Unexpected Large Magnetic Anisotropy of Fe_3Pt Pseudo-ordered Alloy Thin Films*

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In bulk phase, the Fe_3Pt is known to exhibit little magnetic anisotropy in its ordered and disordered phases because of cubic crystal symmetry. However, theoretical band structure calculation revealed a strong hybridization of an ordered Fe_3Pt between the Fe and Pt d state[1,2] and recently, it was predicted that Fe_3Pt alloy thin films could possess large in-plane magnetic anisotropy through deforming fcc to fct or m-DO19[3]. Experimentally, it was observed that the "quasi" $L1_2$–ordered phase of Fe_3Pt alloy thin films deposited onto MgO(100), (111) single-crystal substrates exhibits large in-plane cubic magnetic anisotropy constants (K_1= -4x106, $K_2=2\times10^7$ erg/cm^3) at room temperature[4]. However, the origin of such unexpectedly large magnetic anisotropy of Fe_3Pt alloy thin films is still open to question.

Alloy thin films of Fe_3Pt were fabricated by electron beam evaporation onto (100), (111), and (110) MgO substrates using Fe and Pt separate targets in a vacuum better than 10^{-7}Torr. The substrate deposition temperature was from ambient to 550 C. The resulting deposition rate was 0.7 Å/s and thickness of the samples was about 500 Å. The measured values of the magnetic anisotropy constants, ordering parameter S and lattice spacing ratio c/a of Fe Pt alloy thin films as a function of the deposition temperature are shown in Fig. 1. The values of K_1 and K_2 increase with Ts beyond 250 C. The maximum K_1 and K_2 values of the Fe_3Pt alloy thin films fabricated at350C are 3×10^7 and-6×10^7 erg/cm , respectively. These values of K_1 and K_2 are larger than the values of the Fe_3Pt alloy thin films fabricated onto (100) and (111)MgO (K_1 and K_2 are -4×10^6 and 2×10^7 erg/cm , respectively). Fig. 1(b) shows the degree of ordering S of Fe Pt alloy thin films. The order parameter S for Fe_3Pt alloy thin films fabricated on (110) MgO is estimated from the integrated intensities of the I (011) and I (022) peaks of the XRD pattern, where the Lorentz polarization factor, the temperature factor, absorption factor, and multiplicity factor are taken into account as explained in detail elsewhere. At Ts= 200 C, they are disordered and S increases with Ts . Fig. 1(c) shows the lattice constant ratio c/a which changes with Ts . All of these parameters are found to have strong dependence on Ts, suggesting the origin of the magnetic anisotropy being closely resulting from the short range ordering in the quasi-ordered structure. This quasi ordered structure is stabilized through the lattice expansion. Figure 2 shows the magnetic anisotropy K_1 and K_2 as a function of ℓ, which is defined as

$$\ell = (a^2 + c^2)^{1/2} / 2. \qquad (1)$$

The magnetic anisotropy is clearly found to be enhanced with lattice expansion beyond about 1 % in the basal plane. The result is consistent with the theory and also the previous observation[4].

It is also noted that the temperature dependences of the magnetic anisotropy constants of K_1 and K_2 were measured. The observed dependences of both K_1 and K_2 are in the power of $[M(T)/M(0)]^{1.8}$, which suggests the origin of the magnetic anisotropy is in the two ion-model theoretically put forwarded[5].

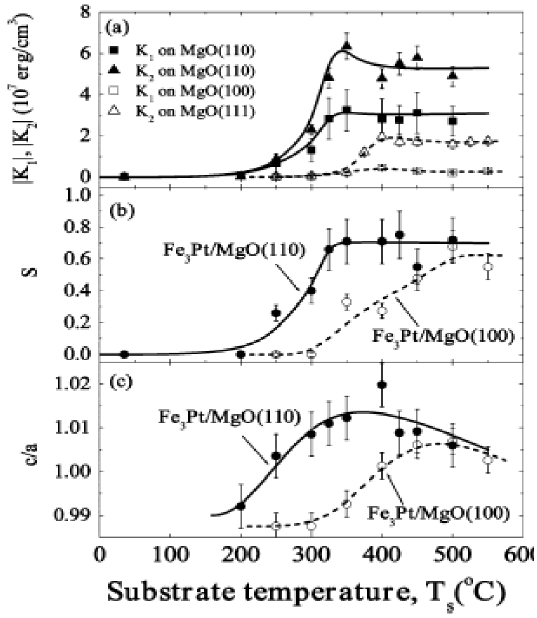

Fig.1 The magnetic constants and lattice constant ratio c/a as a function of substrate deposition temperature

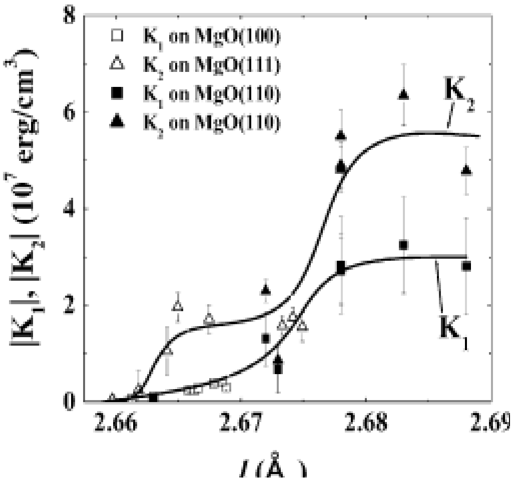

Fig.2 The magnetic anisotropy constants as a function lattice expansion ℓ.

Ref. [1] M. Podgorney, *Phys. Rev. B.*, 43, 11300 (1991). [2] K. J. Kim, S. J. L 89, 244 (2001). [3] R. R. Duplessis, *et al.*,*J. Appl. Phys.*,95, 6589 (2004). [4] M. A. I. Nahid and T. Suzuki, *J. Appl. Phys.*,97,10K307–1 (2005). [5] O. N. Mryasov, *et al.*, *Europhys. Lett.*, 69, 805, (2005).