

Organic Films and Devices

Room 318/319 - Session OF+NS-WeM

Molecular Electronics

Moderator: D. Cahen, Weizmann Institute of Science, Israel

8:20am **OF+NS-WeM1 Electronics and Mechanics with Single Molecules, P.L. McEuen, Cornell University** **INVITED**

It is now possible to make electronic and mechanical devices where an individual molecule is the active element. Examples include devices made from single-walled carbon nanotubes or single organic molecules. These molecular devices are proving to be wonderful systems for the study of the physics of materials at the nanometer scale. In this talk, I will review recent progress within our group on the electrical, electromechanical, and electrochemical properties of individual nanotubes and single molecules, as inferred from both transport and scanned probe measurements.

9:00am **OF+NS-WeM3 Understanding Charge Transport in Molecular Electronics, J.G. Kushmerick, R. Shashidhar, Naval Research Laboratory**

We use an experimentally simple crossed-wire tunnel junction to interrogate how factors such as metal-molecule coupling, molecular structure and the choice of metal electrode influence the current-voltage characteristics of a molecular junction. Results on junctions with symmetric and asymmetric metal-molecule contacts demonstrate that a specific molecular core can act either as a molecular wire or a molecular rectifier depending on its coupling to the metal electrodes. By tuning the coupling at the two metal-molecule interfaces-through the use of different attachment chemistries and metal electrodes-we are able to control the extent of current rectification. Experimental measurements and theoretical calculations demonstrate that the conductance of a molecular wire can be directly related to how well it's π -conjugated backbone mimics an ideal one-dimensional metal. Finally, we will show that the conductance of a molecular junction scales with the number of molecules contacted, and that the π -systems of molecular wires connected in parallel are not strongly coupled. Initial results demonstrating the utility of in situ vibrational spectroscopy to characterize the molecular junction will also be presented.

9:20am **OF+NS-WeM4 Observation of Negative Differential Resistance Measured through Individual Molecules on Silicon at Room Temperature, N.P. Guisinger, R. Basu, A.S. Baluch, M.C. Hersam, Northwestern University**

In recent years, substantial progress has been made in the emerging field of molecular electronics. In particular, metal-molecule-metal junctions have been widely studied. In this paper, charge transport through molecule-semiconductor junctions is considered. The presence of the energy band gap in semiconductors provides opportunities for resonant tunneling through individual molecules, leading to interesting effects such as negative differential resistance (NDR). The ultra-high vacuum (UHV) scanning tunneling microscope (STM) allows individual molecules to be imaged, addressed, and manipulated on semiconducting surfaces with atomic resolution at room temperature. This paper considers two distinct chemistries on the Si(100) surface. Styrene reacts with Si(100) via a covalent silicon-carbon bond. On degenerately n-type Si(100), STM current-voltage characteristics on individual styrene molecules show clear NDR at negative sample biases of approximately -2.5 V and -4 V. However, at positive sample bias, the styrene is liberated from the surface via inelastic electron stimulated desorption (ESD). In an effort to minimize perturbation via ESD, individual 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) molecules were bound to degenerately n-type Si(100). The exceptional stability of the silicon-oxygen bond allows charge transport measurements on TEMPO at high biases up to ± 5 volts without ESD. Similar to styrene, NDR is clearly observable at negative sample biases of approximately -3 V, -4 V, and -4.5 V. These effects will be explained by considering the energy band diagram of the semiconductor-molecule junction.

9:40am **OF+NS-WeM5 Molecular Materials and Devices, C.R. Kagan, A. Afzali, R. Martel, P.M. Solomon, L.M. Gignac, A.G. Schrott, B. Ek, C. Lin, IBM T.J. Watson Research Center** **INVITED**

Efforts to fabricate devices based on active molecular components have been driven by both the fundamental interest in using chemistry to build function at the molecular level and the looming technological expectation of the end of Moore's law. In this talk, we describe the directed assembly of organic and metal-metal bonded supramolecular systems that are interesting materials for potential electronic and memory device

applications. Molecules are chosen with head groups that bind to metal or oxide surfaces and tail groups that bind to metal electrodes or that template the growth of the particular molecular system. Optical spectroscopy, atomic force and scanning tunneling microscopy, electrochemistry, and electrical measurements are used to characterize the chemistry and physics of molecular assemblies and the behavior of devices. Self-assembled organic monolayers are used to fabricate reported field-effect transistor structures and to elucidate the important requirements necessary to successfully design two- and three-terminal molecular devices. We demonstrate the layer-by-layer assembly of metal-metal bonded supramolecules and utilize this approach to fabricate molecular devices.

10:20am **OF+NS-WeM7 Mediating Electronic Switching of Single Molecules Using Chemical Interactions, P.A. Lewis, The Pennsylvania State University; C.E. Inman, University of Oregon; J.M. Tour, Rice University; J.E. Hutchison, University of Oregon; P.S. Weiss, The Pennsylvania State University**

We have studied conjugated phenylene-ethynylene oligomers inserted into amide-containing alkanethiolate self-assembled monolayers using scanning tunneling microscopy in order to determine their physical and electronic properties when surrounded by a hydrogen-bonded matrix. The phenylene-ethynylene oligomers show stability in two conductance states, an ON and an OFF state. We observe fewer switching events between the ON and OFF states than previously reported for n-alkanethiolate matrices and attribute this to the rigidity due to the hydrogen bonds of the amide groups in the matrix. Furthermore, we demonstrate bias-dependent switching as a result of hydrogen bonding between the substituents of the inserted oligophenylene-ethynylene and the matrix molecules. We demonstrate that the chemical and physical environment of proposed molecular devices is crucial to their function and can be exploited to impart tunable electronic properties.

10:40am **OF+NS-WeM8 Two-Photon Photoemission Studies of Molecular Affinity Levels in Oligo-Phenylene Ethynylene Self-Assembled Monolayers, C. Zangmeister, S.W. Robey, R.D. van Zee, National Institute of Standards and Technology**

Two-photon photoemission has been used to study unoccupied electronic levels for a family of thiolated oligomeric phenylene-ethynylene self-assembled monolayers. Self-assembled monolayers of a three phenyl ring oligomer (OPE) and the same oligomer with a nitro group substituted for one hydrogen on the center ring (NO@sub2@-OPE) were formed on polycrystalline Au/Si substrates as well as [111] oriented Au on mica. This class of compounds has received attention because of measured conduction characteristics and the reported negative-differential resistance behavior of these compounds in nanometer-sized pore structures. Single-color, two photon photoelectron spectroscopy measurements were performed in the ultraviolet using frequency-doubled, subpicosecond pulses from a Ti:Sapphire-pumped optical parametric amplifier. For the OPE monolayers we have, based on the excitation energy dependence, identified an unoccupied level ca. 1 eV above the vacuum level. Using previous two-photon photoemission and inverse photoemission of condensed benzene layers as a guide we tentatively identify this as the remnant of the e@sub2u@ unoccupied level for benzene localized on the carbon atoms of the phenyl ring. Results of studies on NO@sub2@-OPE layers will also be discussed.

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