Giant spin-orbit torque generated by BiSb topological insulator

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Topological insulators (TIs) are exotic materials with insulating (semiconducting) bulk states and metallic surface (edge) states. The electron spin on the surface of TIs is locked to its momentum, resulting in many novel physics. These include the quantum spin Hall effect in two-dimensional TIs, the quantum anomalous Hall effect in magnetic TIs, and Majorana Fermions at TI/superconductor interfaces. So far, those novel physics have been observed in TI-based heterostructures at extremely low temperatures, making them less attractive for device applications at room temperature. Here, we present our recent results on the giant spin Hall effect at room temperature in a conductive topological insulator, BiSb. We show that BiSb have both high electrical conductivity[1)] and giant spin Hall angle[2)] at room temperature, which are very promising for applications to ultralow power spin-orbit torque magnetoresistive random access memory (SOT-MRAM). Evaluation of spin-orbit torque in BiSb/MnGa bi-layers reveals a colossal spin Hall angle of 52 and a spin Hall conductivity of $1.3*10^7$ $\hbar/2e$ $\Omega^{-1}m^{-1}$ at room temperature. We demonstrate that BiSb thin films can generate a colossal antidamping-like effective field of 2.3 kOe·$MA^{-1}cm^2$ and a critical switching current density as low as 1.5 $MAcm^{-2}$ in BiSb/MnGa bi-layers. Furthermore, we identify the origin of the giant SHE in BiSb thin films by measuring the spin Hall angle under controllable contribution of surface and bulk conduction. Our quantitative analysis shows that the giant SHE in BiSb is almost governed by contribution from the topological surface states.[3)] We further show that the surface sheet spin Hall angle is proportional to the number of Dirac cones on the topological surface states, indicating the Berry phase nature of the observed giant SHE. BiSb is the best candidate for the first industrial application of topological insulators.

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References

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