19a-S2-2

Electric field modulation of magnetization in MgO/Co/Pt structure

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Electric field gating is a novel means to manipulate magnetization and attracts attention because of its low power consumption compared to conventional ones. A field effect capacitor with an ultra-thin metallic magnet as a bottom electrode is used to change its magnetic properties. Particularly in Co/Pt system, which is widely known as a promising candidate for high-density storage media, its Curie temperature and perpendicular magnetic anisotropy are electrically controllable [1,2]. In this study, we investigate the change in a saturation magnetization M_s using a Co/Pt system under an application of electric field.

To probe the change in M_s by an electric field, we measured the change in the anomalous Hall resistance R_{Hall}, which is proportional to the perpendicular component of magnetization. The sputter-deposited MgO(2.0 nm)/Co(0.33 nm)/Pt(2.4 nm)/Ta(2.5 nm) on GaAs (001) substrate was used for the experiment. First the Hall bar geometry was fabricated from the film using standard photolithography technique and Ar ion milling. Subsequently, 50-nm HfO_2 insulator layer and Au (100 nm)/Cr (3 nm) gate electrode were formed on the Hall bar to apply a gate electric field to the bottom Co layer. The HfO_2 layer was deposited by atomic layer deposition. In our setup, a positive (negative) gate voltage V_G increases (decreases) electrons at the surface of the Co layer. We measured the Hall resistance under various V_G at 5 K.

Figure 1 shows $R_{Hall}(V_G)/R_{Hall}(V_G = 0)$ as a function of V_G, where $R_{Hall}(V_G)$ is the Hall resistance at V_G. The positive slope in the Fig. 1 indicates that M_s increases with increasing applied V_G if R_{Hall} is assumed to be proportional to M_s. In the presentation, we will discuss the mechanism of the electric field controlled magnetization in the MgO/Co/Pt system.

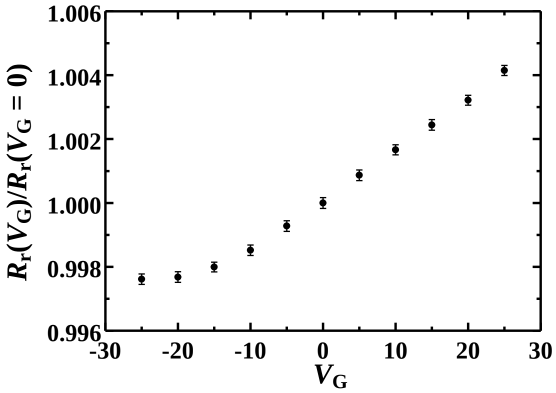

Fig.1. $R_{Hall}(V_G)/R_{Hall}(V_G = 0)$ as a function of V_G.

[1] D. Chiba *et al.*, *Nature Mater.* **10**, 853 (2011).
[2] K. Yamada *et al*., *Appl. Phys. Exp.* **6**, 073004 (2013).