

## Thickness Effect on the Formation of FePt Nanoparticles in FePt/C Multilayers

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The as-deposited FePt thin films are in the form of fcc disordered A1 structure. The magnetically soft fcc structure will transform to the fct L<sub>1</sub><sub>0</sub> structure after high temperature annealing, exhibiting a high magnetic anisotropy, which makes FePt thin films become one of best candidates for high density recording media [1-2]. The role of carbon in the disorder-order transformation of FePt/C thin films has not been clear, although Carbon is used as a non-magnetic matrix to isolate the FePt nanoparticles in FePt/C thin films. This work is to study the effect of both carbon layer thickness and the repetition number on the microstructural evolution in FePt/C thin films. The nanoparticles were formed by annealing multilayers of FePt/C precursors at around 700°C. The FePt/C multilayered films were deposited by dc magnetron sputtering from solid FePt and Carbon targets onto Si (111) substrates using the tandem deposition technique. A 200 Å layer of C was used as an underlayer and overlayer to encapsulate the FePt/C (5Å/5Å and 5Å/20Å) multilayers (consisting of 3-100 repetitions) in order to reduce any effect from the substrate and to avoid oxidation during annealing. Cross-sectional and planar view TEM were carried out on JEOL JEM -2000FX and JEOL JEM-3010 to study the microstructure.

Figure 1 shows the microstructure in the FePt/C (100 repetitions) samples with different carbon layer thickness. No layered structure was observed in the as-deposited 5Å/5Å FePt/C sample (figure 1a). Because the thickness of each deposited carbon layer is only 5Å, the surface mobility during thin film growth is enough to break the layers in the as-deposited sample. This as-deposited sample consisted of a fine microstructure with a uniform narrow particle size distribution centered at 3 nm. The degree of atomic ordering of the fct structure increases with annealing at 700°C. After 1 hr aging, the 5Å/5Å sample shows the aggregation of particles up to 20 nm and a well-ordered fct structure (figure 1b). Similar microstructure is observed in the as-made 5Å/20Å FePt/C sample, but the cross-sectional TEM shows the FePt/C layers (figure 1c). Cross-sectional TEM reveals the layers are completely broken after 5 min annealing. Both particle size and degree of atomic ordering increase very slowly with further annealing in the 5Å/20Å sample. After 1 hr annealing, an average particle size of 6 nm is observed, and only weakly intense (001) superlattice reflection is observed on the electron diffraction pattern (figure 1d). It means that there is a mixture of fcc and fct structures in this 5Å/20Å sample. Both morphology and structure in the as-deposited 5Å/5Å sample with 3 repetitions do not change, in comparison with the 100 repetitions sample. An isolated particle morphology is observed in the both planar and cross-sectional view TEM samples, even after annealed at 700°C for 1hr, with 7 nm of mean particle size and a well-developed fct structure (figure 2). Elongated particles are observed in the cross-sectional TEM sample, which is believed to lead to magnetic anisotropy. Therefore, both carbon layer thickness and repetition number can strongly affect the phase transformation during annealing. The larger carbon layer thickness or fewer repetitions will lead to small and isolated particle morphology in the FePt/C thin films [3].

### References

[1] T. Hayashi, S. Hirono, M. Tomita, and S. Umemura, *Nature (London)* **381**, 772 (1996).

