In-plane components of FePt nanogranular films on MgO underlayer with and without carbon segregant

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L1₀-ordered FePt granular thin film is considered as the most promising candidate for heat assisted magnetic recording (HAMR) media [1]. To achieve recording density higher than 2 Tbit/in^2, $L1_0$-FePt based granular media need to have an ultra-small grain size of about 4 nm, a narrow size distribution below 10% and columnar structure with strong (001)-texture. However, FePt grains deposited on (001) textured polycrystalline underlayer usually show remarkable in-plane components which can severely degrade the signal-to-noise ratio (SNR) of the recording medium [2]. It is believed that the clarification of the origin of the in-plane components for the FePt grains deposited on polycrystalline underlayer would make significant impact on the future development of HAMR media. In this work, we study the effect of carbon segregant on the in-plane components of the FePt thin films deposited on the polycrystalline MgO underlayer. The FePt films with optimized volume fraction of carbon segregant show not only smaller grain size but also enhanced perpendicular coercivity. Moreover, it is worth noticing that the in-plane components is also significantly suppressed compared with the FePt films without carbon segregant.

Figure 1 shows the in-plane TEM images of FePt films (a) without and (b) with carbon segregant. Without carbon segregant (Fig.1a), $L1_0$-ordered FePt grains form an island-like microstructutre with broad size distribution. By introducing 28 vol.% of carbon segregant (Fig.1b), the FePt grain size is reduced down to 9 nm with improved grain size distribution (15%). Such physical isolation weakens the ferromagnetic exchange coupling and lead to the enhancement of the perpendicular coercivity from 2.87 T (without carbon) to 3.90 T (with carbon). Moreover, from the shrinked in-plane M-H loop and reduced remanence ratio ($Mr_{//} / Mr_{\perp}$), the in-plane component is also suppressed by introducing carbon segregant. To clarify the origin of such improvement, detailed microstructure characterization was carried out. Figure 2 presents the cross-sectional TEM image of the FePt film without carbon. It was found that the 001 plane of FePt grains is energy favorable to rotate 72.6^o to match with MgO underlayer with different orientation when the big FePt grains grow cross the grain boundary. It can be detected that the crystal rotation do not triggered immediately at the grain boundary (Fig. 2a). So there is buffer zone in which FePt grains can maintain their initial texture meantime accumulate the strain energy due to the change of template. When the FePt grains grow beyond the buffer zone, it start to misalign to release the strain energy. So, the possibility is higher for big FePt grains to exceed the buffer zone and form in-plane components than small FePt grains on the poly- MgO underlayer.

Reference

1) A. Perumal, Y. K. Takahashi, and K. Hono, Appl. Phys. Express 1, (2008) 101301.
2) J. Wang, S. Hata, Y.K. Takahashi, H. Sepehri-Amin, B. Varaprasad, , T. Schrefl, K. Hono, Acta Mat., 91 (2015) 41

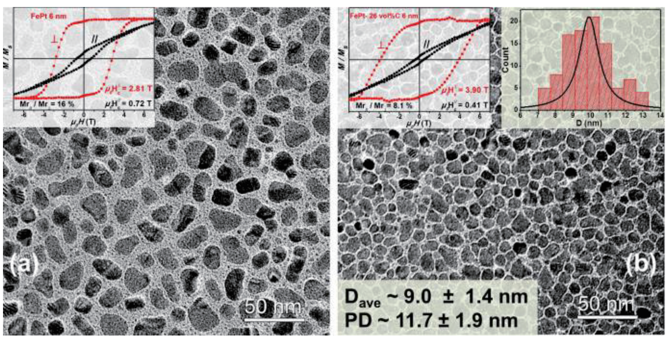

Fig.1 In-plane TEM images of 6 nm FePt- *X* vol. % C granular thin film on MgO (001) underlayer: (a) *X* = 0 and (b) *X* = 28. Inset: corresponding M-H curves and grain size distribution.

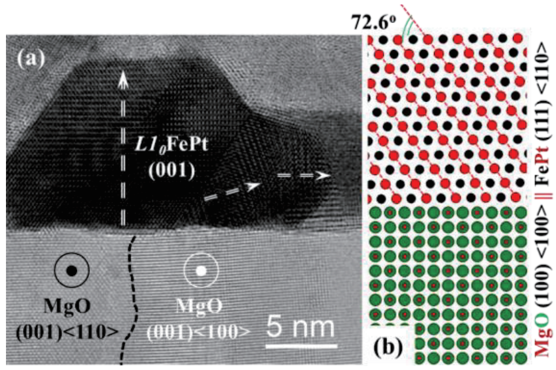

Fig.2 Cross-sectional TEM image FePt-28 vol.% on MgO (001) underlayer (a) and epitaxial relation of misaligned FePt grains at the grain boundary of MgO underlayer (b).