

Modulation of magnetic anisotropy in intentionally oxidized Co thin film by ionic liquid gating

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Two possible mechanisms are suggested to explain the voltage change in magnetic anisotropy (MA) in 3d ferromagnetic metals: the charge accumulation effect [1] and the electrochemical reaction such as reversible redox [2]. We have reported a possibility that the mechanism depends on the sign of the applied gate voltage V_G in the electric double layer capacitor with the Co thin electrode [3].

Ta/Pt/Co/MgO structure from the substrate side was deposited by rf sputtering on GaAs(001) substrate. A polymer film containing ionic liquid and having Au top electrode was directly put on the sample. We defined the Co layer as the cathode (anode) side during the application of a positive (negative) V_G . Hysteresis curves for the as-deposited sample with Co thickness (t_{Co}) of 2 nm are shown in Fig. 1(a). The perpendicular MA was slightly weakened at $V_G = +2$ V. The detailed analysis suggests that the charge accumulation effect dominates the change in MA when the Co layer is on the cathode side, while the anodic oxidization of the Co layer could be one of the causes of the large modulation observed in MA [3].

We have also checked the effect using the sample in which the surface of the Co was intentionally and mildly oxidized by oxygen plasma ashing (a part of the Co layer was confirmed to be CoO by X-ray photoelectron spectroscopy). Compared to the result in the as-deposited sample, larger MA modulation at $V_G = +2$ V was clearly observed [Fig. 1(b)]. The reduction of the CoO by positive V_G application likely dominates the large MA modulation in the sample after mild oxidation. The details will be discussed in my presentation.

This work was supported by Grant-in-Aid for Scientific Research (S) and Specially Promoted Research from JSPS.

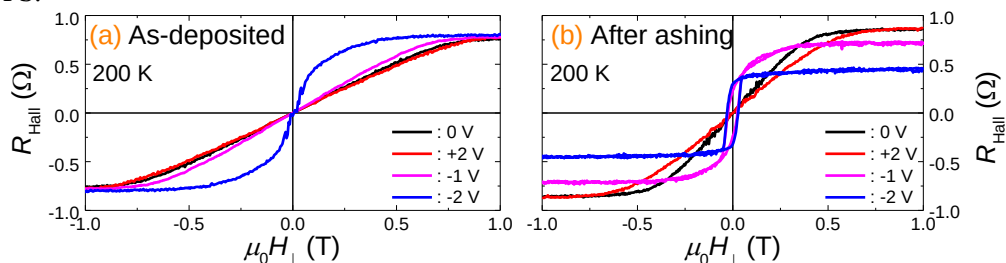


Fig. 1 Magnetic hysteresis curves obtained by sweeping perpendicular magnetic field under various V_G s for (a) the as-deposited sample and (b) the sample after ashing.

[1] T. Maruyama *et al.*, *Nature Nanotech.* **4**, 158 (2009). [2] U. Bauer *et al.*, *Nature Mat.* **14**, 174 (2015).

[3] T. Hirai *et al.*, *Appl. Phys. Express* **9**, 063007 (2016).