Voltage Effect on Magnetic Properties for Fe-Pt-Pd Alloys

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[Introduction] Recently, voltage effects in ferromagnetic metals have attracted much attention because it enables us to control the magnetization direction with low external power. The applied voltage gives rise to the change in the number of carrier in a material, which leads to the change in magnetic properties without magnetic field or electric current flow. In order to use this voltage effect in practical applications, the enhancement in the magnitude of voltage-induced effect is inevitable. Previously, we reported the effect of voltage application in a Hall device with an $L1_0$-ordered FePt ($L1_0$-FePt) layer [1,2]. The $L1_0$-ordered FePt alloy having large uniaxial magnetic anisotropy (K_u) is a promising material for ultrahigh density magnetic storages. However, only small H_c change of 40 Oe was observed, and the detailed mechanism of H_c change has not been understood. For systematic investigation of voltage effect for ordered alloys with high K_u, $L1_0$-orderd Fe-Pt-Pd ternary alloys are one of the candidate systems because the magnetic anisotropy energy of Fe-Pt-Pd can be tuned by changing the ratio of Pt concentration to Pd. Thus, we consider that Fe-Pt-Pd ternary alloys give us the knowledge about the relationship between the magnetic anisotropy and the magnitude of voltage effect. In this study, we investigated the structure and magnetic properties for Fe-Pt-Pd thin films. In addition, the voltage effect was studied for the Fe-Pt-Pd ultrathin layers.

[Experimental Procedure] Fe-Pt-Pd thin films were prepared on an MgO (100) substrate employing an ultrahigh vacuum magnetron sputtering system. The structural characterization was performed by x-ray diffraction with Cu-$K\alpha$ radiation. The magnetic properties were measured using a superconducting quantum interference device magnetometer and a polar magneto-optical Kerr effect (MOKE). For the voltage application experiment, Fe-Pt-Pd ultrathin layers were grown on an MgO (100) substrate with a Pd buffer layer. The device fabrication was carried out through the use of photo-lithography and Ar ion etching. Polar-MOKE loops were measured under the voltage application to evaluate the change in H_c.

[Results and Discussion] When the Fe-Pt-Pd thin films were deposited at 500ºC, the value of K_u was monotonically decreased with increasing the Pd concentration in Pt-Pd keeping the Fe concentration at ~ 50 at. % although the perpendicular magnetization was obtained for all the concentrations. For the Fe-Pt-Pd thin films deposited at 350ºC, on the other hand, the FePd thin film showed the larger K_u than that for the FePt thin film owing to the formation of $L1_0$ ordered structure in FePd even at low temperature at 350ºC. Thus, FePd is suitable for the preparation of ultrathin layer at low deposition temperature. Based on the above results, the voltage effect on H_c was evaluated for the FePd ultrathin layer. In case of FePd, the H_c change of ~ 4 Oe was observed by changing the electric field in the range of ± 2.8 (MV/cm). The detail mechanism will be discussed in the presentation.

[1] T. Seki *et al.*, *Appl. Phys. Lett.* **98**, 212505 (2011). [2] Y. Kikuchi *et al.*, *J. Phys. D: Appl. Phys.* **46**, 285002 (2013).