Large Antisymmetric Interlayer Exchange Coupling in Synthetic Antiferromagnet

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Interlayer exchange coupling (IEC) has widely been studied since 1980's in various metallic multilayers. The symmetric IEC energy is expressed as $J_{AF}(m_1 \cdot m_2)$, where J_{AF} denotes the antiferromagnetic coupling strength, and m_1 and m_2 represent the magnetization vectors of two ferromagnets separated by a nonmagnet. The symmetric IEC aligning m_1 and m_2 in antiparallel provides a synthetic antiferromagnet. Recently, the antisymmetric IEC (AIEC) was reported in metallic multilayers with the in-plane spatial inversion symmetry breaking. The AIEC energy is expressed as $D_{AIEC}(m_1 \times m_2)$, where D_{AIEC} is the AIEC vector determined by system symmetry. Thus, the AIEC cants the magnetizations in the two ferromagnetic layers, which leads to chiral magnetic configurations. However, the controllability and the applicability of AIEC have not been examined yet, and the systematic experiments exploiting well-controlled in-plane structural asymmetry are indispensable.

We exploited the wedge-shaped layers to intentionally break the in-plane spatial inversion symmetry, and investigated the AIEC for the perpendicularly magnetized Pt/Co/Ir/Co/Pt with wedge-shaped layers to clarify the nature of AIEC. The large AIEC was observed as a large asymmetric shift in the switching fields of anomalous Hall effect loop when the additional in-plane magnetic field was applied together with the out-of-plane magnetic field. We found that the effective field of AIEC is related with the symmetric IEC. Thanks to the large AIEC, the perpendicular magnetization switching could be demonstrated solely by applying the in-plane magnetic field [1]. In addition to the field-induced magnetization switching behavior, we studied on the current-induced domain wall motion for the Pt/Co/Ir/Co/Pt wire under the existence of AIEC. Our experimental results indicate that the velocity of domain wall motion triggered by spin orbit torque is remarkably affected by the magnitude of AIEC. Since the enhanced domain wall velocity was observed for the system with large AIEC, the AIEC is a key parameter to achieve the highly-efficient operation of chiral spintronic devices.

[1] H. Masuda, T. Seki, Y. Yamane, R. Modak, K. Uchida, J. Ieda, Y. C. Lau, S. Fukami, and K. Takanashi, Phys. Rev. Appl. 17, 054036 (2022).

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