ORIGIN OF IN-PLANE COMPONENT FOR $L1_0$-FePt GRANULAR FILMS DEPOSITED ON MgO SINGLE CRYSTAL SUBSTRATE

J. WANG, H. SEPEHRI-AMIN, Y.K. TAKAHASHI and K. HONO
National Institute for Materials Science, Sengen 1-2-1, Tsukuba 305-0047, Japan
WANG.Jian@nims.go.jp

I. INTRODUCTION

To achieve optimized recording performance, $L1_0$-FePt based HAMR media need to have strong (001)-texture. However, for the FePt grains deposited on (001) textured polycrystalline underlayers usually show serious in-plane components and can significant affect the signal-to-noise ratio (SNR) of the recording medium. The proposed origin of in-plane components in FePt based granular media, such as surface roughness [1] grain boundary [2], misorientation from the seed layer grains [3] and the formation of different variants [4] are still under debate. It is believed that the clarification of the origin of the in-plane components should make a significant impact on the future development of HAMR media. In this work, with detailed microstructure observation, we unexpectedly found that 90 degree misaligned (in-plane magnetic easy axes) FePt grains were detected even FePt epitaxially grow on MgO (001) single crystal substrate. To clarify the origin of such in-plane grains, FePt granular films with different segregant (carbon) composition were deposited on MgO (001) substrates, and their microstructures were studied in detail by aberration corrected scanning transmission electron microscopy (STEM).

II. EXPERIMENTAL

10-nm-thick FePt – x vol.% C (x= 0, 25, 30, 34 and 38) films were DC magnetron co-sputtered on single-crystalline MgO (001) substrates from FePt alloy target and C targets with a base pressure better than 2.5×10^{-7} Pa. The film microstructure was examined by aberration corrected scanning transmission electron microscopy (STEM), Titan G2 80 – 200.

III. RESULTS AND DISCUSSIONS

Without carbon as segregant, $L1_0$-ordered FePt grains form truncated octahedra or island microstructutre with large size distribution on the MgO substrate (not shown here). By the addition of carbon, the morphology of FePt grains is modified into well isolate nanoparticle. Figure 1 shows the in plane bright field TEM images of MgO (001) / FePt- 25.7 vol.% C 10 nm thin films with 5 nm carbon over coating. One can see that the FePt-C layer gives a well-isolated nano-granular structure with average grain size around 9.8 nm. Such media

J.WANG
National Institute for Materials Science
E-mail: WANG.Jian@nims.go.jp
Tel: +81-298-59-6819

gives nice squareness of the out-of-plane magnetization curve with perpendicular coercivity field μH_c ~ 4.4 T. Also, its narrow and straight in-plane magnetization loop in company with a small remnant magnetization ratio $M_{//}$ / $M_{\perp}$ ~ 3 % indicates limited in-plane components of the medium.

However, details microstructure observation indicates that 90 degree misaligned (in-plane magnetic easy axes) FePt grains are formed even on single crystal MgO substrate. Figure 2 shows a typical example, in which two different crystallographic orientations co-exist in one individual FePt grain. Lattice spacing and nano-beam diffraction patterns confirm the red dot marked resign in Fig. 2 has an in-plane c axis. Interestingly, such kind of feature is rarely observed in carbon free FePt granular thin film. It is believed that the diffusion of carbon into the FePt / MgO interface suppress the epitaxial grow of FePt grains which leads to the in-plane c axis. The FePt grains with partially in-plane c axis can hardly affect the magnetization reversal due to the strong directly ferromagnetic coupling with majority of out-of-plane components in one individual grain. But when they are separated with further increased carbon concentration, and then the fully in-plane orientated small FePt grains should response to the in-plane component of the recording media.

REFERENCES

[1] S. Wicht, V. Neu, L. Schultz, B. Rellinghaus, D. Weller, O. Mosendz, G. Parker, S. Pisana, "Atomic resolution structure–property relation in highly anisotropic granular FePt-C films with near-Stoner-Wohlfarth behaviour", *J. Appl. Phys.*, vol. 114, pp. 063906, (2013).

[2] H. Ho, J. Zhu, A. Kulovits, E. D. Laughlin, J.-G. Zhu, "Quantitative transmission electron microscopy analysis of multi-variant grains in present L1 0 -FePt based heat assisted magnetic recording media ", *J. Appl. Phys.*, vol. 116, no. 19, pp. 193510, (2014).

[3] J. Wang, S. Hata, Y.K. Takahashi, H. Sepehri-Amin, B.S.D.Ch.S. Varaprasad, T. Shiroyama, T. Schrefl, and K. Hono, "Effect of MgO underlayer misorientation on the texture and magnetic property of FePt–C granular film", *Acta Mater.*, vol. 91, pp. 41-49, Jun. (2015).

[4] H. Sepehri-Amin a, H. Iwama b, T. Ohkuboa, T. Shima b, K. Hono, "Microstructure and in-plane component of L10-FePt films deposited on MgO and MgAl2O4 substrates", *Scripta Mater.*, vol. 130, pp. 247–251, Dec. (2017).

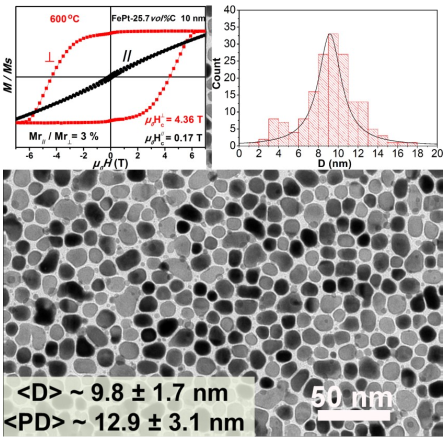

Fig.1 In-plane BF-TEM images of 10 nm FePt-25.7 *vol.%* C on MgO 001 substrate. Inset: OP (red) and IP (black) magnetization curves (left) and grain size distribution (right).

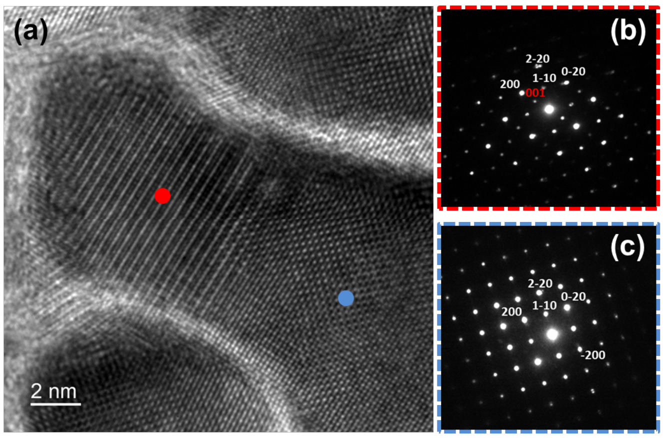

Fig.2 In-plane bright field STEM image (a) and nanobeam diffraction patterns taken from FePt grains with in-plane c axes (b) and out-of-plane c