Molecular Orbitals Gating for a Single Long, Rigid, Planar Molecular Wire

Chun Ouyang, Yuma Ito, Kohei Hashimoto, Hayato Tsuji, Eiichi Nakamura and Yutaka Majima

Materials and Structures Laboratory, Tokyo Institute of Technology, Yokohama 226-8503, Japan
Department of Chemistry, School of Science, University of Tokyo, Tokyo 113-0033, Japan
Department of Chemistry, Faculty of Science, Kanagawa University, Hiratsuka 259-1293, Japan

Email: ouyang.c.aa@m.titech.ac.jp

We have reported that carbon-bridged oligo(phenylenevinylene)s (COPVn) serve as effective molecular wires as demonstrated by photoinduced electron transfer because of their rigid structures to achieve effective π-conjugation. In this presentation, we demonstrate that resonant tunneling through molecular orbitals for SAuSH device, in which COPV5(SH)2 molecular wire (Figure 1) is one-side chemical bonded to electrodes. Due to improved nanogap electrodes of our electroless Au-plated (ELGP) nanogap Pt electrodes with the top radius of a few nm, we report that resonant tunneling is modulated by application of gate voltage. The initial structures of the source, drain, and two side gate electrodes of Ti/Pt were fabricated on a SiO2/Si substrate via electron beam lithography (EBL) and lift-off processes. Electroless Au-plating was carried out to reduce the electrode gaps to ~3 nm (Figure 2), followed by the introduction of a COPV5(SH)2 molecule between the nanogap electrodes by immersing into a solution of COPV5(SH)2. We then measured the current-voltage (I-V) characteristics at 9 K using a mechanical He-refrigerator-type prober station, and differential conductance is numerically calculated in Figure 3. Negative second dI/dV peak have been observed largely shifted by application of gate bias at -8 V (Figure 3, red lines). We suggest that the transport mechanism of this single molecular wire is resonant tunneling phenomena under the alignment of a molecular orbital with Fermi energy of a source or drain electrode.

This study was partially supported by MEXT Elements Strategy Initiative to Form Core Research Center; the collaborative Research Project of the Laboratory for Materials and Structures, Tokyo Institute of Technology; the BK Plus program, Basic Science Research program (NRF-2014R1A6A1030419); and Grant-in-Aid for scientific research (15H05754 to E.N. and 16H04106 to H.T.).