Electric field control of magnetism in surface-oxidized Co

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Electric field (EF) effect on magnetism in 3*d*-transition metals has attracted a great attention as an efficient way for controlling magnetization in next generation spintronic devices. Change in the electronic structure by electrostatic charge accumulation and/or electrochemical reaction has been proposed for underlying mechanism. The latter leads to dramatic change in magnetic properties, but is not suitable for the device application because of slow response and low endurance. Although a magnetization switching in a sub-nanosecond speed is possible using the former mechanism (charge accumulation) [1], the efficiency of the EF-induced change in the magnetic anisotropy (MA) should be enhanced for real application. In this talk, the EF control of magnetism in surface-oxidized Co in a solid state capacitor structure is discussed.

Ta(3.3 nm)/Pt(3.0)/Co(1.0) was deposited from the bottom side on an intrinsic Si(001) substrate by rf-sputtering. After the deposition, the sample was exposed to the air for ~10 minutes to form the oxidized layer on the surface of Co. As a gate dielectric layer, 45-nm-thick-HfO_2 was formed in an atomic layer deposition chamber at 150°C. Clear perpendicular magnetic anisotropy (PMA) with square hysteresis and the decrease in saturation magnetic moment are clearly observed in the present surface-oxidized sample, whereas a non-oxidized Co (1.0 nm) sample with 2-nm-thick MgO cap layer has an in-plane MA as shown in Fig. 1(a) [2]. Figs. 1 (b) and (c) indicate out-of-plane and in-plane magnetization curves for the surface-oxidized sample at each gate voltage measured by anomalous Hall measurement, respectively. The coercivity and PMA are enhanced (reduced) by positive (negative) gate voltage. An efficiency of the EF effect on MA shows ~230 fJ/Vm, which is larger than those in 3*d*-transition metals. Good reversibility with small resistance change (~0.02%) by gating, and conventional ac frequency dependence of capacitance and phase (not shown) suggest that charge accumulation without voltage-driven ion migration is most probable origin for the EF effect observed here [3]. This work was supported by Grant-in-Aid for Scientific Research (S) and Specially Promoted Research from JSPS and CSRN of Japan.

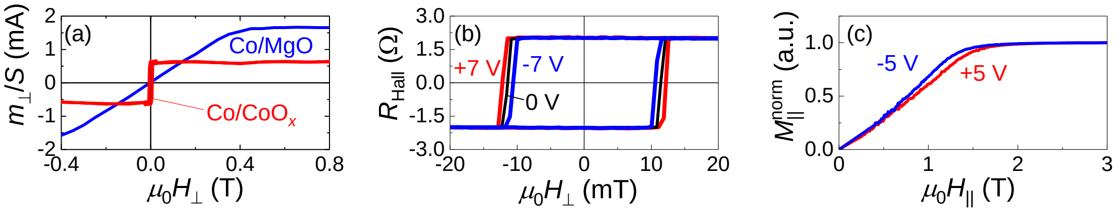

Fig. 1 (a) Magnetization curves of natural oxidized-Co (Co/CoO_x) and non-oxidized-Co (Co/MgO) sample. (b) Out-of-plane and (c) In-plane magnetization curves with the gating experiment for Co/CoO_x sample.

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