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# Structural Studies of Mono-atomic Layer-deposited $(FePt)_{1-x}Cu_x$ Thin Films and FePt Thin Films with Pt Top-layer Deposition

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Due to large magnetocrystalline anisotropy, $L1_0$ FePt and related films are investigated as potential candidates for high density magnetic recording media [1]. Great progress has been made in the synthesis of the $L1_0$ FePt and related films with controlled nanostructures and enhanced magnetic properties. Nevertheless, further studies are needed to achieve the final goal. Two important areas of focus remain in reducing the $L1_0$ phase transformation temperature and improving the practical methods to produce high degree of (001) texture in the $L1_0$ FePt and related films.

It is known that the $L1_0$ phase transformation temperature in FePt films can be reduced with an additive of third-element (e.g. Cu and Ag) [2]. Experiments carried out by various research groups have reached some conclusive results, the addition such as Cu can increase the rate of atom diffusion during the phase transformation and Cu can substitute Fe atomic sites in the $L1_0$ phase. Alternate monoatomic layer deposition technique was also applied in the synthesis of FePt thin films with the aim of reducing the $L1_0$ phase transformation temperature [3]. In the first part of the present work, we synthesized FePt and $(FePt)_{1-x}Cu_x$ thin films with a nominal thickness of 12 nm by monoatomic layer deposition followed by post-annealing at various temperatures. TEM/ED/EDS studies and magnetic measurements reveal that the samples with x=5% are transformed into the $L1_0$ phase by post-annealing at 300°C for 60s while the samples without Cu remain in the A1 fcc phase for those conditions. The TEM image of the $(FePt)_{1-x}Cu_x$ (x=5%) thin film, out-of-plane and in-plane hysteresis loops are shown in Figure 1. EDS analysis shows the distribution of Cu in the $(FePt)_{1-x}Cu_x$ (x=5%) films is not uniform causing the ratio of Fe-Pt to slightly vary from area to area. In contrast, the composition of the FePt film is uniform and close to $Fe_{52}Pt_{48}$. This shows that the decrease of the transformation temperature is related to the composition variation.

It has been shown that a suitable underlayer (e.g. Ag and Pt) can aid the formation of (001) textured FePt films [4]. It has also been found that a Ag cap layer can improve the formation of $L1_0$ phase for FePt thin film [5]. In the second part of the present work, we compare FePt films with and without a 1 nm Pt top layer. The films with total thickness of 12 nm were synthesized by multilayer deposition followed by post-annealing at 600°C for 30s. A cross-sectional TEM image of the FePt film is shown in Figure 2(a). It is synthesized with a Pt top layer in as-deposited films and the Pt top layer diffuses into the FePt layer during annealing treatment. The SAED pattern of the sample with an incident electron beam along the film surface normal is shown in Figure 2(b), together with a simulated diffraction pattern using the PECD2.0 software [6]. The diffraction rings can be indexed by (hh0) indices only, which indicates that nearly perfect (001) texture of $L1_0$ phase is obtained. In comparison, the (001) texture in the FePt films without a Pt top layer exists to a much lower degree. This result indicates that the diffusion of the Pt top layer enhances the formation of the (001) texture.

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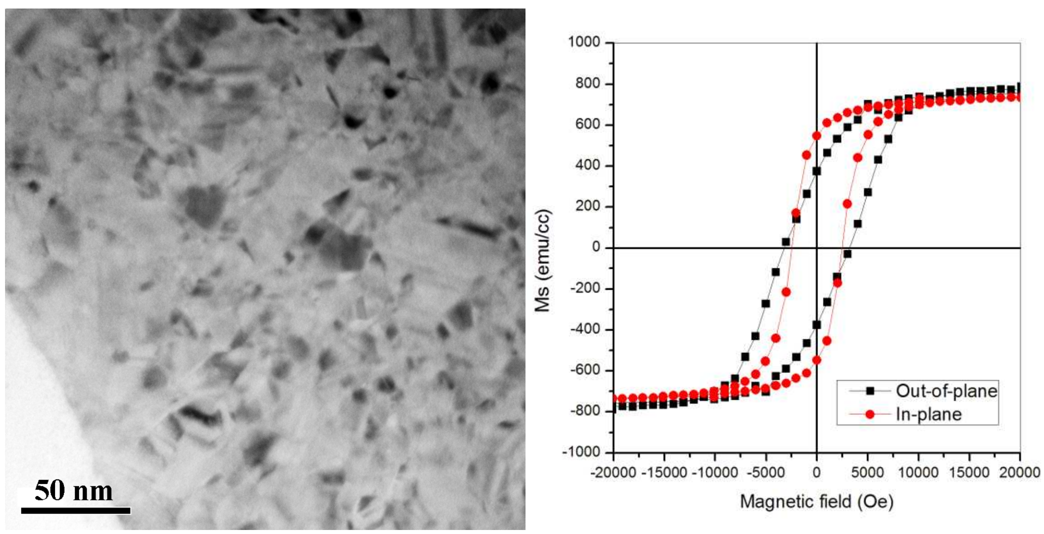
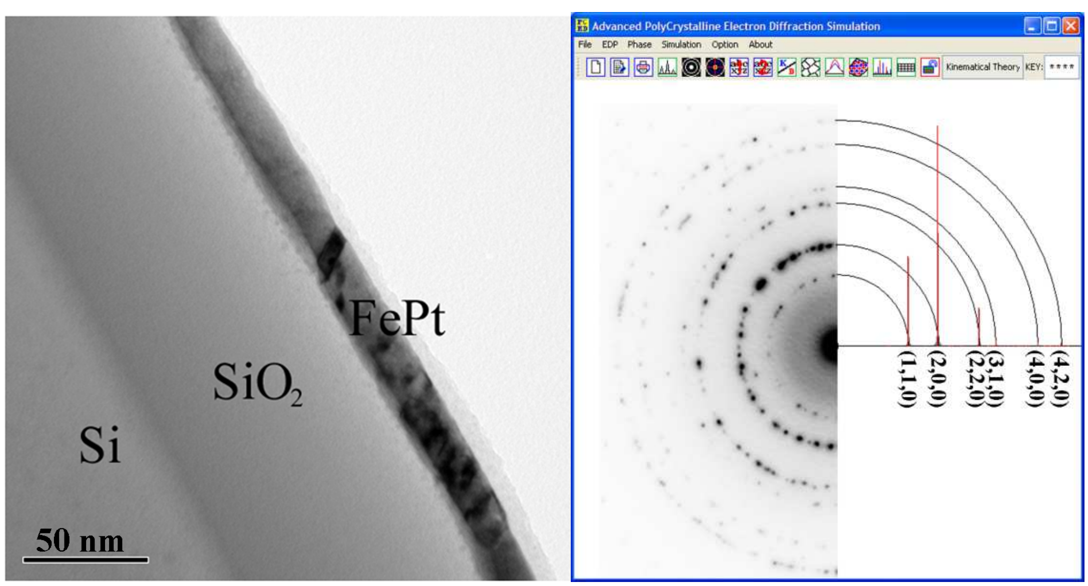



(a) (b)

Figure 1. FePt thin film with 5 at% Cu additive post-annealed at 300°C for 60s, (a) a plane-view TEM image of the sample, (b) an out-of-plane and in-plane hysteresis loops of the sample.




(a) (b)

Figure 2. FePt film with Pt top layer post-annealed at 600°C for 30s, (a) a cross-sectional TEM image of the sample, (b) an experimental SAED pattern of the sample with the incident beam along the film surface normal and a simulated diffraction pattern of the (001) textured FePt $L1_0$ phase.

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