# Origin of in-plane component for $L1_0$-FePt nanogranular films deposited on MgO single crystal substrate

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To achieve recording density larger than 4 Tbit/in$^2$, $L1_0$-FePt based granular media need to have an average grain size of about 4 nm, a size distribution below 10%, columnar structure and strong (001)-texture[1]. It is well accepted that by depositing FePt grains on MgO (001) single crystal substrate at elevated substrate temperature, strong (001)-texture can be easily developed in FePt grains due to the epitaxial growth at the MgO(001)/FePt(001) interface[2,3]. In this work, with detailed microstructure observation, we surprisingly found that 90 degree misaligned (in-plane magnetic easy axes) FePt grains were detected even they were epitaxially grown on MgO (001) single crystal substrate. Also, there is a reduction of FePt magnetic moment with high carbon concentration.

To clarify the mechanism of such a phenomenon, 10-nm-thick FePt – *x* vol.% C (*x*= 0, 12, 25, 30, 34,38 and 40) films were DC magnetron co-sputtered on single-crystalline MgO (001) substrates from FePt alloy target and carbon targets. The film microstructure and magnetic properties were examined by aberration corrected - STEM and X-ray magnetic circular dichroism (XMCD).

Figure 1 a shows the cross-sectional HAADF images of MgO (001)/FePt- 38vol.% C 10 nm thin film. It clearly demonstrates one individual FePt grain with fully in-plane orientated 001 texture (c axes) indicated by the red arrow. With the model in Fig.1 b, it is believed that the diffusion of carbon at the FePt/MgO interface suppress the epitaxial contact area.
Meanwhile, the compress stress received from neighboring FePt grains when grains are highly packed can tune the stress distribution in the FePt grains which may leads to formation the in-plane components. More interestingly, with the result from XMCD spectra, it is found that there is a reduction of the FePt magnetic moment with systemically increasing the carbon concentration (> 34.5 vol%) (Fig.2). In order to confirm the formation of new phase such as iron carbide ($Fe_3C$), X-ray photoelectron spectroscopy analysis will be carried out.

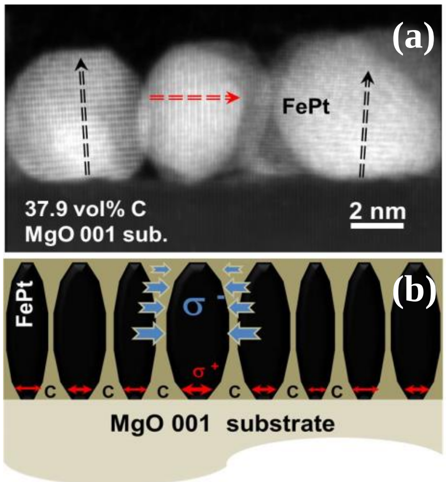


Fig.1 Cross-sectional HAADF TEM images MgO (001)/FePt- 38vol.% C 10 nm thin film (a) and model of stress distribution In FePt grains (b).

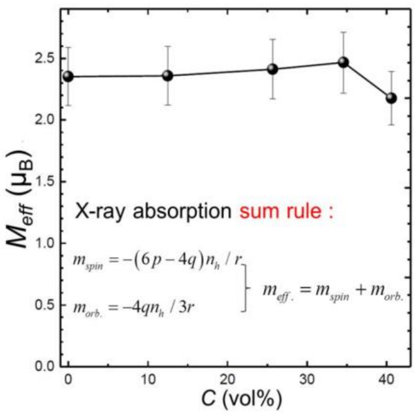


Fig.2 The calculated effective magnetic moment of Fe from Fe $L_{2,3}$-edge XMCD spectra with various carbon concentration.

## References

1) S. Wicht, *et. al.*, *J. Appl. Phys.*, 114, 063906, (2013);
2) H. Ho, *et. al*, *J. Appl. Phys.*, 116, 19, 193510, (2014);
3) J. Wang *et. al*, *Acta Mater.*, 91, 41, Jun. (2015).