MAR16-2015-000437

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Role of transparency of platinum-ferromagnet interface in determining intrinsic magnitude of spin Hall effect

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The spin Hall effect (SHE) converts charge current to pure spin currents in orthogonal directions in materials that have significant spin-orbit coupling. The efficiency of the conversion is described by the spin Hall Angle (SHA). The SHA can most readily be inferred by using the generated spin currents to excite or rotate the magnetization of ferromagnetic films or nano-elements via spin-transfer torques. Some of the largest spin torque derived spin Hall angles (ST-SHA) have been reported in platinum. In this talk, I will discuss that the transparency of the Pt-ferromagnet interface to the spin current plays a central role in determining the magnitude of the ST-SHA [1]. Using spin torque ferromagnetic resonance (ST-FMR) measurements, we measure a much larger ST-SHA in Pt/cobalt (0.11) compared to Pt/permalloy (0.05) bilayers when the interfaces are assumed to be completely transparent. Taking into account the transparency of these interfaces, as derived from spin–mixing conductances, we find that the intrinsic SHA in platinum has a much higher value of 0.19 0.04 as compared to the ST-SHA. The importance of the interface transparency is further exemplified by the insertion of atomically thin magnetic layers at the Pt/permalloy interface that we show strongly modulates the magnitude of the ST-SHA. Improving the interface transparency can make the SHE more effective for spintronic applications and is critical to understanding the fundamental origin of the SHE. [1] W. Zhang*, Wei Han*, Xin Jiang, See-Hun Yang and Stuart S. P. Parkin, Nature Physics, 11, 496–502 (2015).