- [2] J.-U. Thiele, L. Folks, M. F. Toney, and D. K. Weller, *J. Appl. Phys.* **84**, 5686 (1998).  
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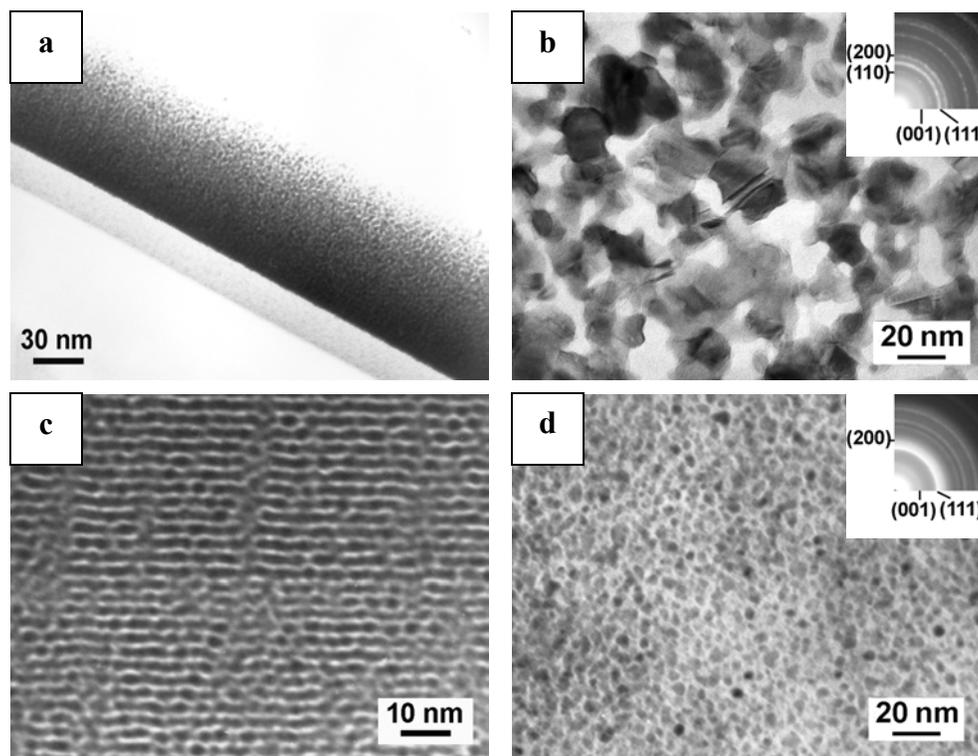


Figure 1 TEM microstructure of  $5\text{\AA}/5\text{\AA}$  and  $5\text{\AA}/20\text{\AA}$  FePt/C samples with 100 repetitions: (a) Cross-sectional of the as-deposited  $5\text{\AA}/5\text{\AA}$  sample; (b) Planar view of the  $5\text{\AA}/5\text{\AA}$  sample annealed at  $700^\circ\text{C}$  for 1 hr, the insert EDP showing a well-ordered fct structure; (c) Cross-sectional of the as-deposited  $5\text{\AA}/20\text{\AA}$  sample; (d) Planar view of the  $5\text{\AA}/20\text{\AA}$  sample annealed at  $700^\circ\text{C}$  for 1hr, and the insert EDP showing a mixture of fct plus fcc.

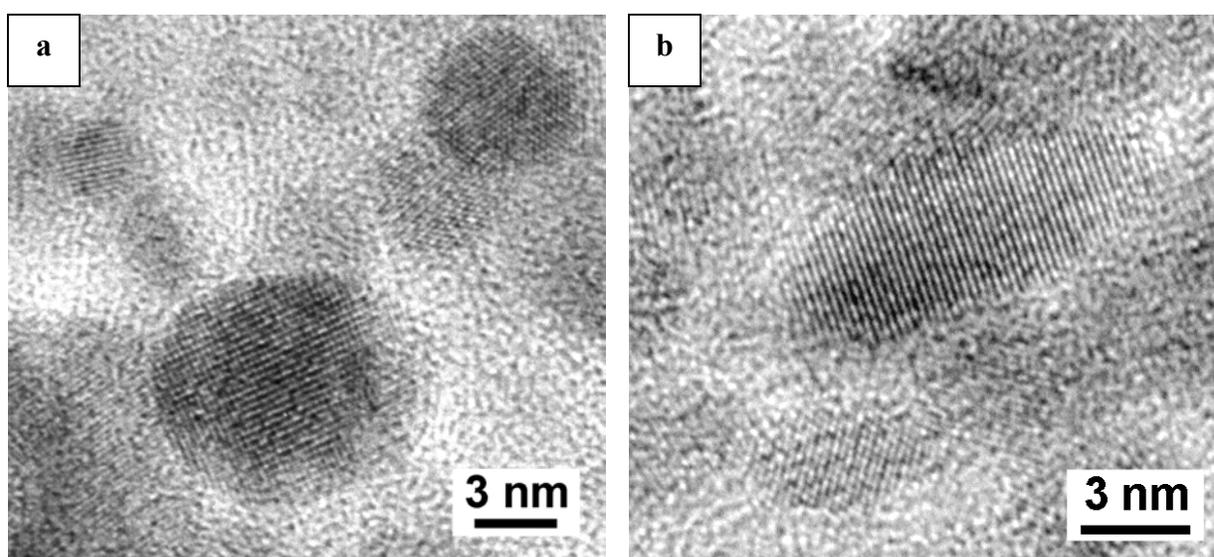


Figure 2 HREM of  $5\text{\AA}/5\text{\AA}$  FePt/C samples with 3 repetitions: (a) Planar view; (b) Cross-sectional.