Microstructure and magnetic properties of $L1_0$ ordered FePt-C nanogranular films: Influence of graded structure with different C volume fraction

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$L1_0$ ordered FePt nanogranular thin films are considered as one of the leading candidates for heat assisted magnetic recording media [1] with areal density beyond 1 Tbits/in^2. Considering the feature of its high magnetocrystalline anisotropy, it is possible to fabricate thermally stable FePt particles with size down to 4 nm [2]. Hence, enormous efforts are being made to produce FePt grains with minimum size, high coercivity and columnar growth with the aspect ratio of more than 1.5. However, to realize the nanogranular structure in FePt films, various spacer materials such as C, SiO_2, Al_2O_3, ZrO_2, TiO_2, Cr_2O_3, etc must be used. Although the spacer materials help to reduce the grain size below 7 nm with narrow size distribution, the magnetic properties degrade due to reduction in degree of $L1_0$ ordering and enhancement of misaligned FePt grains.

Therefore, in this study, we present FePt-C granular films deposited as graded layer structure with different C volume fraction by co-sputtering FePt alloy and C targets on single crystalline (001) MgO substrate as a model system. The graded structure was implied to suppress growth of randomly oriented grains on top of FePt granular layer [3] and thickness of FePt-C film was optimized for obtaining a single layered structure with columnar growth. Crystal structure and degree of $L1_0$ ordering were analyzed using X-ray diffraction (XRD) with Cu-K_α radiation (λ = 1.54056 Å). Microstructure was characterized by using transmission electron microscope (TEM, FEI Technai F20 and F30). The room temperature magnetic properties were measured by superconducting quantum interference device vibrating sample magnetometer (SQUID-VSM) with an applied magnetic field up to ± 70 kOe.

The present investigation reveals that the average FePt grain size as shown in Fig.1 decreases with increasing C volume fraction. The cross sectional TEM analysis confirmed the column growth of FePt grains without the formation of second layer of FePt grain. A minimum grain size of around 6.5 nm and the pitch distance of 7.6 nm is achieved with perpendicular coercivity of 4.4 Tesla (see inset of Fig.1). A systematic investigation on the effect of C volume fraction and graded structure on the degree of ordering, microstructure refinement with columnar growth and the resulting magnetic properties will be discussed in detail.

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Reference

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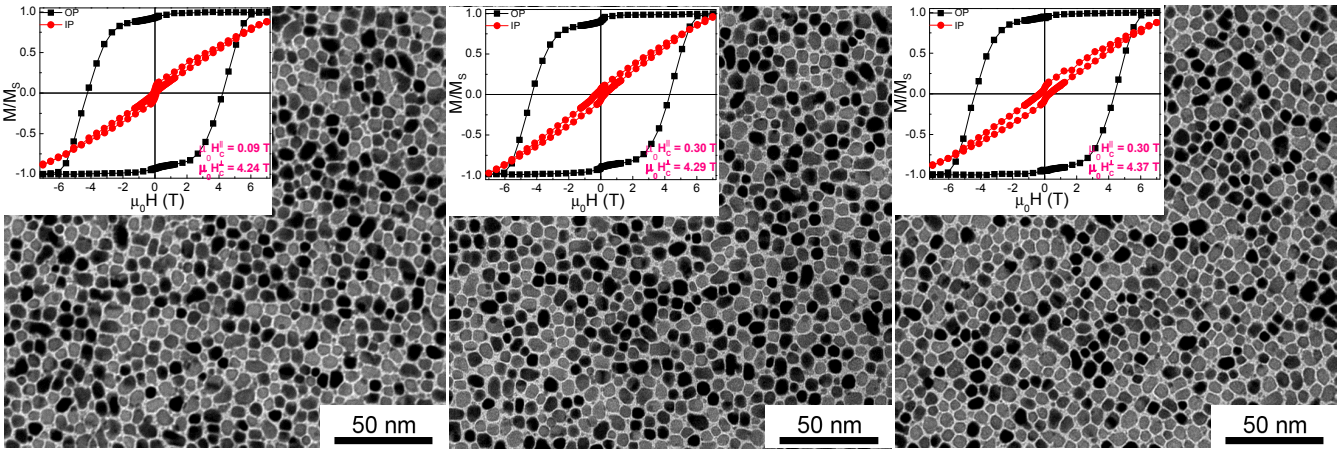

Fig.1: Plane view TEM images of FePt-C thin films with different carbon volume fraction in graded structure. Room temperature M-H loops are plotted in the inset.