Interface-dependent Spin Transfer Torque at Ferromagnetic Topological-Insulator Contacts

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In previous work, we have shown large magnetoresistances at room temperature (RT) for three Ferromagnet/Topological Insulator (FM/TI) devices (Fe/Bi_2Te_3-based devices with and without an evaporated SiO_2 oxide, and an Fe/Bi_2Se_3-based device without evaporated oxide) [1]. The observed magnetoresistance was substantially larger than previously reported for the same system at RT [2] and at low temperatures [3, 4], and was particularly enhanced when an evaporated SiO_2 layer was introduced between the Fe and Bi_2Te_3, and when Bi_2Se_3 was used instead of Bi_2Te_3. We have speculated that the Fe deposition directly onto the TI might form an Fe-rich FeTI compound [5] which might have been prevented in the case when an evaporated oxide was present between Fe and Bi_2Te_3.

In this presentation, we will show large interface-dependent magnetoresistances in these devices due to spin polarization of the Fe bar via electron injection and extraction from the TI to the Fe (STT) at 2 K. The required switching current for STT in our case is comparable to the previous results in [6] for Cr-TI/TI contacts. Moreover, to support our speculation regarding the interfacial dependencies, we have performed cross-sectional transmission electron microscopy (XTEM) at the FM/TI interfaces. Cross-sectional samples were prepared using focussed Ga-ion beam milling. Fig. 2 shows XTEM images from (a) Fe/Bi_2Se_3, and (b) Fe/SiO_2/Bi_2Te_3 interfaces. The Fe/Bi_2Se_3 interface shows an extra crystalline layer at the interface with a slightly larger half period of 0.53 nm compared to the Bi_2Se_3 fringes (1.02 nm/2 = 0.50 nm). Energy dispersive X-ray spectroscopy (EDX) profiling using scanning transmission electron microscopy (STEM) imaging across the interface confirmed the inclusion of Se into Fe. Fig. 1(b) shows an abrupt interface between the crystalline Bi_2Te_3 and evaporated SiO_2.

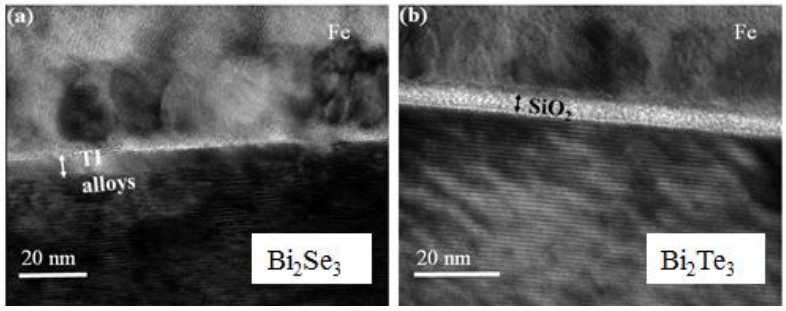

Fig. 2 Bright-field XTEM images (a) Fe directly deposited on TI (Bi_2Se_3) and (b) Fe/evaporated oxide (SiO_2)/TI (Bi_2Te_3). In (a) there is an unexpected 5 ± 1 nm interface layer present with a layered structure but with a slightly larger half-period (0.53 nm) compared to that of the substrate Bi_2Se_3 (1.02 nm). In (b) the Bi_3Te_2 (001) fringes (1 nm) are visible parallel to the surface and an expected oxide layer (5 nm thick) present between the Fe and Bi_3Te_2.

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