Development of Molecule-Qubit Combining Single-Molecule-Magnet and Superconductor Electrode

Tadahiro Komeda

Tohoku University, IMRAM

tadahiro.komeda.a1@tohoku.ac.jp

The application of magnetic molecules to the materials of the devices for the quantum information process attracts attention. It is critical to make the sharp spin state of the molecule coupled efficiently with the electric current and substrate. The double-decker phthalocyanine complex of bis(phthalocyaninato)terbium(III) (TbPc2) molecule showed intriguing single-molecule magnet (SMM) behavior and was examined on the substrates Au(111) and Ag(111). Here, we studied the $TbPc_2$ molecule adsorbed on the superconducting substrate of NbSe2 to demonstrate the use of the mix states between the SMM spins and the superconducting state. By combing with the radio frequency microwave injection shown in Figure 1, we can manipulate the qubit system of the SMM molecule.

Experimentally, we show the scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS) studies at the sample temperature of 400 mK (Unisoku, Japan) for the system of $TbPc_2$ molecules. The system is equipped with 10 T magnet and the microwave injection system.

First, we observed Yu-Shiba-Rusinov (YSR) states formed by the superconductor and the magnetic molecule systems, which appear in the superconducting gap. Figure 2 shows the YSR state induced by the magnetic field of the $TbPc_2$ molecule, which can be manipulated with the molecule's structural configuration. Next, we examine the ESR/NMR signals detected by the RF signal injection (Figure 3). This has been achieved by monitoring the YSR signal intensity as the function of the RF frequency. The plot shows the resonance at the frequencies expected for the ESR/NMR resonances of the $TbPc_2$ molecule. We anticipate our results can be contributed towards the utilization of SMM as the building blocks of the future spintronics devices as well as fascinating application to the data storage or quantum computing.

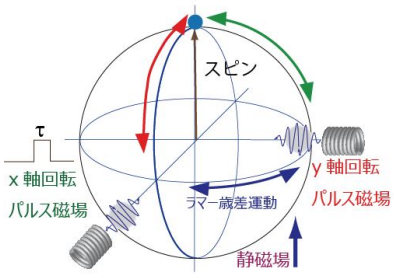

Figure 1 Illustration of the spin qubit manipulation with pulse RF.

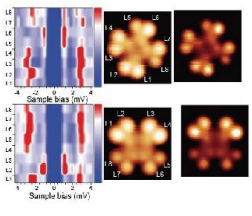

Figure 2 Topographic and spectroscopic mapping of the $TbPc_2$ molecule on NbSe2

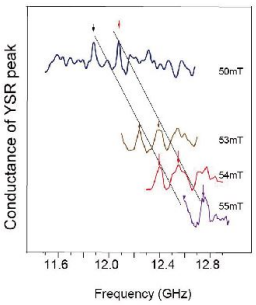

Figure 3 ESR/NMR detected by the tunneling current for $TbPc_2$ molecule

© The Chemical Society of Japan