Monday Morning, October 25, 1999

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

Organic Devices

Moderator: A. Kahn, Princeton University

8:20am OE+EM+FP-MoM1 Invited Paper, C.W. Tang, Eastman Kodak Company INVITED

NO ABSTRACT SUBMITTED.

9:00am **OE+EM+FP-MoM3 Ultrafast Electron Relaxation in Excited, DCM Doped Alq Films, K. Read**, University of Michigan; H.S. Karlsson, Royal Institute of Technology, Sweden; M.M. Murnane, H.C. Kapteyn, University of Michigan; R. Haight, IBM T.J. Watson Research Center

Electrons photoexcited into the lowest unoccupied molecular orbital (LUMO) of Alq (tris(8-hydroxyquinoline)aluminum) films doped with DCM (4-dicyanomethylene-2-methyl-6-p-dimethylaminostyryl-4H-pyran) have been studied using excite-probe laser photoemission. DCM doping, achieved by co-evaporation with Alq, is an important means of color tuning and enhancing Alg organic LED emission. In addition, DCM doped Alg films have been shown to lase at low photoexcitation thresholds. A detailed understanding of the involved relaxation mechanisms is beneficial to both applications. Using 3.14 eV excite, and 26.7 eV probe, 100 femtosecond laser pulses, we have observed the LUMO decay rate over the first 175 picoseconds, during which time diffusion is insignificant, and all dynamics occur in the absence of electron transport. We have found that the LUMO population fits to a model wherein the majority of the excitation rapidly transfers from the Alg to the DCM and decays via stimulated emission in the DCM, concentration quenching in the DCM, and bimolecular singletsinglet annihilation in both the Alq and the DCM. Increasing either the DCM doping percentage, or the excitation intensity, is seen to significantly enhance the early, fast processes. The occupied to unoccupied molecular orbital energy gap shrinks as a function of excite-to-probe delay, in accordance with the expected energy relaxation within the excited states. Pure DCM yields a correspondingly smaller energy gap, and rapid LUMO decay. Analyzing the LUMO decay mechanisms allows an improved understanding of the functions served by DCM doping of Alq films.

9:20am OE+EM+FP-MoM4 Unoccupied Molecular Orbitals in Organic Electroluminescent Materials Studied by Femtosecond Harmonic Photoemission, H.S. Karlsson, Royal Institute of Technology, Sweden; K. Read, University of Michigan; R. Haight, IBM T.J. Watson Research Center We have studied the lowest unoccupied molecular orbital (LUMO) in three organic electroluminescent materials using pump-probe harmonic photoemission based on a femtosecond laser system. The energy gap between the LUMO and the highest occupied molecular orbital (HOMO) in thin films of the blue-light-emitting molecules bis(2-methyl-8quinolinolato)(para-phenyl-phenolato)aluminum (BAlq) and 1,4-bis(2,2diphenylvinyl)biphenyl (DPVBi) was established and compared with the green-light-emitting molecule tris(8-hydroxyquinoline)aluminum (Alq). We have also studied the LUMO decay characteristics for the three materials and relate the differences in decay times to the morphology of the evaporated thin films. The effect on the electronic structure of the organics induced by deposition of metallic overlayers will also be shown and discussed.

9:40am OE+EM+FP-MoM5 Femtosecond Charge Transfer Processes in Organic Molecular Heterostructures, A.J. Mäkinen, S. Schoemann, Y. Gao, University of Rochester; M.G. Mason, A.A. Muenter, Eastman Kodak Company; A.R. Melnyk, Xerox Wilson Center for Research & Technology The charge transfer (CT) process in organic semiconductor heterostructures is an important problem for applications such as photoreceptors and lightemitting devices. The operation of a photoreceptor structure is based on a CT process at the interface of a charge generator layer and a charge transport layer. We have investigated such a structure formed by vacuum grown thin films of two organic molecules, N,N'-diphenethyl-3,4,9,10perylenetetracarboxylic-diimide (DPEP) and N,N'-diphenyl-N,N'-(3methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD), with femtosecond timeresolved photoemission spectroscopy (TR-PES). By measuring the lifetimes of the excited electron states in the mixtures and in the bilayer structures of these molecules, and by recording the UPS spectra of the films we are able to determine the time-scale and the energy regime for the CT process. Our results show that the CT takes place in less than 10 fs between the

DPEP and the TPD molecules. We also demonstrate the significance of the film interface in separating the charges upon CT.

