Observation of spin-transfer torque induced by spin anomalous Hall effect

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The anomalous Hall effect (AHE) is a well-known phenomenon observed in ferromagnet (FM). Recently, it was theoretically demonstrated that spin direction of spin current generated by AHE can be controlled by the magnetization direction in FM, which will be an attracted technique to perform the spin-transfer torque switching of a perpendicularly magnetized film without external magnetic field [1]. In this study, we observed the spin-transfer torque generated by the AHE in FM, which we named spin anomalous Hall effect (SAHE).

We prepared Si / SiO sub. / CoFeB (20) / Cu (6) / NiFe (4) / MgO (thickness in nm) trilayer schematically illustrated in Fig. 1(a). The film was patterned into the stripe shape as shown in Fig. 1(b). We injected the radio frequency (RF) current into the stripe with the frequency of 12 GHz. The RF Oersted field created by the RF current excites a ferromagnetic resonance (FMR). Simultaneously, a direct spin current is generated by the SAHE in FM1 (CoFeB layer). The spin current modulates the FMR linewidth in FM2 (NiFe layer). The RF current and the oscillating anisotropic magnetoresistance due to the magnetization precession give a direct voltage having a shape of antisymmetric Lorentzian.

Figure 1(c) shows the FMR spectra of NiFe layer measured with different DC bias currents. The modulation of linewidth by injecting DC bias current was observed, which indicates the existence of SAHE. The field angle dependence of the modulation of linewidth was also studied, which was found to agree with the theoretical model of SAHE. The spin anomalous Hall angle, which is an efficiency of the spin current generation, was evaluated to be -0.14±0.05 [2].

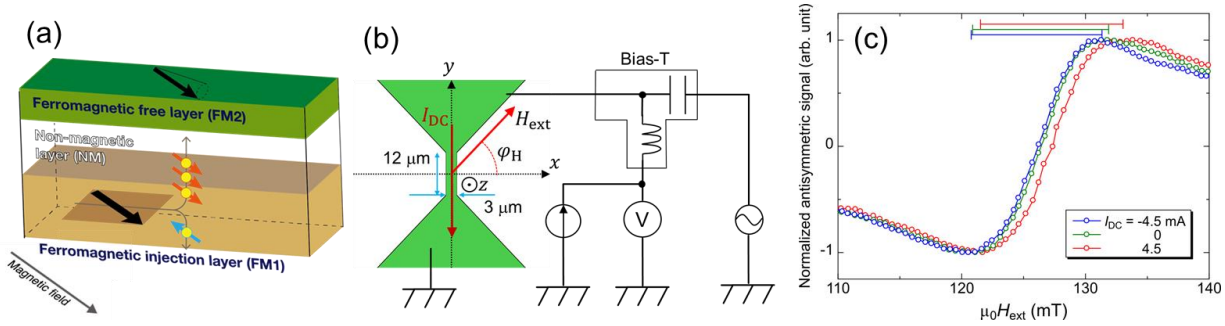

Figure 1 (a) Schematic illustration of sample. (b) Schematic illustration of measurement circuit for ferromagnetic resonance (FMR) experiment. (c) The normalized antisymmetric FMR spectra of NiFe for different DC bias currents. The horizontal bar indicates the linewidth of each spectra.

[1] T. Taniguchi *et al*. Phys. Rev. Appl. **3**, 044001 (2015). [2] S. Iihama *et al*. Submitted 2017.