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Magnetic Properties of Ordered Fe/Pt Multilayer Thin Films

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I. Introduction

The Fe-Pt system attractsincreasing research interest due to its rich variety of crystal and magnetic structures. Three typical superlattice phases, Fe_3Pt $L1_2$, FePt $L1_0$ and $FePt_3$ $L1_2$can be formed respectively from the sample with a different composition at room temperature. The FePt (A1), FePt3 (A1)and Fe3Pt (L12) compounds are ferromagnetic, whereas A1 Fe3Pt and L12 FePt3 are paramagnetic at RT. L10 FePt is ferromagnetic and exhibits high magnetic anisotropy, high coercivity, saturation polarisation and Curie temperature. The unique properties make Fe-Pt alloys interesting from a scientific point of view, as well as for applications.

But the as-prepared Fe-Pt film has a disordered fcc phase. To order the film, post-annealing is necessary. However, the high ordering temperature is still a problem that prevents wide commercial production. Fe/Pt multilayer film, comparing with Fe-Pt alloy film, can lower the ordering temperature [1, 2]. More importantly, through controlling the thickness ratio of the Fe and Pt layer, different composition can be obtained. Thus study the Fe/Pt multilayer thin films systemicallyis meaningful.

We tried to prepare Fe/Pt multilayer thin films with different composition by DC magnetron sputtering through varying the thickness of Fe and Pt layers. Samples were annealed toform the alloy film. Structure and magnetic properties of the films were studied.

II. Experiment

The multilayer [Fe(6nm)/Pt(1nm)]20, [Fe(2nm)/Pt(1nm)]20, [Fe(0.85nm)/Pt(1nm)]20 and [Fe(0.66nm)/Pt(1nm)]20 films were grown by dc magnetron sputtering on well-cleaned SiO_2 substrate with a starting vacuum of $\sim 510^{-8}$ torr and working pressure of 6 mtorr. The films were post-annealed by conventional annealing (CA) in vacuum 10^{-6} torr of the quartz tube in the electrical furnace at 700 °C for 48hrs, in order to completely order the film.

Composition and thickness of the film were determined by EDX and α-step, respectively. The structure of the film was checked by XRD with Cu K_α radiation. The M-H curve was obtained by a vibrating sample magnetometer (VSM) option of quantum design PPMS.

III. Results and discussion

Fe/Pt multilayer thin films with different composition were obtained through varying the thickness of Fe and Pt layers. The nominal and measured composition was shown in Table 1.

Table 1. Nominal and measured composition for specimens.

Structure of film	Thickness (nm)	Composition	
		Nominal	Measured
$[Fe(6nm)/Pt(1nm)]_{20}$	140	Fe75Pt25	Fe70.04Pt29.96
$[Fe(2nm)/Pt(1nm)]_{20}$	60	Fe50Pt50	Fe51.98Pt48.02
$[Fe(0.85nm)/Pt(1nm)]_{20}$	37	Fe30Pt70	Fe33.52Pt66.48
$[Fe(0.66nm)/Pt(1nm)]_{20}$	33.2	Fe25Pt75	Fe22.98Pt77.02

XRD analysis showed that three typical phases, Fe_3Pt $L1_2$, FePt $L1_0$ and $FePt_3$ $L1_2$ can be formed respectively with a different composition after annealing by controlling the film thickness of Fe/Pt. Figure 1 displays the XRD pattern for as-deposited and post-annealed [Fe (2nm)/Pt (1nm)] $_{20}$ multilayer film with a near-equiatomic composition. The as-deposited film showed only two obvious peaks. The broadened peak ~41° is identified as fundamentalfcc FePt (111) peak. The other peak with a higher intensity is the Si (200), which is observed from the SiO_2/Si substrate. After annealing, the alloy film was formed and the film yielded a set of superlattice peaks, (001) and (002) included. Specially, separation of (002) and (200) peak was observed, which indicates that $L1_0$ structure has been formed after annealing.

Good hard magnetic properties were obtained for the sample with a L10 structure after annealing.