Composition dependence of spin-orbit torque in $Pt_{1-x}Mn_x$/CoFeB heterostructures

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Spin-orbit torque (SOT) in antiferromagnet (AFM)/ ferromagnet (FM) heterostructures is prospective for digital and analogue spintronic devices [1-4]. The crucial requirements of co-existing large effective spin-Hall angle [5] and significant exchange-bias field [1] in a single material are satisfied in Mn-Y (Y = 4*d* or 5*d* transition metal) metallic AFMs, making them promising candidate for AFM-based spintronic devices. Previous experimental results on polycrystalline Mn-Y/FM structures suggested the primary role of spin-orbit coupling of the *d*-transition element in determination of strength of SOTs [6], while subsequent results indicated an important role played by staggered magnetization of Mn [7]. Thus, systematic studies of SOTs in metallic Mn-Y/FM structures with the variation of composition are of necessity for better comprehension of SOT generation mechanism. Here, we quantify SOTs in AFM/FM PtMn/CoFeB heterostructures as a function of PtMn composition to obtain insights into the origin of SOT generation in AFM/FM structures.

We utilize Si/SiO_2 sub./Ta(3)/Ru(1.5)/$Pt_{1-x}Mn_x$(10)/($Co_{25}Fe_{75}$)B_{25}(1.8)/MgO(1.5)/Ru(1) (in nm) structure, with various Mn-composition (x at.%). We use extended harmonic Hall measurement technique for quantification of SOTs [8]. Slonczewski-like (H_{SL}) and field-like (H_{FL}) components of SOT effective fields are determined from fitting analysis of external magnetic field H dependence of 1st and 2nd harmonic signals. Figure 1 shows the obtained H_{SL} and H_{FL} as a function of x. The results show a non-monotonic variation for H_{SL} and H_{FL} with x. We will discuss possible scenarios accounting for the observed composition dependence of SOT. The present results show the possibility for tuning SOTs in Mn-based AFMs for next generation AFM/FM structures.

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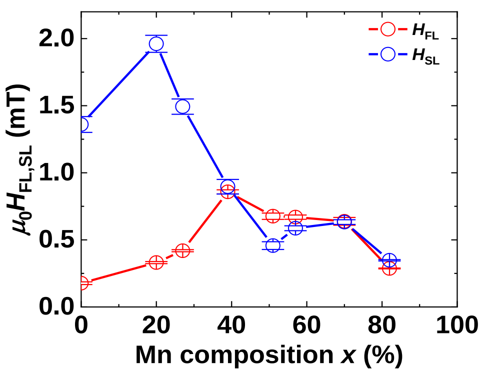

Figure 1: Slonczewski-like (H_{SL}) and field-like (H_{FL}) SOTs as a function of Mn composition x for Mn_xPt_{1-x}/CoFeB structures.