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Spin-charge conversion at magnetic insulator/topological insulator interfaces

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The development of next-generation spintronic devices has driven extensive studies of spin-charge conversion through measurements of the inverse spin Hall effect and/or the inverse RashbaEdelstein effect in both three-dimensional and two-dimensional material systems. Topological insulators such as the Bi-chalcogenides are naturally relevant in this context due to the expected large spin-orbit coupling strength and the inherent spin-momentum locking in their surface states. We report the observation of robust ferromagnetic resonance-driven spin pumping signals in three-dimensional topological insulator thin films – Bi_2Se_3 and $(Bi, Sb)_2Te_3$ – deposited by molecular beam epitaxy on the ferrimagnetic insulator $Y_3Fe_5O_{12}$. By systematically varying the Bi_2Se_3 film thickness, we show that the spin-charge conversion efficiency, characterized by the inverse RashbaEdelstein effect length, increases dramatically as the film thickness is increased from two quintuple layers, saturating above six quintuple layers [Phys. Rev. Lett. 117, 076601 (2016)]. For bulk insulating $(Bi, Sb)_2Te_3$ thin films, by electrical gating and varying the chemical compositions, we demonstrate that the spin-charge conversion efficiency follows a constant value when the Fermi level lies within the bulk band gap and shows opposite variation trends when Fermi level enters the conduction and valance bands. Our results uncover the spin-charge conversion mechanism in topological insulators and suggest the dominant role played by spin-momentum locking and spin-orbit coupling for surface and bulk states respectively.
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