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Extremely large, gate tunable spin Hall angle in 3D Topological Insulator pn junction[1] K M MASUM HABIB, REDWAN SAJJAD, AVIK GHOSH, Univ of Virginia — The band structure of the surface states of a three dimensional Topological Insulator (3D TI) is similar to that of graphene featuring massless Dirac Fermions. We show that due to this similarity, the chiral tunneling of electron in a graphene pn junction also appears in 3D TI. Electrons with very small incident angle (modes) are allowed to transmit through a TI pn junction (TIPNJ) due to the chiral tunneling. The rest of the electrons are reflected. As a result, the charge current in a TIPNJ is suppressed. Due to the spin momentum locking, all the small angle modes are spin-down states. Therefore, the transmitted end of the TIPNJ becomes highly spin polarized. On the other hand, the spin of the reflected electron is flipped due to spin momentum locking. This enhances the spin current at the injection end. Thus, the interplay between the chiral tunneling and spin momentum locking reduces the charge current but enhances the spin current at the same time, leading to an extremely large ($\sim$20) spin Hall angle. Since the chiral tunneling can be controlled by an external electric field, the spin Hall angle is gate tunable. The spin current generated by a TIPNJ can be used for energy-efficient switching of nanoscaled ferromagnets, which is an essential part of spintronic devices.

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