Fabrication of tetragonal FeCo based alloy films with uniaxial magnetic anisotropy to develop an innovative permanent magnet

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Based on the first principles calculation, tetragonal distorted FeCo alloy has large uniaxial anisotropy energy K_{u1} and high saturation magnetization M_s, which is the most desirable feature for innovative permanent magnets [1,2]. In fact, the epitaxial tetragonal FeCo films with c/a~1.2 prepared on Rh buffer layer shows K_{u1} larger than 1.5x10^7 erg/cm^3 [3,4]. FeCo-Al forms a B2 ordered phase in a wide composition range and is expected to enhance K_{u1} through a B2 ordering and a huge magneto-elastic interaction [5]. In this study, the tetragonal $(Fe_{1-x}Co_x)_{1-y}M_y$ (x:0~1, y:0~0.2, M:Al, Ga etc) films are prepared on Rh buffer layer, and the uniaxial magnetic anisotropy is studied.

$(Fe_{0.5}Co_{0.2})_{0.9}M_{0.1}$(2~20nm)/Rh (20 nm)/MgO(100) and $Fe_{0.5}Co_{0.5}$(2~20nm)/Rh (20 nm)/ MgO(100) films were prepared in a high vacuum multiple dc-sputtering system with a base pressure lower than 1×10^{-6} Pa. Rh thin film was first sputtered on the MgO (100) substrate at 300 °C. Then, after decreasing the temperature to 200 °C, FeCoM films were epitaxially grown on the Rh layer. Finally, SiO_2 was sputtered as a capping layer to prevent oxidation. The film structure was analyzed by in-plane and out-of-plane XRD. Magnetic properties were measured by VSM, Polar-Kerr measurements and torque magnetometer.

The values of K_{u1} for $(Fe_{0.5}Co_{0.2})_{0.9}Al_{0.1}$ and $Fe_{0.5}Co_{0.5}$ films are plotted in Fig.1 as function of film thickness. These data are re-plotted as a function of the lattice distortion *c/a* in Fig.2, and its K_{u1}-*c/a* relation is understood by a tetragonal distortion [2]. $(Fe_{0.5}Co_{0.2})_{0.9}Al_{0.1}$ exhibits a maximum (2.1x10^7 erg/cm^3) around *c/a*~1.2. A coercivity *Hc* over 10 kOe is calculated from the single domain theory and, in fact, the coercivity of 3-7 kOe was observed in dot patterns with less than 100 nm in diameter. With taking account of *Ms*~1500 emu/cm^3, the tetragonal FeCo based alloy is one of the most probable candidates to develop an innovative permanent magnet with 60 MGOe. The results for other M metals will be introduced in the conference.

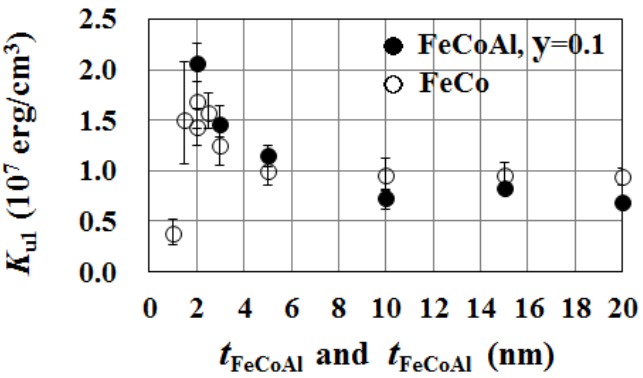

Fig.1　K_{u1} as a function of film thickness for $(Fe_{0.5}Co_{0.5})_{0.9}Al_{0.1}$ and $Fe_{0.5}Co_{0.5}$ films.

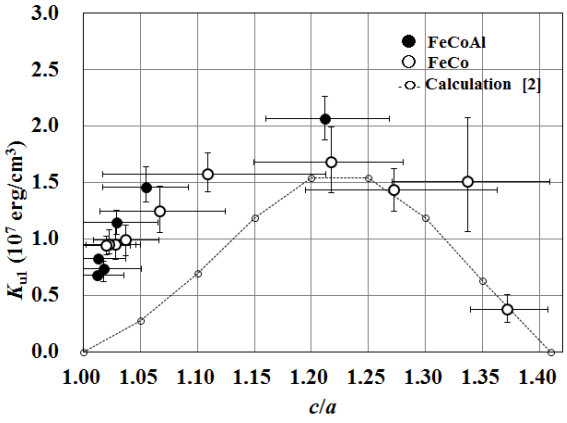

Fig.2　K_{u1} as a function of *c/a* for $(Fe_{0.5}Co_{0.5})_{0.9}Al_{0.1}$ and $Fe_{0.5}Co_{0.5}$ films.

References

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