SES16-2016-000205

Abstract for an Invited Paper
for the SES16 Meeting of
the American Physical Society

Spin filtering using PN junctions in topological insulators[1]

AVIK GHOSH, Dept of Electrical and Computer Engineering, Dept of Physics, University of Virginia

3D topological insulators share a lot of properties with other 2D Dirac cone systems such as graphene. In both systems, the Dirac bands can be labeled with an index that corresponds to the phase of its eigenfunction (pseudospins representing bonding-antibonding combinations of the dimer pz orbitals in graphene, vs real spins in 3D TIs). The locking of momentum with these phases makes it possible to filter the latter simply by gating the former. For graphene PN junctions, we expect rich chiral physics such as Klein tunneling, negative index behavior, and Veselago lensing that should also show up in Bi2Se3 topological insulators. The ability to steer or collimate the electrons through angular filtering (ie, gate geometry alone), for instance using a PN junction, would allow us to open gate-tunable transport gaps that can be used to filter the spins, amplify the torques and turn off the overall device. We present analytical, numerical and experimental demonstrations of pseudospin filtering in graphene, and show how we can use these properties for a cascaded sequence of angled junctions in order to turn it off without compromising the electron mobility. The analogous physics can be studied more directly on a topological insulator using a ferromagnetic tip. Accordingly, we can use a single PN junction to amplify the charge to spin conversion rate (analogous to a spin Hall angle, except it is tunable from 0 to 30). This tunability can then be used to amplify the torque at the injection side and the polarization on the transmitted side, and build spin based logic circuits with isolation and gain. (Ref: Science 353, 6307, 2016; PRL 114, 176801, 2015; ACS Nano 7, 9808, 2013)

[1]SRC-NRI