Generation and transport of spin current in $SrTiO_3$-based magnetic heterostructure

N. Soya,[1] T. Katase,[2] and K. Ando[1,3,4]

[1] *Department of Applied Physics and Physico-Informatics Keio University*
[2] *Laboratory for Materials and Structures Tokyo Institute of Technology*
[3] *Keio Institute of Pure and Applied Sciences Keio University*
[4] *Center for Spintronics Research Network Keio University*

The generation and manipulation of a spin current is fundamental for the spintronics devices. The conversion phenomena between spin and charge currents in solids have been intensely investigated in a wide variety of systems. One of the promising candidates is the two-dimensional electron gas (2DEG) in $SrTiO_3$-based structures with a strong Rashba spin-orbit coupling. In a Rashba system, an in-plane charge current generates a transverse spin density, which is known as the Edelstein effect (EE). An efficient spin-to-charge conversion through the inverse EE has been demonstrated in metal oxide/$SrTiO_3$ heterostructures with 2DEGs at the interfaces[1]. However, evidence for the charge-to-spin conversion, a technologically more important process, has been lacking. Furthermore, the spin transport mechanism in this system has been unclear.

In this research, we demonstrate the highly efficient charge-to-spin conversion by the direct EE in a 2DEG at an $AlO_x/SrTiO_3$ interface[2]. We conduct the spin torque ferromagnetic resonance measurements on $Ni_{81}Fe_{19}$ (4.2 nm)/AlO_x (2 nm)/$SrTiO_3$ devices. The effective charge-to-spin conversion efficiency of the 2DEG exceeds 10% at room temperature, which is comparable to that of the archetypal charge-spin converter, Pt. The effective charge-to-spin conversion efficiency is found to be suppressed by decreasing temperature, which is ascribed to the decrease of the spin transmission through the AlO_x layer. We analyze the measured effective charge-to-spin conversion efficiency taking into account the temperature dependence of the tunneling conductance of the elastic and inelastic tunneling. Our results demonstrate a crossover of the dominant spin transport mechanism from the inelastic tunneling to elastic tunneling induced by decreasing temperature.

These findings will provide a clue to unlock the full potential of oxide-based spin-orbitronic devices.

References:

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