Positive exchange bias and vertical shift of magnetization curve in Cr_2O_3/Co exchange coupling system

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Magnetoelectric material Cr_2O_3 has received much attentions as a promising candidate for voltage-controlled spin devices. It is also interesting as a exchange coupling system with unique properties. Before we observed positive-exchange bias (H_{ex}) phenomena for Cr_2O_3/Pt/Co system. [1] When the cooling filed H_{fc} during field cool process is sufficient large, spin of Co was pinned against the cooling field direction, i.e. positive-H_{ex} was obtained, while when H_{fc} is small, normal negative H_{ex} is obtained. Negative coupling between ferromagnet and antiferromagnet surface spin and existence of surface magnetization of antiferromagnet were said to be the requirements to observe positive-H_{ex}. In the previous report, larger H_{fc} is required to observe positive-H_{ex} for larger H_{ex} sample. For example, H_{fc} ~ 20kOe (3kOe) was required to observe positive-H_{ex} for samples with H_{ex} ~ 1000Oe (400Oe). (see Fig.1 (b)) In this study we observed positive-H_{ex} for sample with very large H_{ex} (~ 4000Oe) and the H_{fc} required for positive H_{ex} was as small as 5kOe. (Fig. 1(a) and (b)) In addition, vertical shift of magnetization curve also observed for this sample. We will discuss the possible reason.

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[1] T. Nozaki et al., Appl. Phys. Lett., 105 (2014) 212406.

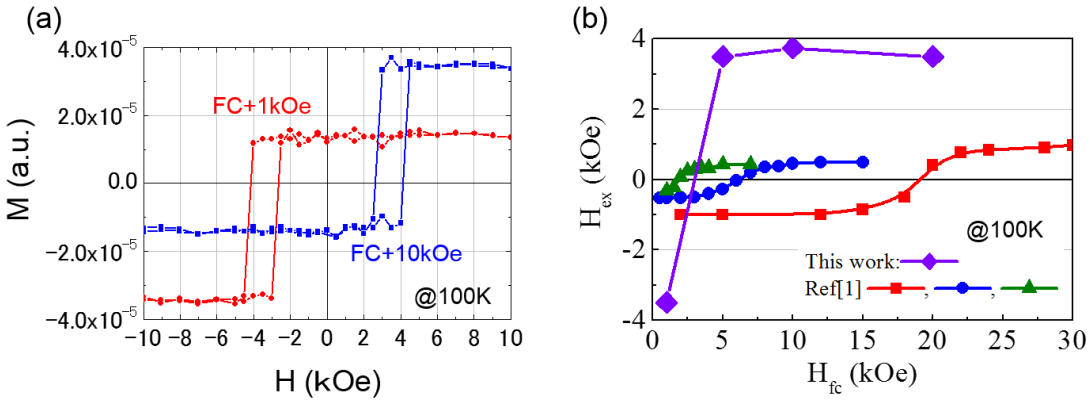

Fig. 1 (a) Magnetization curve of a Cr_2O_3/Co sample at 100K after field cooling at +1kOe (red circles) and at +10kOe (blue squires). (b) Cooling field H_{fc} dependence of H_{ex} of the sample. Those of ref [1] are also shown as a reference.

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