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Spin polarized tunneling study on spin Hall effect metals and topological insulators[1]

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Spin orbit interactions give rise to interesting physics phenomena in solid state materials such as the spin Hall effect (SHE) and topological insulator surface states. Those effects have been extensively studied using electrical detection techniques so far. However, to date most experiments focus only on characterizing electrons near Fermi surface, while the spin-orbit interaction is expected to be dependent on electrons' energies. Here we develop a tunneling spectroscopy technique to measure spin Hall materials and topological insulators under finite bias voltages. By electrically injecting spin polarized current into spin Hall metals or topological insulators through nonmagnetic material/oxide/ferromagnet (FM) junctions and measuring the induced transverse voltage, we are able to quantify the magnitude of the SHE in typical 5d transition metals and the spin momentum locking in topological insulators. The obtained spin Hall angles in Ta, Pt, W and Ir at zero bias are consistent with the results from spin torque experiments, verifying the SHE origin of those earlier observations. At finite biases, the transverse signals provide important information in determining the mechanisms of the observed effects, such as intrinsic vs extrinsic, surface vs bulk. Because of the impedance matching capability of tunnel junctions, the spin polarized tunneling spectroscopy technique is expected to be a powerful tool to measure a wide group of matters including the various newly discovered or proposed topological materials.

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