Self-Torque in Ferromagnetic using ST-FMR and Harmonic Measurements

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Primary CNF Tools Used: ASML, JEOL 6300, Veeco AFM

Abstract:

Spin-orbit torque in heavy metal/ferromagnet heterostructures with broken spatial inversion symmetry provides an efficient mechanism for manipulating magnetization using a charge current. We report the presence of a spin torque in a single ferromagnetic. According to the fitting results of ST-FMR and Harmonic measurements, it is clear the spin orbit torque that should come from the SHE and anomalous spin orbit torque of FM induced σz with σy spin current. However, there still remains a main problem to further clarify about the original of non-equilibrium spin accumulation between bottom Cu/FM interface and top FM/Cu interface.

Summary of Research:

When a charge current passes through a ferromagnet (FM) due to the imbalance in electron density of states at the Fermi level and scattering asymmetry between spin-up and spin-down electrons, it becomes polarized, thereby generating a net spin current flowing in the charge current direction. In addition to longitudinal charge and spin currents, transverse charge and spin currents are also generated by the anomalous Hall effect (AHE), leading to charge and spin accumulation at the side surfaces or edges at steady state. So far, the study of AHE has mainly been focused on charge accumulation because it can be detected directly as a voltage signal, and very little attention has been devoted to the spin accumulation. Recently, several groups have attempted to exploit the AHE-induced spin accumulation and related spin torque (ST) for magnetization switching applications in FM/nonmagnet (NM)/FM trilayers which, compared to spin-orbit torque (SOT) generated by the spin Hall effect (SHE), offers the possibility of controlling the spin polarization direction by manipulating the magnetization direction of one of the FM layers. However, there still remains a main problem to further clarify about the original of non-equilibrium spin accumulation between bottom Cu/FM interface and top FM/Cu interface.

We fabricated a series of Hall bar devices. We will discuss the spin torque, and the H_{FL0} values of all samples are shown on Figure 1. We get similar results with the ST-FMR results. The field-like torque in Cu/Py/Cu is opposite with MgO/Py/MgO, and the Ir/Py/Ir fall in between Cu/Py/Cu and MgO/Py/MgO. The torque in Cu/CoFeB/Cu have the same signal with Cu/Py/Cu. And the torque efficiency increases with increasing the FM thickness. All of these results mean the σ_y from the bulk effect. The possible mechanism is bulk SHE or the anomalous spin orbit torque.

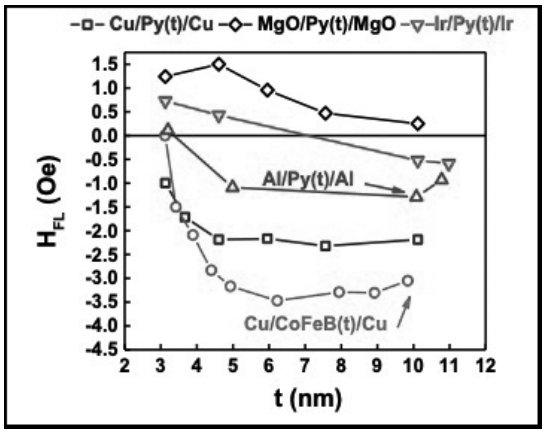

Figure 1: FM thickness dependence of H_{FL0}.

References:

[1] Z.Luo, Q.Zhang, Y.Xu, Y.Yang, X.Zhang and Y.Wu, Spin-Orbit Torque in a Single Ferromagnetic Layer Induced by Surface Spin Rotation. Phys. Rev. Appl. 11, 064021 (2019).