

Study of microstructure and magnetic properties of L1₀ FePt/SiO₂ thin films

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Abstract. Achieving magnetic recording densities in excess of 1Tbit/in² requires not only perpendicular media with anisotropies larger than 7 MJ/m³, making FePt alloys an ideal choice, but also a narrow distribution below 10 nm for a reduced S/N ratio. Such grain size reduction and shape control are crucial parameters for high density magnetic recording, along with high thermal stability. Previous work has shown that the L1₀ FePt grain size can be controlled by alloying FePt with materials such as C, Ag, and insulators such as AlO_x, MgO. Au and Al₂O₃ also act to segregate and magnetically decouple the FePt grains. Better results were obtained with C with respect to the uniformity of grains and SiO₂ with respect to the shape. We present our results on co-sputtering FePt with C or SiO₂ (up to 30 vol %) on MgO (001) single crystal substrates at 350 and 500 °C. With C or SiO₂ addition we achieved grain size reduction, shape control and isolated structure formation, producing continuous films with high uniformity and a narrow grain size distribution. These additions thus allow us to simultaneously control the coercivity and the S/N ratio. We also will report structural and microstructural properties.

1 Introduction

Areal density is one of the most important figures of merit for magnetic recording media [1]. The central issue is to develop media that exhibit excellent thermal stability (large energy barrier E_a), while maintaining easy writability, (relative small coercivity H_c of the order of 1-1.5 T). In order to achieve this we tuned the high magnetocrystalline anisotropy of FePt by co-sputtering with C and SiO₂. Addition of C leads to a grain size reduction [2], an improvement of main diameter distribution, which is very important in S/N ratio maximization, and to the isolation of the magnetic particles [3,4]. With the addition of SiO₂ better control of the coercivity is achieved, a columnar shape is realised with cuboid-like particles which are considered more suitable for the magnetic recording [5].

2 Experimental procedure

Single films were prepared by multitarget magnetron sputtering using a AJA ATC 2200-V with a base pressure of 5×10^{-9} Torr. Samples are prepared by co-sputtering from FePt and either C or SiO₂ targets, on polished single crystal MgO (001) substrates. The FePt deposition power in the 2" DC gun used was 0.6W/cm², whereas for C and SiO₂ the power was varied from 0 to 6.5W/cm² (DC), the deposition pressure being fixed at

1.5mT. The C and SiO₂ percentages were varied up to 30%. In order to investigate the effect of variation of the magnetocrystalline anisotropy in crystallographic and magnetic properties, samples were prepared at two different temperatures, 350 and 500°C. XRD measurements were performed using a Siemens D500 diffractometer with Cu-K α radiation, while magnetic measurements were carried out using a Quantum Design MPMS SQUID magnetometer. Surface morphology was observed with a JEOL 7401F SEM (Scanning Electron Microscope).

3 Results and discussion

A drastic change in the microstructure in FePt films with C addition is observed with SEM, Figure 1.

From columnar grains with diameters larger than 120nm, in the case of pure FePt film deposited at 500°C, a gradual reduction down to 12nm is observed in the case of FePt-C films. Further improvements in the desired shape are achieved at higher C percentages (>20%), producing films with well isolated spherical particles and improved mean size distributions, in contrast with arbitrary shape grains that appear in the single phase FePt system. It is worth noting that the results at 350°C deposition temperature follow a similar trend Figure 2.

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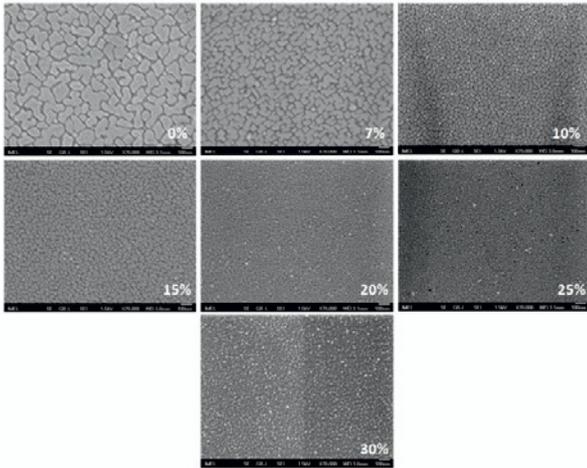


Fig. 1. SEM surface images with different C percentage, for 500°C deposition temperature.

