Large Unidirectional Magnetoresistance in GaMnAs/BiSb bilayers

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Recently, unidirectional magnetoresistance (UMR) has been observed in bi-layers of ferromagnets and spin Hall materials, such as Pt, Ta, and (Bi,Sb)Te [1-4]. This unique UMR is believed to originate from interfacial spin accumulation through the spin Hall effect (SHE) or Rashba-Edelstein effect (REE) [1, 2] that leads to GMR-like spin-dependent electron/magnon scattering, depending on the sign of the current density J [3]. However, the magnitude of UMR observed so far is small (maximum ~ 0.4% [4]) and its origin is still under discussion.

In this study, we report on UMR as large as 1% in $Ga_{0.91}Mn_{0.09}As$ (10 nm)/$Bi_{0.85}Sb_{0.15}$ (10 nm) bi-layers. Here, $Bi_{0.85}Sb_{0.15}$ is a topological insulator with a huge spin Hall angle θ_{SH} [5,6]. Figure 1(a) shows the bi-layer structure and the experiment setup. Figure 1(b) shows the difference of resistance $\Delta R_{xx} = R_{xx}(J) - R_{xx}(-J)$ of a Hall bar as a function of the external magnetic field H, measued at 4 K. Here, ΔR_{xx} increases with increasing of J and reaches maximum at $J = 16\times10^5$ A/cm^2. Moreover, the UMR ratio ($=|\Delta R_{xx}|/R_{xx}$) increases with increasing temperature as shown in Fig. 1(c). We obtained a large UMR ratio of 1.0%, which is an order of magnitude larger than those observed in bi-layers with heavy metals (Pt, Ta). Interestingly, we found that the magnitudue of UMR is not simply related to the magnitude of θ_{SH} as expected from the SHE or REE mechanism. Our results provide helpful insight into spin transport in strongly spin-orbit-coupled systems.

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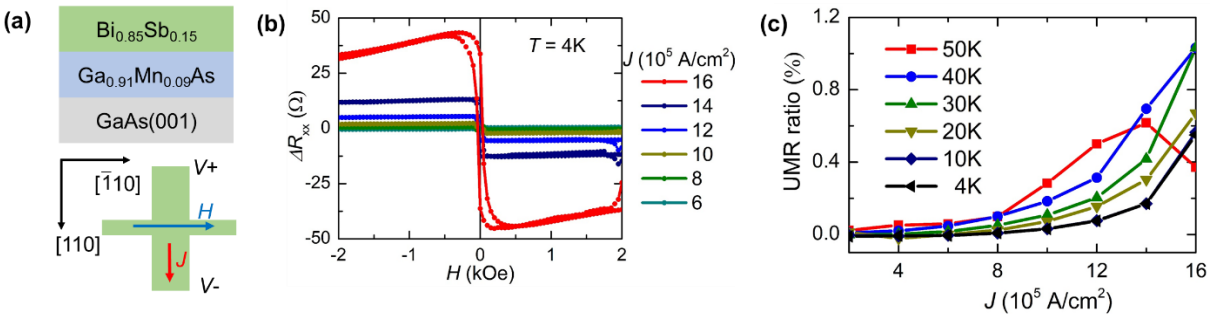

Fig. 1. (a) Device structure of $Ga_{0.91}Mn_{0.09}As$ (10 nm)/$Bi_{0.85}Sb_{0.15}$ (10 nm) bi-layers (top figure) and measurement setup (bottom figure). (b) Difference of resistance $\Delta R_{xx} = R_{xx}(J) - R_{xx}(-J)$ as a function of H, meusured at 4K. (c) UMR ratio ($= |\Delta R_{xx}|/R_{xx}$) as a function of J at various temperuatures. Here, the ΔR_{xx} values are taken at 2 kOe.