金属内包 Ce@C_{82} 単一分子トランジスタにおける分子回転効果

Rotation effect in endohedral metallofullerene Ce@C_{82} single-molecule transistors

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Fullerene molecules can accommodate a variety of metal atoms into their hollow cage. By incorporating the metal atoms, the endohedral metallofullerenes (EMFs) can exhibit diverse physical properties, which manifest EMFs as useful electronic elements. In fact, EMFs often exhibits anisotropic molecular orbitals because the encapsulated metal atom prefer to locate at the off-center, which induces electric dipole in the EMFs. In such a single-molecule transistors (SMT), switching the orientation of the molecular configuration with respect to the electrodes can drastically change the transport characteristics [1,2]. In-situ manipulation of the EMF molecule in nanogap electrodes and systematic study of the anisotropic molecular effect in SMTs remain to be explored.

We have investigated the electron transport in Ce@C_{82} SMTs with different molecular configurations modulated by applied voltage V_{SD} across the nanogap, as shown in Fig. 1(a). Figure 1(c) shows the Coulomb stability diagram of a Ce@C_{82} SMT measured at 4.2 K before applying an electric stress. The vibrational excitations of the Ce atom at 5 mV and 24 mV are clearly observed. After the application of V_{SD} = 0.6 V, the excited-state line at 24 mV is still observed, as indicated by the arrow in Fig. 1(d). This confirms electron transport through the same molecule. From the slopes of the ground state lines, we find that the capacitance to the source electrode increases, while the gate coupling slightly decreases. This suggests the switching of the molecular orientation caused by the interaction between electric field and its diploe moment. We also systematically switch the polarity of the applied electric field, tending to redirect the dipole moment generated by the doped atom in the Ce@C_{82} molecule. We consistently observe two molecular configurations, reflected in the distinct Coulomb stability diagrams. From the analysis of the stochastic switching of the tunneling current I_{SD} at different V_{SD}, we also deduce the dwell time for the Ce@C_{82} molecule in each configuration.

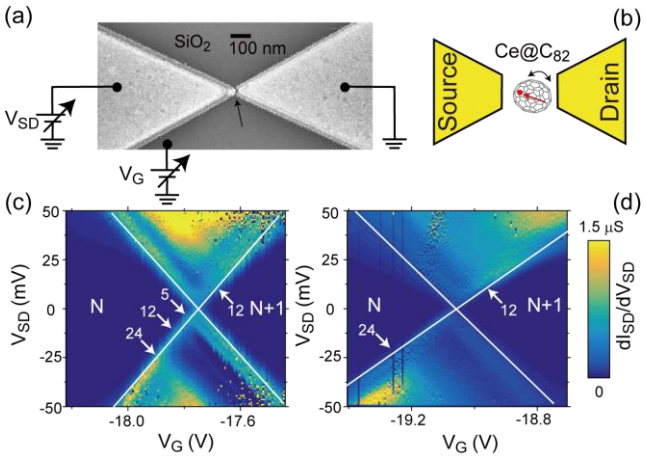

Figure 1. (a) Scanning electron micrograph of a electromigrated nanogap, where the position is indicated by the arrow. V_{SD} and V_G are source-drain voltage and gate voltage, respectively. (b) Schematic of the device structure of a Ce@C_{82} single-molecule transistor (SMT). The dipole moment induced by the Ce atom in fullerene is denoted by red arrow. (c) and (d) Coulomb stability diagrams for the same SMT before and after the application of V_{SD} = 0.6 V, respectively.

References [1] N. Okamura, et al., Appl. Phys. Lett., **106**, 043108 (2015), [2] S. Sakata, et al., Phys. Rev. Lett., **111**, 246806 (2013)