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Antiferromagnetic anisotropy of buffered Cr_2O_3 thin films

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Magnetization reversal using Magneto-electric (ME) effect and perpendicular exchange bias (PEB) in antiferromagnetic (AF) Cr_2O_3 has been established. For switching the PEB at low voltage, thin Cr_2O_3 is required. But with decreasing thickness, blocking temperature (T_B) of PEB in thin Cr_2O_3 decreases due to the product of AF anisotropy and thickness (K_{AF}*t_{AF}) become smaller than exchange coupling energy $J_K = H_{ex}M_st_{FM}$. Previously we have reported the enhancement of T_B of Cr_2O_3 film by inducing lattice strain through different buffer layers. T_B of 20nm thick Cr_2O_3 film with Fe_2O_3 buffer layer modulation of K_{AF}. In this study, we evaluate the K_{AF} of Cr_2O_3 layers with different buffers, based on Meiklejohn-Bean's exchange anisotropy model [1].

Sample design is c-Al_2O_3 sub. /Pt 25 or α-Fe_2O_3 20/Cr_2O_3 t_{Cr2O3}/Ru t_{Ru}/Co 1/Pt 5 (nm). Samples are fabricated by using a RF/DC magnetron sputtering. Ru spacer layer thickness t_{Ru} was varied from 0 to 1.25 nm. Structural characterization is performed by XRD and TEM. Magnetic properties are measured by SQUID magnetometer after field cool from 340 K to 10 K with magnetic field of +1 T.

We fabricated samples with different t_{Ru}, i.e. samples with different J_K. Using these samples we decided the critical J_K (J_K^{cr}) where the H_{ex} disappears. Then we evaluated the K_{AF} of Cr_2O_3 films assuming the relationship $J_K^{cr} = K_{AF}t_{AF}$. Figure 1 shows the temperature dependence of K_{AF} of 20nm thick Cr_2O_3 film with different buffer layers evaluated using above mentioned relationship. The K_{AF} are ~ 10^5 erg/cc at 50 K, which is same orders of magnitude with previous report [2]. Cr_2O_3 film with α-Fe_2O_3 buffer layer exhibit 2~3 times larger K_{AF} compared with those with Pt buffer layer. The change in K_{AF} is due to the lattice distortions of Cr_2O_3 induced by buffer layers. We confirmed the buffer layer effect on K_{AF}.

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References

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[2] J. O. Artman et al., Phys. Rev. 138, A912 (1965).

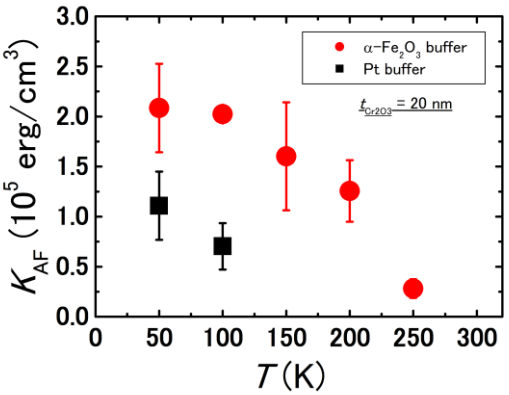

Fig. 1 Temperature dependence of K_{AF} of 20nm thick Cr_2O_3 film with α-Fe_2O_3 buffer (red circles) and that with Pt buffer (black squires)