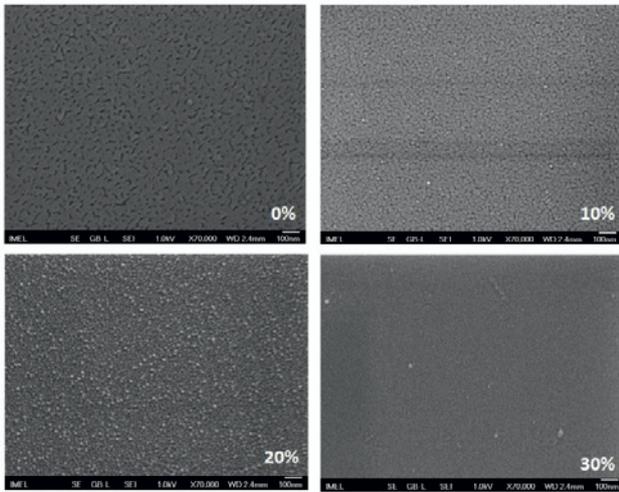


Fig. 2. SEM surface images with different C percentage, for 350°C deposition temperature.

In accordance with theoretical expectations, a small increase in the coercive field is observed due to grain size reduction Figure 3, while the carbon addition does not affect the crystallographic orientation in comparison with the pure FePt films.

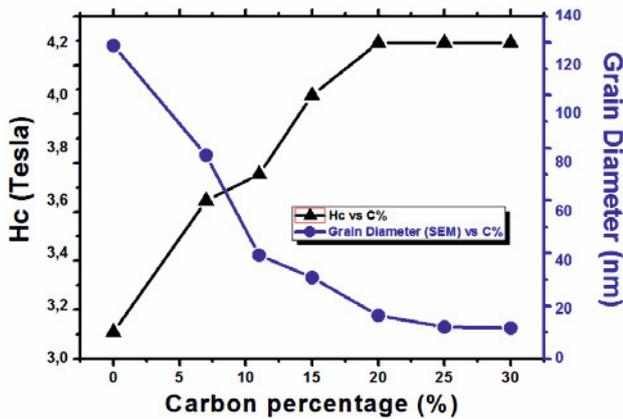


Fig. 3. Coercive field and SEM grain diameter variation versus C percentage, for 500°C deposition temperature.

As is revealed in the X-ray diffraction diagrams Figure 4 a(350°C)-b (500°C) the films grow epitaxially along the (001) axis, with the L1₀ phase is formed at both deposition temperatures.

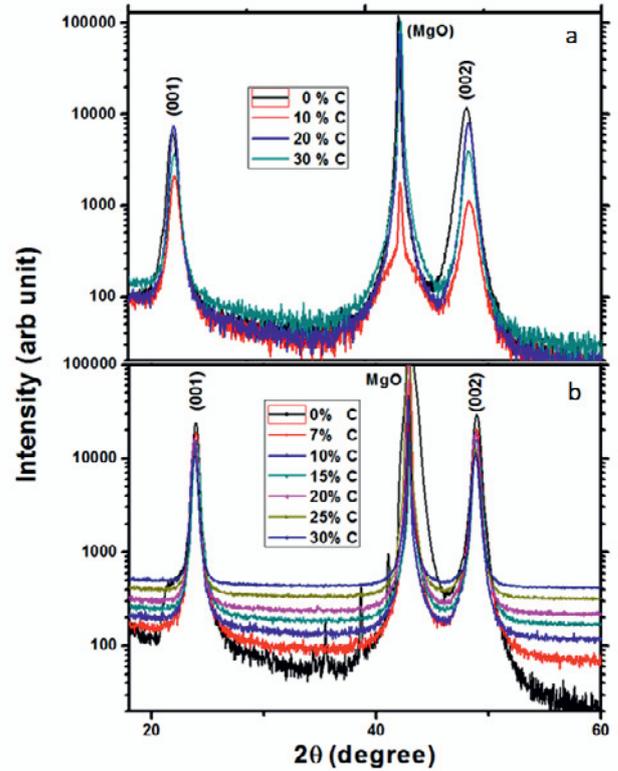


Fig. 4. FePt-C x-ray diffraction pattern for (a) 350°C and (b) 500°C.

Addition of SiO₂ also leads to a significant reduction in the mean grain diameter down to 10nm, as is observed with SEM microscopy Figure 5, with isolated spherical particles formed at high percentages (>20%).

