

# Nanoscale Crossed-Wire Molecular Junction Devices

<sup>1</sup>Heayoung Yoon, <sup>1</sup>Lintao Cai, <sup>2</sup>Masato Maitani, <sup>3</sup>David L. Allara, and <sup>1</sup>Theresa S. Mayer

<sup>1</sup>Department of Electrical Engineering, <sup>2</sup>Material Science and Engineering, and <sup>3</sup>Chemistry  
The Pennsylvania State University, University Park, PA 16802

Considerable attention is being devoted to developing an understanding of the mechanisms that dominate electrical transport in metal-molecule-metal junctions comprised of small ensembles of molecules. Here we present a new nanoscale crossed-wire molecular junction device that is ideally suited for studying variable and low-temperature electrical and spectroscopic properties of molecular junctions. The junctions are comprised of self assembled monolayers (SAMs) of molecules sandwiched between lithographically defined bottom metal electrodes and electrofluidically aligned top metal nanowire electrodes. This fabrication process permits rapid integration of junctions with different molecules and metal contacts, and minimizes process induced damage common in SAMs contacted using evaporated top metal. Temperature dependent (10 – 300 K) current-voltage (I-V) characteristics and vibrational spectra measured by inelastic electron tunneling (IET) spectroscopy were collected for candidate molecular wires and bistable switching molecules. The I-V of the oligo(phenylene-ethynylene) (OPE) molecular wire junctions was stable and reproducible between  $\pm 1V$ . The junctions had temperature independent I-V that is indicative of coherent tunneling transport. Three predominant peaks at 130 mV, 202 mV, and 274 mV were observed in the IET spectra of the OPE junctions, which can be tentatively assigned to the vibration of  $\nu(18a)$ ,  $\nu(8a)$ , and alkyne stretch of this molecule. Measurements on junctions that incorporate thiol substituted oligoaniline derivatives show reproducible bistable switching with an on-off ratio of  $>5:1$  at 1V and a room temperature retention time much longer than 24 hours. A significant peak intensity change was observed around 170 mV C-N stretch mode that depends on the state of the junction and are indicative of a change in the electron delocalization around the  $-N$  atoms. These data suggest that the switching is due to a voltage-induced change in the conformation of the molecule.

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**Figure 1:** Crossed-wire molecular junction device: Field Emission Scanning Electron Microscope (FESEM) images showing the device structure comprised of lithographically defined 70-nm wide bottom electrode and 200-nm diameter NW top electrode. Inset shows a schematic of metal-molecule-metal junctions.

