Low power spin-orbit torque magnetization switching in all-sputtered BiSb topological insulator / perpendicularly magnetized CoPt / MgO multilayers on Si substrate

Tokyo Tech[1], Univ. of Tokyo[2], JST-CREST[3]

Tuo Fan[1], Nguyen Huynh Duy Khang[1], Pham Nam Hai[1,2,3]

E-mail: tuo.f.aa@m.titech.ac.jp

BiSb topological insulator (TI) is a promising candidate for spin-orbit-torque (SOT) magnetoresistive random-access memory (MRAM), thanks to its giant spin Hall effect and high electrical conductivity at room temperature. A giant spin Hall angle up to 52 and 10.7 has been observed for BiSb deposited by molecular beam epitaxy on single crystalline GaAs(111) and by sputtering on c-plane Al_2O_3 substrates, respectively. In realistic MRAM, however, magnetic tunnel junctions (MTJ) whose core structure includes an MgO barrier layer and a free ferromagnetic (FM) layer on top have to be deposited on Si/SiO_x substrates. In this work, we demonstrate low power and fast SOT magnetization switching in all-sputtered BiSb / perpendicularly magnetized CoPt / MgO multilayers on Si/SiO_x substrates. The magnetization can be efficiently switched by the spin Hall effect of BiSb with a large spin Hall angle of 2.4. We investigate the switching behaviors at different pulse width, demonstrating the robustness and reliability of BiSb as a spin current source.

We deposited BiSb (10 nm) / Pt (0.8 nm) / Co (0.6 nm) / Pt (0.8) nm / MgO (10 nm), from top to bottom on Si/SiO_x substrates at room temperature. The (Pt/Co/Pt) trilayers, referred here as CoPt, are perpendicularly magnetized with a large perpendicular magnetic anisotropy field of 4.5 kOe. We employed the second harmonic Hall measurement technique to evaluate the spin Hall angle θ_{SH} in 50 μm × 25 μm Hall bars. Figure 1(a) shows the second harmonic Hall resistance ($R_{2\omega}$) – in-plane magnetic field (H) characteristics at different current densities, and a representative fitting curve (dashed) for evaluation of the antidamping-like field H_{AD}. Figure 1(b) shows the estimated H_{AD} at various BiSb current density J^{BiSb}, which yields $\theta_{SH} \cong 2.4$. Figure 1(c) and 1(d) show the pulse width dependence and field dependence of the SOT switching loop, respectively. The magnetization of CoPt multilayers can be efficiently switched by a small threshold current density $J_{th}^{BiSb} = 2.3 \times 10^6$ Acm^{-2} at pulse width of 50 μs under a small bias external field H = 183 Oe. We also demonstrate robust switching by consecutive pulses, and fast switching down to 100 ns. Our work shows that it is possible to implement ultralow power SOT-MRAM using BiSb on Si/SiO_x substrates. **References:** [1] N. H. D. Khang *et al.*, Nat. Mater. 17, 808 (2018). [2] T. Fan *et al.*, arXiv:2007.02264 (2020).

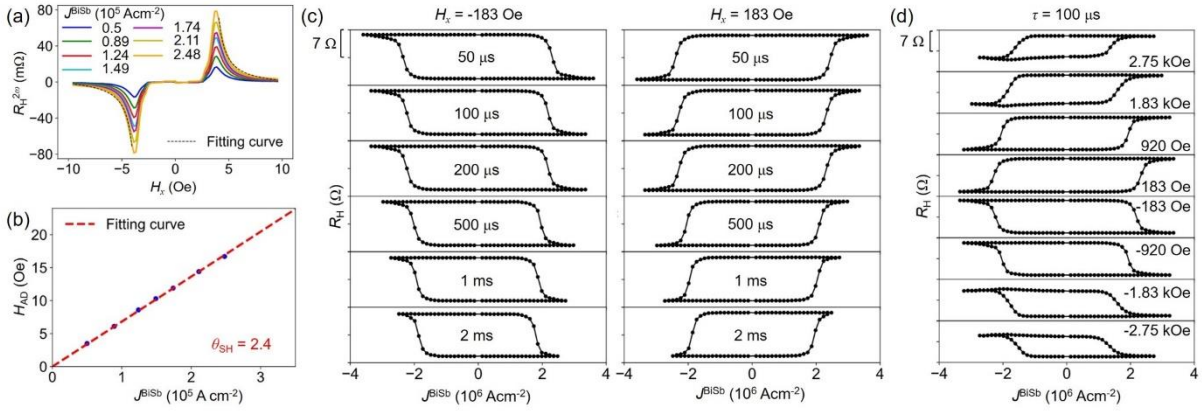

Fig. 1. (a) 2nd harmonic Hall resistance and representative fitting curve (dashed line). **(b)** H_{AD} at various J^{BiSb}. **(c)** Switching loops at various pulse width. **(d)** Field dependence of switching loop.