Giant inverse spin Hall effect in BiSb topological insulator-based SOT reader

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Scaling of TMR reader for magnetic recording beyond 4 Tb/in^2 encounters increasing difficulties due to its complex film stack and increase of noise. Recently, a spin-orbit torque (SOT) reader employing the inverse spin Hall effect was introduced to solve these problems [1]. The SOT reader is very simple, consisting of only a SOT layer and a ferromagnetic layer (FM). When a spin-polarized current is injected from the FM layer to the SOT layer, an output voltage is generated as a result of the inverse spin Hall effect. However, the output voltage and signal-to-noise ratio (SNR) of SOT reader using heavy metals as the SOT layer are insufficient due to small spin Hall angle (SHA) and low sheet resistance of heavy metals [2]. Thus, a SOT layer with large SHA and sheet resistance is essential for enhancing the output signal and SNR. Topological insulator (TI) BiSb is very promising thanks to its giant SHA and larger sheet resistance [3].

In this work, we demonstrate a proof-of-concept for a BiSb-based SOT reader with large output voltage and SNR. Figure 1(a) shows the schematic structure of the device. The SOT reader is a 20 μm × 20 μm pillar of CoFe (5 nm)/MgO (2 nm)/BiSb (10 nm) on top of a 20 nm-thick Ta/Pt bottom current electrode deposited on an oxidized silicon substrate. Then, a top current electrode was deposited on top of the pillar. A perpendicular bias current I_{app} was injected into the pillar, and the output voltage of the inverse spin Hall effect V_{ISHE} was read out while scanning an in-plane magnetic field H_x. Figure 1(b) shows a representative inverse spin Hall resistance $R_{ISHE} = V_{ISHE}/I_{app}$ at J_{app}=6.25 kA/cm^2. Figure 1(c) shows the $V_{ISHE} - J_{app}$ characteristics of the reader. The output is as large as 15 mV, which is 3 orders of magnitude larger than that of Pt-based devices [2]. We project a giant inverse spin Hall angle of 24 for this device, which demonstrates the potential of BiSb for SOT reader application.

Reference: [1] US patent application No. US9947347B1. [2] V. T. Pham *et al., Nat. Elec.* 3, 309 (2020). [3] N. H. D. Khang, Y. Ueda, and P. N. Hai, *Nat. Mater.* 17, 808 (2018).

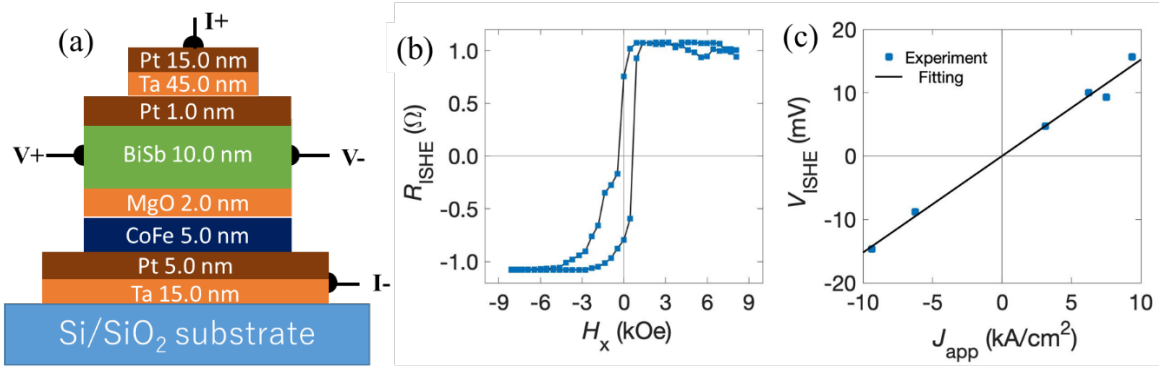

Figure 1. (a) Schematic device structure of our BiSb-based SOT reader. (b) Inverse spin Hall resistance at J_{app} = 6.25 kA/cm^2. (c) Output voltage at various applied current density.