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Non-local spin transport in topological insulator nanowires

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The momentum and spin of charge carriers in the topological insulators are constrained to be perpendicular due to strong spin-orbit coupling. Sb_2Te_3 is one of the topological insulator materials with a bulk band gap of 0.28 eV and simple surface states consisting of a single Dirac cone in the band gap. We have synthesized single crystalline Sb_2Te_3 nanowires using low pressure catalytic chemical vapor deposition, via vapor-liquid-solid growth mechanism. Two levels of aligned e-beam lithography were used to pattern non-magnetic outer Au leads and two magnetic tunnel junction inner leads on individual Sb_2Te_3 nanowires. The tunnel junction leads consist of a free Py ($Ni_{80}Fe_{20}$) layer, whose magnetization determines the magnitude and direction of spin current injected into the Sb_2Te_3 nanowire. Measurements of the device resistance between the two Au leads reveal that the Au/Sb_2Te_3 contact is ohmic. The two-point resistance measured between these contacts as a function of magnetic field shown exhibits positive magneto-resistance, originating from weak anti-localization of carriers in the Sb_2Te_3 nanowire induced by spin-orbit interaction. The weak anti-localization signal serves as evidence of a strong impact of spin orbit interaction on transport in the Sb_2Te_3 nanowire system. We have also measured a non-local spin valve signal in Sb_2Te_3 nanowire channels. The symmetry of this non-local spin valve (NLSV) signal is dramatically different from that of an NLSV with a channel that lacks spin-momentum locking (such as graphene). Two parallel states of the injector and detector magnetic moments give rise to different non -local voltage values, which is never observed in conventional NLSVs. This unusual symmetry is a clear signature of the spin-momentum locking in the Sb_2Te_3nanowire surface state.

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