Room Temperature Operation of Porphyrin Protected Au Nanoparticle Single-Electron Transistor

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Nanodevices such as single-electron transistors (SETs) have been studied extensively because of their potential merits such as low voltage operation, low power consumption and high-speed operation. However, for practical applications of SETs, it should be required to operate at room temperature. Towards a room temperature operation, the charging energy of the device needs to be higher than thermal energy k_BT (26 meV at 300 K). Chemically synthesized Au nanoparticles with few nanometers size as Coulomb island are good candidates for this purpose, since the size and shape of our nanoparticles can be well controlled with the size distribution of ±10%. Moreover, a ligand of porphyrin derivatives can give the rigid structure and availability of resistance control which show stable Coulomb blockade and Coulomb staircase at room temperature. Previously, we investigated this materials as Coulomb island for SET study and obtained the clear Coulomb staircase behaviors at room temperature[1]. The nanoparticle size of 1.4 nm showed the high charging energy of 235 meV that is more than 9 times larger than the thermal energy. However, more detailed clues are required to demonstrate clear working concept at room temperature of this SET. More stable structures need to be fabricated to get higher charging energy or rigid structures of SET.

In this study, we fabricated the SET based Sn-Porphyrin protected Au nanoparticles as Coulomb island based on electroless Au plated (ELGP) Pt nanogap electrodes. We observed clear Coulomb blockade and Coulomb staircase behavior at 9K and room temperature (Figure 1). We also report clear Coulomb oscillation at both 9K and room temperature (Figure 2), which indicate the room temperature operations of the SET.

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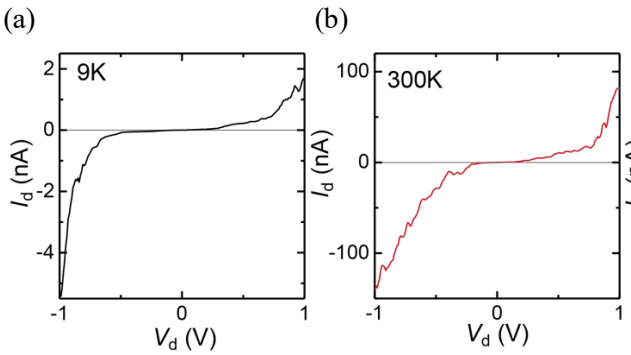

Fig 1. Experimental I_d-V_d characteristics of a Sn-Porphyrin protected Au nanoparticle SET at (a) 9 K, and (b) RT.

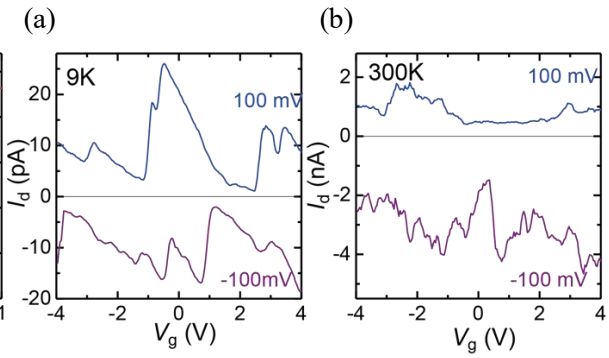

Fig 2. Experimental I_d-V_g characteristics of the same SET (a) 9 K, and (b) RT.