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Effects of Ion-beam Bombardment and Post-annealing on the Structural and Magnetic Properties of Fe/Pt Multilayers

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Perpendicular magnetic anisotropy is one of the most important properties in the design of information storage applications, and in thin-films, is very sensitive to structure and individual layer thickness [1]. To clarify the effect of ion-beam bombardment and rapid thermal annealing on the growth process of Fe/Pt multilayers, we have investigated the structures and magnetic properties of as-deposited and annealed [Pt(20 Å)/Fe(15 Å)]$_{10}$ multilayers under different End-Hall voltages (V_{EH} = 0 ~ 150 V) by using a ion-beam deposition technique [2]. The as-deposited sample (V_{EH} = 0 V) consisted of Fe (a = 2.91 Å) and Pt (a = 4.02 Å) phases, and exhibits a small coercivity (H_c ~ 30 Oe) whereas magnetic hardening (due to formation of $L1_0$ FePt phase (a = 3.84 Å, c = 3.72 Å)) was found in annealed sample (550℃, 6 min.) with H_c ~ 9200 Oe. The order parameter of this annealed sample has been determined to be S ~ 0.9. The addition of a Pt underlayer results in the formation of $L1_0$ FePt at a lower annealing temperature. When increasing the annealing temperature to 550℃, the formation of $L1_2$ $FePt_3$ (a = 3.85 Å) results in a reduction in coercivity (H_c ~ 4600 Oe). Samples after ion-beam bombardment exhibit similar structures and magnetic properties to those of the as-deposited ones. However, after annealing at 550℃ for 6 min., the $L1_0$ FePt and $L1_2$ $FePt_3$ phases were suppressed when higher End-Hall voltages (V_{EH} = 150 V) were used during deposition. These results indicate that the activation barrier of diffusion increase dramatically with the compressive strain induced by ion-beam bombardment.

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Structure and Magnetic Properties of Sputtered FePd Thin Films

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INTRODUCTION

FePt and FePd thin films have drawn considerable attention as a potential high-density magnetic recording material due to the large magnetocrystalline anisotropy of ordered tetragonal $L1_0$ FePd phases. Since FePd occurs at temperatures lower than that in FePt, FePd may be suitable for the nanostructure control required for magnetic recording media [1].

EXPERIMENTS

FePd alloy thin films were manufactured on MgO (001) substrates by DC magnetron sputtering system. The composition of the films was measured by EDS. The crystal structure of FePd alloy thin film was measured by x-ray diffraction (XRD). The magnetic characterization was carried out both parallel and perpendicular to the film plane SQUID at room temperature. The applied magnetic field was in the range of -50 to +50 kOe.

RESULTS AND DISCUSSION

Fig. 1 shows a series of XRD patterns for FePd thin films with Fe compositions of 27-60 at.%. Since only (00n) diffraction peaks are observed, the films are strongly textured to the (001) planes, indicating that the films were grown epitaxially on MgO (001) substrates. The fundamental (002) peaks of the FePd L10 phases are clearly observed for all samples. The clear superlattice (001) peaks are observed for Fe compositions, x of 27-60 at.%. When Fe composition, x equals to stoichiometric composition (50 at.% of Fe), the intensity of superlattice peak corresponds to maximum. With further decrease or increase of x, the intensities of superlattice peaks decrease and the positions of fundamental peaks shift to a lower angle. The long-range order parameter, S, was calculated as the average of the order-parameter determined from the ratio of superlattice-to-fundamental (001)/(002) total integrated peak intensities. It was found that the order parameter, S had a maximum for the stoichiometric composition, whereas the magnetic anisotropy, Ku increased as the Fe content increased from below to close to the stoichiometric composition. It is believed the tensile strain of the c plane is considered to play a significant role in the formation of the FePd ordered structure [2]. Therefore the value of c is expected to give a major influence on Ku, because S is closely related with Ku. These results of our study imply that nonstoichiometric FePd compositions, with a slight excess of Pd, may in fact be preferred for applications that require high magnetic anisotropy.

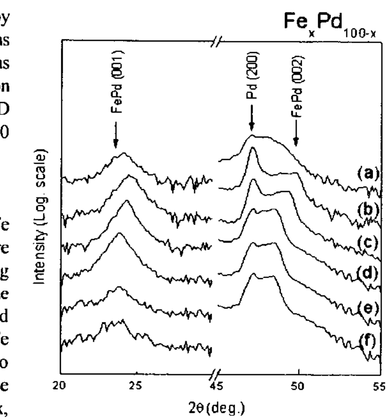

Fig. 1. X-ray diffraction patterns for FePd films. The Fe compositions x for FePd films are 60 (a), 50 (b), 48 (c), 42 (d), 34 (e), and 27 (f).

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