Exploiting Spin Fluctuations for Enhanced Pure Spin Current

It is widely accepted that spin Hall angle, which measures the prowess to generate pure spin current, is intrinsic to the material. We show that the value of spin Hall angle can be greatly enhanced beyond their intrinsic values by exploiting spin fluctuations in 3d magnets. In this work, we demonstrate the interplay of pure spin current, spin-polarized current, and spin fluctuation in 3*d* Ni_xCu_{1-x}. By tuning the compositions of the Ni_xCu_{1-x} alloys, we separate the effects due to the pure spin current and spin-polarized current. By exploiting the interaction of spin current with spin fluctuation in suitable Ni-Cu alloys, we obtain an unprecedentedly high spin Hall angle of 46%, about 5 times larger than that in Pt, at room temperature. Furthermore, we show that spin-dependent thermal transport via anomalous Nernst effect can serve as a sensitive magnetometer to electrically probe the magnetic phase transitions in thin films with in-plane anisotropy. The enhancement of spin Hall angle by exploiting spin current fluctuation via composition control makes 3d magnets functional materials in charge-to-spin conversion for spintronic application.

Po-Hsun Wu, Danru Qu, Yen-Chang Tu, C. L. Chien, and Ssu-Yen Huang, "Exploiting spin fluctuations for enhanced pure spin current", Phys. Rev. Lett. **128**, 227203 (2022).

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.128.227203

Detection and manipulation of the antiferromagnetic Néel vector in Cr_2O_3

Detection and manipulation of the Néel vector in antiferromagnetic materials are promising for more stable, faster, and much higher-density spintronic devices. However, the electrical manipulation of the antiferromagnetic Néel vector remains challenging and controversial due to the difficulty in the detection of the zero net magnetization and the unavoidable complications from thermal artifacts. Previously, we showed that, contrary to many prior claims, there is no evidence of spin current-induced spin-orbit torque switching in antiferromagnetic insulator NiO [Phys. Rev. Lett., **123**, 227203 (2019)]. However, in this work, by utilizing the uniaxial antiferromagnet (AFM) Cr_2O_3, we demonstrate the detection and manipulation of the antiferromagnetic Néel vector. We reveal unambiguously the spin-dependent electrical responses of the coherent Cr_2O_3 Néel vector switching, where a symmetric Hall signal and a fourfold angular-dependent magnetoresistance are captured. We also demonstrate

the in-plane arbitrary manipulation of the Cr_2O_3 Néel vector when the magnetocrystalline anisotropy energy is compensated. Our work for detecting and manipulating Néel vectors offers a critical guide for antiferromagnetic-based Néel vector switching exploration.

Yi-Hui Zhang, Ting-Wei Weng, Tsao-Chi Chuang, Danru Qu, and Ssu-Yen Huang, "Detection and manipulation of the antiferromagnetic Néel vector in Cr_2O_3", Phys. Rev. B **105**, 094442 (2022)

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.105.094442