Activity Report on MERIT Internship

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【Implementation Period】 August 27, 2018 – September 27, 2018

【Accepting Institution】 RIKEN Quantum Nanomagnetism Research Team

【Overview】

RIKEN Quantum Nanomagnetic Research Team is a team that conducts pioneering research in spintronics research. The team is investigating the dynamic and static fundamental physical properties of nano-scale magnetic material. In the magnetic vortex structure, paying attention to its spin dynamics, fabrication of "magnetic artificial lattice (Magnonic crystal)" in which they are two-dimensionally arranged · The team is conducting research on the flow of only spin angular momentum called "pure spin current" without control flow, using control and nanoscale magnetic material. By injecting a pure spin current into a nonmagnetic metal or superconductor, they have successfully observed various interesting phenomena such as spin Hall effect, spin injection magnetization reversal, spin accumulation effect and so on. Especially in recent years, we have various experiments such as bulk spin conversion, observation of spin current-current conversion at metal / insulator interface, and have fulfilling experiment facilities.

【Research content】

In recent years, the spin current, which is the flow of the spin angular momentum, is attracting attention not only from the basic physical point of view. In the pure spin current without the flow of electric charge with respect to the current used for information transmission in conventional electronics, further miniaturization of wiring and element size is expected, and the amount of current required for driving can be minimized from the beginning.The spin Hall effect in transition metals such as platinum has been used to generate and detect spin currents required to drive spintronic devices. In recent years, highly efficient spin current-to-current conversion (Edelstein effect) beyond transition metals is possible by using spin-splitting surface states that are developed on solid interfaces that have broken space inversion symmetry or on the surface of topological insulators which is shown that it is attracting attention.

In the research related to this internship, we focused on molecules with electric dipoles called lead phthalocyanine and newly discovered the spin-to-charge current conversion effect at the molecule/metal interface. In this conversion, a large conversion ratio exceeding the existing conversion efficiency was observed. We also found that conversion efficiency can be systematically controlled by varying the coverage of lead phthalocyanine. However, the spin-to-charge current conversion phenomenon at these molecule/metal interfaces has not been observed before this research, and the details of the formation mechanism of the interface states and the spin current conversion mechanism therein are hardly understood. In this internship, dynamic spin injection method was performed on the lead phthalocyanine and copper interface, and its temperature dependence was measured. A maskless photo-lithography machine and an ion shower milling machine were used for device fabrication and a vacuum prober for low temperature measurement was used for the measurement. The output voltage transformed from the spin current at this interface had a behavior with temperature dependence. Through the discussions and additional experiments with the research team, we revealed the correlation between the relaxation time of electrons in the copper and spin-to-charge conversion efficiency. This observation demonstrates that the spin-to-charge conversion efficiency at the molecule/metal interface can be controlled by tuning the electric conductivity of the metal. Based on the results of this research, design of the interface with even greater conversion efficiency is expected.

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