, the modification of C60 molecules with the [CN] "graft" does not noticeably change the structure of the Langmuir films: for both C60 and C60[CN] monolayer samples have a disordered island-like structure, whereas the multilayer C60 and C60[CN] samples indicate their more regular structure. The modification of C60 molecules with the [ind]-"graft" significantly increases homogeneity of the monolayer samples. In all films the characteristic spatial scale of in-plane fluctuations of the HRS sources has been estimated.

OE-MOP5 Structure and Properties of the System of Nanometer-scale Quantum Wells Fabricated by the Incorporation of Organic Molecules in Sol-gel SiO@sub 2@ Glass, J. Perez-Bueno, Univ. Autonoma de Queretaro, Mexico; L.L. Diaz-Flores, Inst. Tecnologico de Saltillo, Mexico; F.J. Espinoza-Beltran, CINVESTAV-IPN, Mexico; R. Ramirez-Bon, Universidad de Sonora, Mexico; Y.V. Vorobiev, J. Gonzalez-Hernandez, CINVESTAV-IPN, Mexico

Organic molecules of the colorants (like Fast Green, Brilliant Black, Tartrazine, etc.)were encapsulated in SiO@sub 2@ glass derived by the solution-gelatinization process. The doping organic material in a power form was added to the initial solution, and after its solidification and annealing the colored glass was obtained containing the molecules of the colorants within the vitreous matrix. The optical and photoacoustic absorption as well as the photoluminescence excitation and emission spectra reveal the existence of sets of the discrete energy levels in these systems. The levels separation were determined by the structure of the colorant's molecule and the percentage of doping. The quantum mechanical description of the system is given considering the organic molecules as the two-dimensional or circular potential wells, depending on the molecular structure. The finite depth of the wells is taken into account by introduction of the periodic boundary conditions, which essentially influences the calculated energy spectra. The dependence of the spectra upon the colorant concentration is explained on the basis of the perturbation theory and, in itself, confirms the importance of the account of the finite depth of the potential wells. The theory was a reasonable

Monday Evening Poster Sessions, November 2, 1998

agreement with the experiment. The results obtained demonstrate that the sol-gel technology gives a simple and cheap method of fabrication of a system of the nanometer-scale potential wells with a set of the energy levels which could be regulated by the structure of the doping molecules and their concentration.

OE-MOP6 Structures and Growth of Monolayers of 4-methyl-4'mercaptobiphenyl on Au(111): The Role of the Molecular Backbone, **T.Y.B. Leung**, Princeton University; *P. Eisenberger*, Columbia Earth Institute; *F. Schreiber*, Max-Planck-Institut für Metallforschung, Germany; *P. Schwartz*, Princeton University; *A. Ulman*, Polytechnic University; *G. Scoles*, Princeton University

We present the results of a comprehensive diffraction study of monolayers of 4-methyl-4'-mercaptobiphenyl assembled on Au(111) [abbreviated as mbp]. Two phases of different density are observed. The diffraction patterns suggest that a low-density phase can be comprised of molecules assembling in rows with their molecular axes parallel to the surface. A second, high-density phase is thought to be composed of a hexagonal arrangement of molecules, which are aligned along the surface normal. We denote the low-density phase as the "striped" phase and the high-density phase as the "hexagonal" phase. Although the striped phase and the hexagonal phase are also observed in monolayers of n-alkanethiol on Au(111) [abbreviated Cn], interesting differences have been found. Apart from the structural differences, annealing experiments show that both phases of mbp are more thermally stable than the phases of Cn. In addition, the growth behaviour of mbp is investigated and different growth protocols have been attempted. Unlike the case of Cn where the hexagonal phase can be grown reliably and reproducibly, the hexagonal phase of mbp has only been observed a few times. We will address the role of the molecular backbone in the self-assembly process process of thiol on gold, based on the disparities in the structures, the thermal behaviour, and the growth behaviour between mbp and Cn.

Author Index

Bold page numbers indicate presenter

- A -Aktsipetrov, O.A.: OE-MoP4, 1 Avendano, F.M.: OE-MoP3, 1 - D -Diaz-Flores, L.L.: OE-MoP5, 1 - E -Eisenberger, P.: OE-MoP6, 2 Espinoza-Beltran, F.J.: OE-MoP5, 1 - F -Forsythe, E.W.: OE-MoP2, 1; OE-MoP3, 1 Gonzalez-Hernandez, J.: OE-MoP5, 1 - H -Hill, I.G.: OE-MoP1, 1 - K --Kahn, A.: OE-MoP1, 1 - L --Leung, T.Y.B.: OE-MoP6, 2 - M --Mishina, E.D.: OE-MoP4, 1 Misuryaev, T.V.: OE-MoP4, 1 - N --Nikulin, A.A.: OE-MoP4, 1 Novak, V.R.: OE-MoP4, 1 Nüesch, F.A.: OE-MoP2, 1 - P --Perez-Bueno, J.: OE-MoP5, 1 - R --Ramirez-Bon, R.: OE-MoP5, 1 Rasing, Th.: OE-MOP4, 1 — S — Schreiber, F.: OE-MOP6, 2 Schwartz, P.: OE-MOP6, 2 Scoles, G.: OE-MOP6, 2 — T — Tang, C.W.: OE-MOP6, 2 — U — Ulman, A.: OE-MOP6, 2 — V — Vorobiev, Y.V.: OE-MOP5, 1