MAR13-2012-000731

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Giant spin Hall effect in CuBi alloys

YOSHICHIKA OTANI, ISSP University of Tokyo

Spintronic devices manipulating pure spin currents, flows of spin angular momentum without net charge current, should play an important role in low energy consumption electronics for next generation. This explains the current interest for the spin Hall effect (SHE) which provides a purely electrical way to create spin currents without ferromagnets and magnetic fields. In this work, we have studied extrinsic SHEs in Cu-based alloys [1]. Copper itself does not show any SHE, but by adding impurities with strong spin-orbit interactions such as Ir and Bi, the extrinsic SHEs can be generated and one can tune the SH angle which represents the maximum yield of conversion of charge to spin current density. The SH resistance was measured by means of spin absorption method using a lateral spin valve structure with an inserted wire of SHE material [1]. We found that $Cu_{99.5}Bi_{0.5}$ exhibited a very large negative SH resistance whereas Pt and a $Cu_{99}Ir_1$ alloy had positive SH resistances. From nonlocal spin valve measurements with the SHE materials, we can obtain the spin absorption rates as well as the spin diffusion lengths of the SHE materials. The spin Hall angle was determined by fitting experimental data to two theoretical models, i.e., a purely 1D model [2] and a 3D spin transport model based on an extension to 3D of the Valet-Fert formalism [3]. For Pt and CuIr alloys, the spin diffusion lengths are smaller than their thickness (20 nm), and the SH angles obtained from the 1D and 3D analyses are similar to each other (about 2% for both Pt and CuIr). For CuBi alloys, however, the analysis in the 3D model gave much larger SH angle of about - 24% than the 1D of about -12%. More interestingly the fact that Bi impurities generated much larger SH angle than Pt and Ir, was consistent with a recent ab-initio theoretical calculation [4].

[1] Y. Niimi et al., Phys. Rev. Lett. 106 (2011) 126601; Y. Niimi et al., Phys. Rev. Lett. 109 (2012) 156602.
[2] S. Takahashi and S. Maekawa, Phys. Rev. B 67 (2003) 052409.
[3] T. Valet and A. Fert, Phys. Rev. B 48 (1993) 7099.
[4] M. Gradhand et al., Phys. Rev. B 81 (2010) 245109.