Dzyaloshinskii-Moriya interaction in an antiferromagnet/ferromagnet heterostructure

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Antiferromagnet (AFM)/ferromagnet (FM) heterostructures with spin-orbit interaction are perceived to open new opportunities for digital and analogue spintronic applications [1-3]. In addition to spin-orbit torques (SOTs) generated by an in-plane current, the asymmetry of the stack structure with the spin-orbit interaction results in an interfacial Dzyaloshinskii-Moriya interaction (DMI). The presence of DMI entails chirality of domain wall (DW) and assists magnetization reversal [4]. A quantitative evaluation of DMI is crucial for understanding of magnetization reversal in these heterostructures. Here, we study AFM PtMn thickness (t_{PtMn}) dependence of DMI in a PtMn/[Co/Ni] system using two methods, a SOT-driven DW motion and a bubble expansion technique, and compare the results to a reference Pt/[Co/Ni] system.

The heterostructures used in this study are Ta (4)/ Pt (2)/ PtMn ($0 \leq t_{PtMn} \leq 5$)/ Pt (0.4)/ [Co (0.3)/ Ni (0.6)]$_2$ /Co (0.3)/ MgO (1.5)/ Ru (1) (thickness in nm). Figure 1(a) shows the in-plane magnetic field (H_X) dependence of current-induced DW motion at two different current densities (J) for PtMn(3)/[Co/Ni] structure. Both up-down (↑↓) and down-up (↓↑) DWs move in the direction of J, signifying SOT-driven DW motion. The horizontal intercept indicates the presence of DMI. Subsequently, DMI strength (given by DMI constant D) have been investigated from field-driven bubble expansion. The obtained results indicate right-handed chirality of DWs at PtMn/[Co/Ni] interface. The observed chirality is opposite, and the magnitude is one order of magnitude smaller compared with the DWs at archetype Pt/[Co/Ni] interface [5]. Moreover, the obtained DMI strength at PtMn/[Co/Ni] interface is enhanced with the increase of t_{PtMn} as shown in Fig. 1(b). The obtained sign and strength of D for the PtMn/[Co/Ni] structure is presumed to be related to the electronic structure and AFM spin ordering over the PtMn interface. These findings offer significant insight for design of spintronic devices with AFM/FM heterostructures.

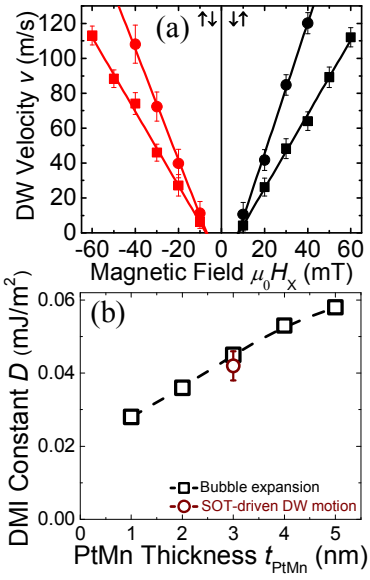

Fig. 1: (a) v vs H_X at two different J (= 6.4×10^{11} A/m^2 for squares and 7.4×10^{11} A/m^2 for circles) for ↑↓ and ↓↑ configuration for PtMn(3)/[Co/Ni]. (b) t_{PtMn} dependence of D obtained from two methods.

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