10:00am OE+EM+FP-MoM6 A Comparison of Organic Light-Emitting Devices Using Transient Current-Transient Voltage, Transient Brightness-Transient Voltage, and Transient Brightness-Transient Current Analysis, *B.J. Norris, J.F. Wager*, Oregon State University; *J. Liu, Y. Yang*, University of California, Los Angeles

Four types of organic light-emitting devices (OLEDs) are compared using transient current-transient voltage [i(t)-v(t)], transient brightness-transient voltage [b(t)-v(t)], and transient brightness-transient current [b(t)-i(t)] analysis.@footnote 1@@footnote 2@ These analysis methods consist of obtaining the instantaneous brightness [b(t)], current [i(t)], and voltage [v(t)] of the device under test when it is subjected to a bipolar, piecewiselinear applied voltage waveform and then plotting these quantities parametrically. The four types of OLEDs considered are: two types of green OLEDs and a blue OLED, provided by the Eastman-Kodak Co., and a polymer light-emitting device (PLED) fabricated at the UCLA. The OLEDs are duallayer heterostructures, involving an electron transport layer (ETL) and a hole transport layer (HTL). In contrast, the PLED is a single-layer device. The ETL and HTL capacitances of heterostructure OLEDs can be estimated from b(t)-i(t) curves. The b(t)-v(t) curves allow the conduction current to be estimated. Perhaps the most interesting aspect of this study is the existence of a small bump in the retrace portion of i(t)-v(t) curves of heterostructure OLEDs, which is not observed in single-layer PLEDs. This bump is ascribed to the removal of accumulated holes at the ETL/HTL interface. Hole accumulation at the ETL/HTL interface of OLED heterostructures is manifest as hysteresis in b(t)-v(t) curves. @FootnoteText@ @footnote 1@B. J. Norris, J. P. Bender, and J. F. Wager, "Steady-State Transient Voltage-Transient Current Characterization of OLEDs," SID Digest, in press. @footnote 2@ B. J. Norris, "Characterization of Organic Light-Emitting Devices," MS Thesis, Oregon State University, 1999.

10:20am OE+EM+FP-MoM7 Organic and Polymer Transistors: Device Physics, Functional Blocks, and Circuits, A. Dodabalapur, B.K. Crone, Y.Y. Lin, J.A. Rogers, S. Martin, R. Sarpeshkar, Z. Bao, W. Li, H.E. Katz, V.R. Raju, Bell Laboratories, Lucent Technologies INVITED

This presentation will begin with a description of the basic physics of typical organic and polymer transistors and the factors which determine and influence the apparent mobility. The transient characteristics organic transistors with sub-microsecond switching speeds will be described. The integration of organic light emitting diodes and transistors is promising for emissive displays. We have developed designs for 'smart' pixels in which an analog circuit consisting of 6-7 transistors drives each LED. The simulated and experimental characteristics of such pixels will be presented. The development of air-stable n-channel organic transistors led to our demonstrating the first organic complementary circuits. The design considerations and characteristics of organic complementary circuits with > 100 transistors will be described. The noise properties of organic transistors and their use in gas sensors will be described.

11:00am OE+EM+FP-MoM9 Sub-microsecond Switching of n and p-Channel Organic Field Effect Transistors, *B.K. Crone*, *A. Dodabalapur*, *Z. Bao*, *W. Li*, Lucent Technologies, Bell Laboratories

Steady state and transient electrical characteristics are presented for pchannel (@alpha@,@omega@-dihexyl quinquethiophene) and n-channel (copper hexadecaflourophthalocyanine) organic field effect transistors. The structure of the transistor is as follows. The gate electrode is a doped silicon wafer with a thermal oxide gate oxide. Gold source and drain contacts are evaporated and photolithographically defined on the oxide, and finally the active organic film is evaporated. The transistors measured had channel length of 4 μm and width 250 $\mu m.$ Field effect carrier mobilities are determined for both the steady state and transient response using a simple model for the saturated drain current. The steady state mobility and threshold voltage were determined by a linear fit to the square root of the saturated drain current versus gate voltage. Steady state mobilities of 1.5x10@super -2@cm@super 2@/Vs for the p-channel and 3x10@super -2@cm@super 2@/Vs for the n-channel were measured. Transient mobilities were determined using the same model for the saturated drain current and the threshold voltage obtained in the steady state case. Transient mobilities were higher, 3x10@super -2@cm@super 2@/Vs for the p-channel and 1.5x10@super -1@cm@super 2@/Vs for the n-channel devices. The transient responses showed switching times less than 1 µsec for both p and n-channel devices.

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