スピンバルブ構造を用いた非磁性金属/トポロジカル絶縁体接合におけるスピン流電流変換の評価

Evaluation of Spin-Charge Conversion at Nonmagnetic Metal and Topological Insulator Contact Using Spin Valve Structure

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Three dimensional topological insulator (TI) is an attracting material as a host of spin and charge (S-C) interconversion because its gapless surface state has a unique property, spin angular momentum is locked perpendicular to the wave vector of the electron. Utilizing TIs, highly efficient S-C interconversions have been reported [1,2]. However, main stage of S-C conversion with TIs has been ferromagnetic metal (FM) and TI contact although magnetic perturbation can break time reversal symmetry resulting in opening gap on the surface state. In fact, measured spin to charge conversion efficiencies were varied among reports [1,3] although they are using the same TI material. In this study, we focused on S-C conversion at nonmagnetic metal (NM) and TI contact where gapless surface state is expected to be protected.

Figure 1 shows a schematic of lateral spin valve (LSV) like structure which has four FM electrodes. We used $Ni_{80}Fe_{20}$ (Py), Cu and epitaxially grown Bi_2Se_3 as FM, NM and TI, respectively. Ref.1 is a conventional (LSV). Ref.2 is a LSV with NM cross at the center of two FM electrodes. w/ TI has TI stripe at the center of two FM electrodes and NM cross on it. First, non-local four terminal (NL4T) measurements were performed. As a result, the NL4T resistance of Ref.1 and w/ TI were 1.59 mΩ and 1.12 mΩ, indicating additional spin diffusion to the NM cross and spin absorption to the TI stripe. Second, spin to charge conversion was tested. Figure 2 shows a schematic of the experimental set up and result. The vertical axis shows normalized S-C conversion resistance ($R_{S\text{-}C}$), electromotive force divided by applied current. It was confirmed that the sign of S-C resistance changes due to the reversal of the direction of accumulated spin in NM channel as the magnetization of FM electrode changes, and $\Delta R_{S\text{-}C}$ was 0.04 mΩ. This result successfully demonstrates the S-C conversion at NM/TI area. Next, its inverse effect, charge to spin (C-S) conversion was also demonstrated, and C-S conversion signal was successfully observed. Furthermore, the normalized C-S conversion resistance, $\Delta R_{C\text{-}S}$ was almost same as $\Delta R_{S\text{-}C}$, obtained from S-C conversion. In the presentation, temperature dependence and conversion efficiency will be discussed.

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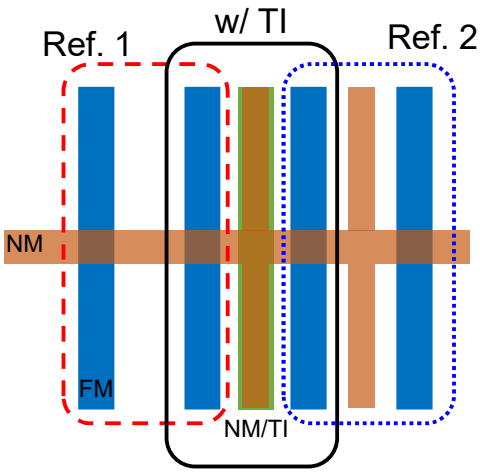

Fig. 1. A schematic of spin valve like structure.

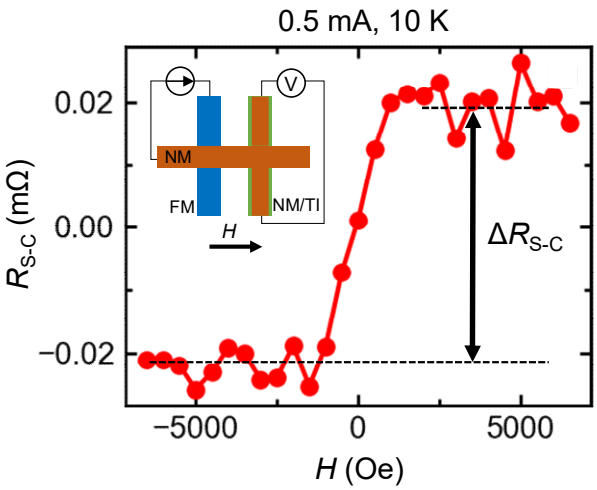

Fig. 2. A result of spin to charge conversion. The inset is the experimental setup.

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