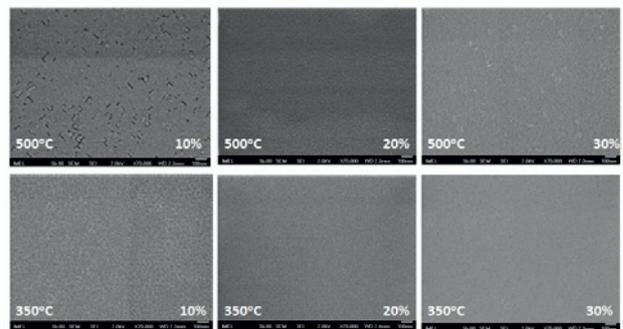


Fig. 5. SEM surface morphology for different SiO₂ percentages.

Magnetic measurements show a large coercive field reduction, from 3.2T for a single FePt film down to 0.37T in the case of 10% SiO₂ at 500°C deposition, while a decrease from 0.5T to 0.17T was observed when the deposition temperature was 350°C Figure 6, indicating the ability to control the magnetic properties of the system.

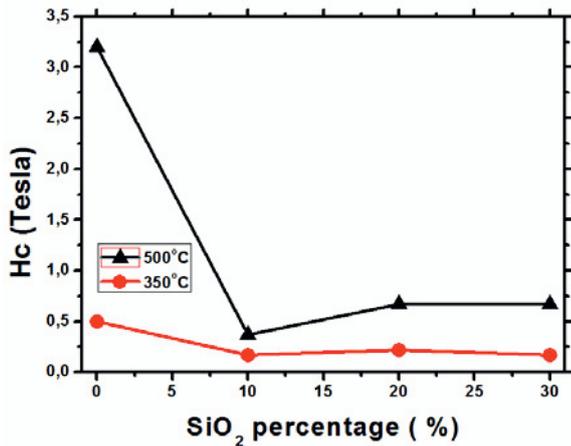


Fig. 6. Coercive field as a function of SiO₂ percentage for both 350 °C and 500°C deposition temperature.

Moreover, the XRD measurements of the SiO₂ samples prepared at 350°C show that the phase transformation from fcc to fct is partial, the (001) reflection showing a decreased intensity Figure 7. The FePt atoms' mobility is limited by the addition of SiO₂ thus impeding the fcc to fct transformation, leading to a coercive field reduction in comparison with the pure FePt film. Again, at both deposition temperatures FePt/ SiO₂ film growth is along the (001) crystallographic axis.

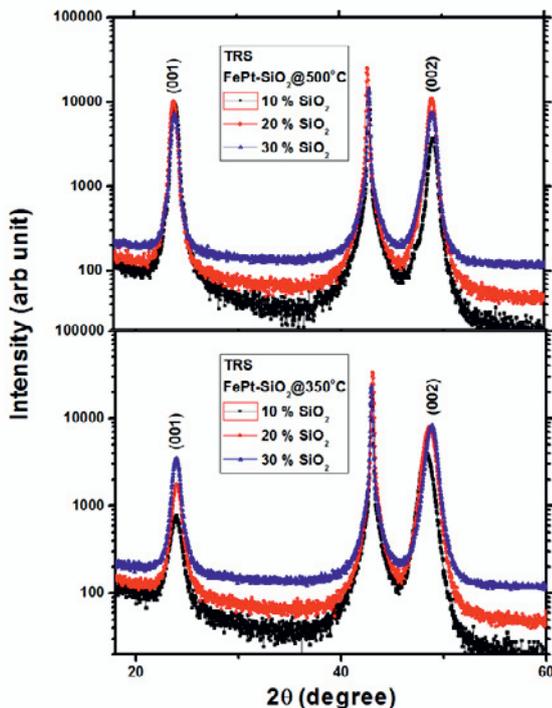


Fig. 7. FePt-SiO₂ x-ray diffraction diagram for 500°C and 350°C

4 Conclusions

Tailoring the magnetocrystalline anisotropy of the FePt films is achieved by co-sputtering C or SiO₂ at two different deposition temperatures. With C or SiO₂ additions we achieved desirable grain size reductions,

isolated structure formation and shape control while producing continuous films with high uniformity and narrow size distributions. Such grain size reductions down to 10 nm also allows us to vary of coercivity as a function of the additional phase, thus giving us a possibility to simultaneously control the coercivity and the S/N ratio. Better results were obtained with C with respect to the uniformity of grains and SiO₂ with respect to the shape.

5 Acknowledgements

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