Spin-charge interconversion in topological surface states

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A surface state of the three dimensional topological insulator (TI) has been expected to realize a highly efficient spin-charge interconversion.[1] Much effort has been paid for quantitative investigation of spin-charge interconversion phenomena by using various ways such as potentiometric measurements[2, 3], spin pumping,[4] spin transfer torque ferromagnetic resonance[5, 6] and so on. However, reciprocal interconversion between spin current and charge current in the same topological surface state has not been achieved so far. In this study, we investigated reciprocal spin-charge interconversion in topological surface state using a copper (Cu) based lateral spin valve with a TI middle wire.

A SEM image of the fabricated lateral spin valves is shown in Fig. 1(a). The single crystalline topological insulator $Bi_{1.5}Sb_{0.5}Te_{1.7}Se_{1.3}$ were grown by a Bridgeman method in evacuated quartz tubes. Mechanically exfoliated topological insulator flakes, with the thickness of several tens of nanometers, were put on a thermally oxidized SiO_2 layer formed on a Si substrate. The thickness and position of the topological insulator flakes were measured by a laser microscope. $Ni_{80}Fe_{20}$ (Py) ferromagnetic electrodes were fabricated by lift-off process with electron beam lithography and electron beam evaporation. After cleaning of the Py surface with Ar^+ ion milling, Cu/Titanium (Ti) spin transport channel was fabricated by the lift-off process. 2 nm thick Ti layer was deposited by EB evaporation to realize good connection of the Cu layer with the TI. The Cu layer was deposited by thermal evaporation. Nonlocal magnetoresistances measurements were carried out by using Physical Properties Measurement System (PPMS).

Nonlocal magnetoresistances measured at 10 K of Cu based lateral spin valves with and without TI are shown in Fig. 1(b). Although the same spin injector, detector and Cu/Ti spin channel were employed, magnitude of ΔR_S for W/TI device is obviously smaller than those of the Ref. 1 or Ref. 2. This result indicates that spin current transported to the spin detector was reduced because of the spin absorption of the TI. Reciprocal interconversion between spin current and charge current was also demonstrated. In the presentation, we will discuss a quantitative estimation of efficiency of spin-charge interconversion in the topological surface state.

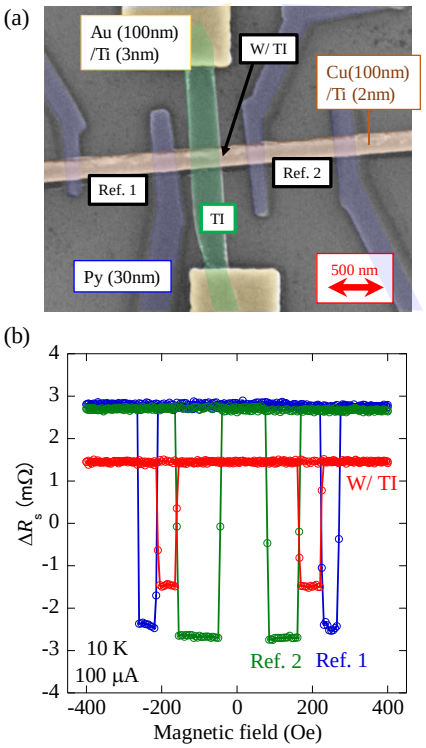

Figure 1 (a) A SEM image of fabricated Cu-based lateral spin valve with TI. (b) Nonlocal magnetoresistance for Ref.1, Ref.2 and W/ TI device at 10 K.

Reference
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