Temperature dependence of spin-orbit torques in an antiferromagnet/ferromagnet heterostructure

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Utilization of antiferromagnet (AFM) materials as a source of spin-orbit torques (SOTs) has attracted great attention owing to its prospect for new-concept devices including digital and analogue spintronic applications [1-3]. Understanding of the SOT generation mechanism is of great importance for successful implementation of AFM/ferromagnet (FM) structures. While a previous work has pointed out that an intrinsic mechanism of spin Hall effect in metallic AFMs [4] contributes to SOT generation, there are few experimental studies on SOTs in AFM/FM systems [4-7]. Thus, systematic studies on SOTs in AFM/FM structures are of necessity for better understanding of the SOT generation mechanism. Here, we study SOTs in AFM/FM PtMn/CoFeB heterostructures as a function of temperature to obtain insight into the origin of SOT generation in AFM/FM systems.

We employ Si/SiO_2 sub./Ta(3)/Pt (or Ru)(1.5)/$Pt_{38}Mn_{62}$(9)/CoFeB(1.8) (units in nm) stacks. In order to quantify SOTs, we use extended harmonic Hall measurement technique [8,9]. The 1^{st} and 2^{nd} harmonic Hall voltages are simultaneously measured from patterned Hall-bar structures at various temperatures while applying AC current along the wire and rotating magnetic field in the film plane. From a fitting analysis of the magnetic field dependence of 2^{nd} harmonic Hall signals, we obtain Slonczewski-like and field-like components of SOT, free from thermoelectric effects. The results show both Slonczewski-like and field-like torque efficiencies are almost independent of temperature. The observed trends are different from those in Ta/CoFeB/MgO system [10-12] and Pt/Co/Pt system [13], implying a different origin of SOT generation in PtMn as compared to widely-studied nonmagnetic Ta or Pt.

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