Magnetoresistance in a nonmagnet/antiferromagnet metallic heterostructure

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Utilization of antiferromagnets (AFMs) as active components of spintronic devices offers several unique advantages which complement current ferromagnet (FM) based devices [1]. Theoretical investigations have shown that the injection of current in nonmagnet (NM)/AFM heterostructures results in magnetoresistive effects owing to spin-orbit torques (SOTs) [2]. Experimental investigations concerning spin current injection and manifestations of SOTs are expected to provide key insights into pertinent questions concerning manipulation and detection of AFM moments. Here, we study current-induced magnetoresistive effects in a non-collinear AFM Pt/PtMn symmetric heterostructure; an attractive candidate for AFM spintronics [3].

The multilayer film with a structure sub./Ta(3)/Pt(3)/PtMn(10)/Pt(5)/Ru(1) (in nm) is grown by sputtering and patterned into devices with 10-μm-wide and 60-μm-long channels (Fig. 1(a)). Figures 1(b)-(d) show the measured longitudinal resistance (R_{XX}) as a function of the applied in-plane (along y) and out-of-plane (along z) fields H for two different temperatures T = 20 K and 300 K under an applied current (I_{DC}) = 20 mA. The results indicate positive magnetoresistance (MR) with a difference of R_{XX} between zero field and +8 T (ΔR_{XX}) = 0.32 and 0.21 Ω at 20 K and 0.67 and 0.59 Ω at 300 K for H along y and z, respectively. The positive MR is expected to arise from SOTs generated from Pt while its T dependence originates from T dependence of inter-sublattice AFM coupling. Angle-dependent MR measurements indicates spin-Hall magnetoresistance (SMR) as the dominant origin of the observed behavior. Calculations using models for SMR results in a close spin mixing conductance to some reported values on NM/FM systems [4-6]. Our results indicate that spin currents in NM/AFM systems are efficient in manipulating AFM moments. This work opens new opportunities for metal based AFM spintronic devices.

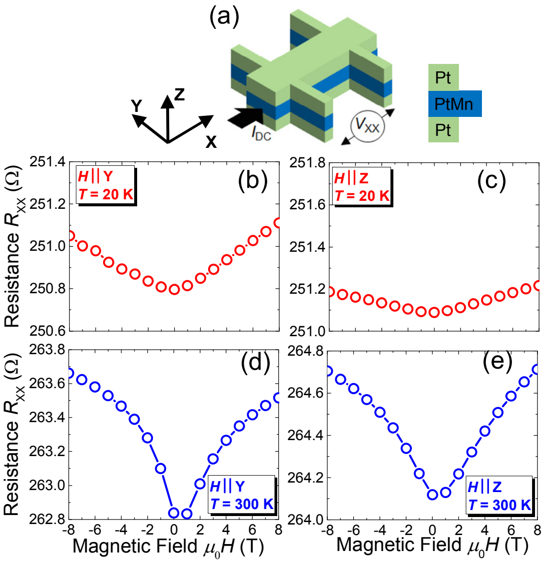

Figure 1: (a) Schematic of NM/AFM device and definition of coordinate. (b)-(c) R_{XX} vs H at I_{DC} = 20 mA for H along y and z axes, respectively at T = 20 K. (d)-(e) Similar results at T = 300 K.

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