Control of The Sign of Anomalous Hall Conductivity by Ti doping in $(Ti_xCr_{1-x})_2O_3$/Pt Thin Films

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The antiferromagnetic (AFM) insulator Cr_2O_3 is promising for future applications in low-power electrically driven magnetic storage [1,2]. The anomalous Hall effect (AHE) in Cr_2O_3/Pt thin films have been proposed as a reading mechanism [2]. However, the origin of AHE below and above the Néel temperature (T_N) is not well understood [3]. In previous works, we found that doping Cr_2O_3 films resulted in a spontaneous magnetization, which is oriented parallel or anti-parallel to the AFM ordering [4,5]. Conversely, the external magnetic field can be used to switch the AFM vector.

In this report, we investigated the anomalous Hall effect (AHE) in Cr_2O_3/Pt thin films, where Cr_2O_3 was doped by Ti. Using Molecular-Beam Epitaxy (MBE) method, we fabricated epitaxial thin films of c-Al_2O_3 sub./Pt (25 nm)/$(Ti_xCr_{1-x})_2O_3$ (50 nm) /Pt (2 nm), where x = 8%, and 15%. We measured the transverse resistance in the top Pt layer, after microfabrication into Hall bars. At temperatures below T_N = 260 K, we found square hysteresis in the field scan loops [Fig. 1(a,b)]. The sign of anomalous Hall conductivity (σ_{AH}) was negative at x = 8%, and changed to positive at x = 15% [Fig. 1(c)]. Above T_N, the field scan loops show a Langevin-type response, where σ_{AH} was negative and equal for both doping cases. If we consider that the AHE response is related to surface Cr spins, they will orient parallel or anti-parallel to external field depending on the location of Ti dopants, at $T < T_N$. Above T_N, surface Cr spins will form fluctuating spin clusters, that are not coupled to the bulk spins. Therefore at $T > T_N$, σ_{AH} has the same value irrespective of doping.

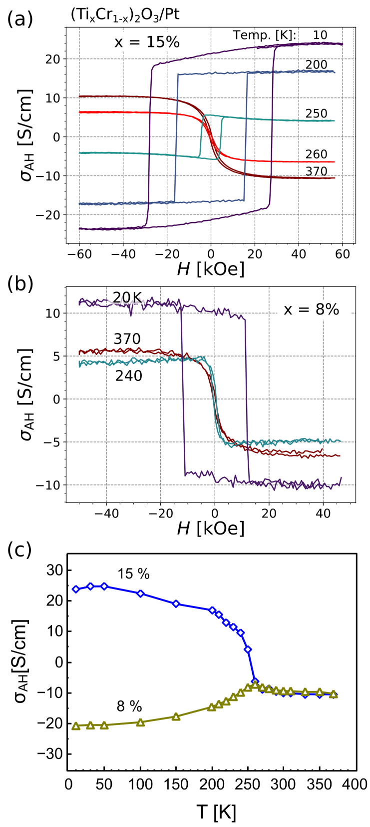

Fig. 1: Anomalous Hall conductivity in $(Ti_xCr_{1-x})_2O_3$/Pt. Field loops at (a) x = 15%, and (b) x = 8%. (c) Temperature dependence of AHE.

The access by external magnetic field to AFM domain direction in doped Cr_2O_3 should increase the understanding of AHE and related effects at the interface.

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