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Electronic Conduction in Metal/Molecule/Semiconductor Devices

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In the field of molecular electronics, the contacts to the molecular elements are critical interfaces. The use of semiconductor contacts allows direct covalent bonding, provides an additional degree of freedom due to the semiconductor states, and, in certain circumstances, can minimize the effects of electrical shorting due to direct metal/substrate contacts. This talk will describe the development and electrical characterization of metal/molecule/semiconductor device structures on GaAs and Si active layers. In order to observe the conductance of the molecular species, rather than that of the semiconductor barrier, the semiconductor layers used in this study are generally highly doped. In these structures, the electronic conduction between the metal and semiconductor can be modulated by choice of molecular species. Several alkyl thiol and aromatic thiol molecules have been employed in order to determine the effects of molecular length, conjugation and intrinsic dipole moment. In certain molecules, conductance peaks or memory/switching effects have been observed. The current-voltage characteristics and conductance versus temperature both indicate that the molecular layers change the transport mechanism, generally involving a lower effective barrier height than that of a metal/semiconductor Schottky barrier. Studies on both n- and p- type substrates, including those with nanometer scale cap layers, allow the effects of the molecular and semiconductor barriers to be isolated. A basic conduction model has been developed, based on the electrostatics of the structure and thermionic-field-emission analysis of the semiconductor portion of the barrier.