Control of Grain Density in FePt-C Granular Thin Films

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I. INTRODUCTION

As a next-generation magnetic recording system with an ultrahigh areal density, a heat assisted magnetic recording (HAMR) using $L1_0$-ordered FePt-based granular media is promising and the development of the FePt-based media with a small grain size and a narrow size distribution is strongly required. To reach the targeted recording density of 4 T/in^2, the granular films which are uniformly miniaturized to pitch distance of about 5 nm are necessary. Various researches have been done for this purpose, but most of them focus on grain size control [1]. However, since the areal density depends on both of the grain density and its dispersion, the control in the initial growth stage is quite important. In this study, we investigated the microstructure change during the film growth of FePt as a function of the substrate temperature and the volume ratio of the nonmagnetic matrix. It is found that the grain density of FePt granular films are strongly influenced on the growth temperature at the initial growth stage.

II. EXPERIMENTAL

FePt and FePt-C samples were prepared by a magnetron sputtering method. MgO (001) single crystal was used for the substrate to exclude the influence of the quality of the underlayer. The crystallinity and degree of order of the samples were characterized by XRD. The magnetic properties and the microstructure were evaluated by SQUID-VSM and TEM, respectively.

III. RESULTS&DISCUSSION

In order to investigate the microstructure at the initial growth, 0.5-nm-thick FePt films were deposited at the different substrate temperatures. Fig. 1(a) shows a bright field TEM image of 0.5-nm-thick FePt film deposited at 100 °C. The FePt grains with average grain size of 2.0 nm are uniformly dispersed. The pitch distance and the grain density are 3.9 nm and 6.5×10^{12}/cm^2, respectively. When the substrate temperature increases to 650 °C, the grain size and the pitch distance increase to 2.6 nm and 5.1 nm as shown in Fig. 1(b). As a result, the grain density decreases to 3.9×10^{12}/cm^2. To realize the recording density of 4 T/in^2, 6.2 grains are necessary within 1-bit [2]. It requires at least 24.8 T/in^2 which corresponds to the grain density of 3.85×10^{12}/cm^2. However, the sample deposited at 650 °C has already reached this density at the initial growth stage. As the film grows through nucleation - nuclear growth / coalescence, the grain size increases during the film deposition [3]. Therefore, the density of the grain at the initial growth stage must be higher than that of the final stage of the film deposition. To increase the grain density further, the

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microstructure of 0.5-nm-thick-FePt with carbon was deposited. Fig. 1(c) shows the bright field TEM image of 0.5-nm-thick FePt-C deposited at 200 °C. Unlike our expectation, the grain density shows lower than that of the FePt. We summarize the change of the grain density as a function of the substrate temperature in Fig. 1(d). The grain density decreases with increasing the substrate temperature. From these results, the deposition of the FePt at the lower temperature without carbon at the initial growth can be a candidate way to prepare an ultrahigh grain density. In the presentation, we will also report on the results of the microstructure and the magnetic properties of the samples prepared by the temperature and C concentration graded deposition method.

REFERENCES

1) H. Pandy *et. al.*, IEEE Trans. Magn. **52**, 3201004 (2016).
2) Roadmap of Advanced storage technology consortium (2016).
3) T. Shiroyama, *et. al.*, AIP Advances **6**, 105105 (2016).

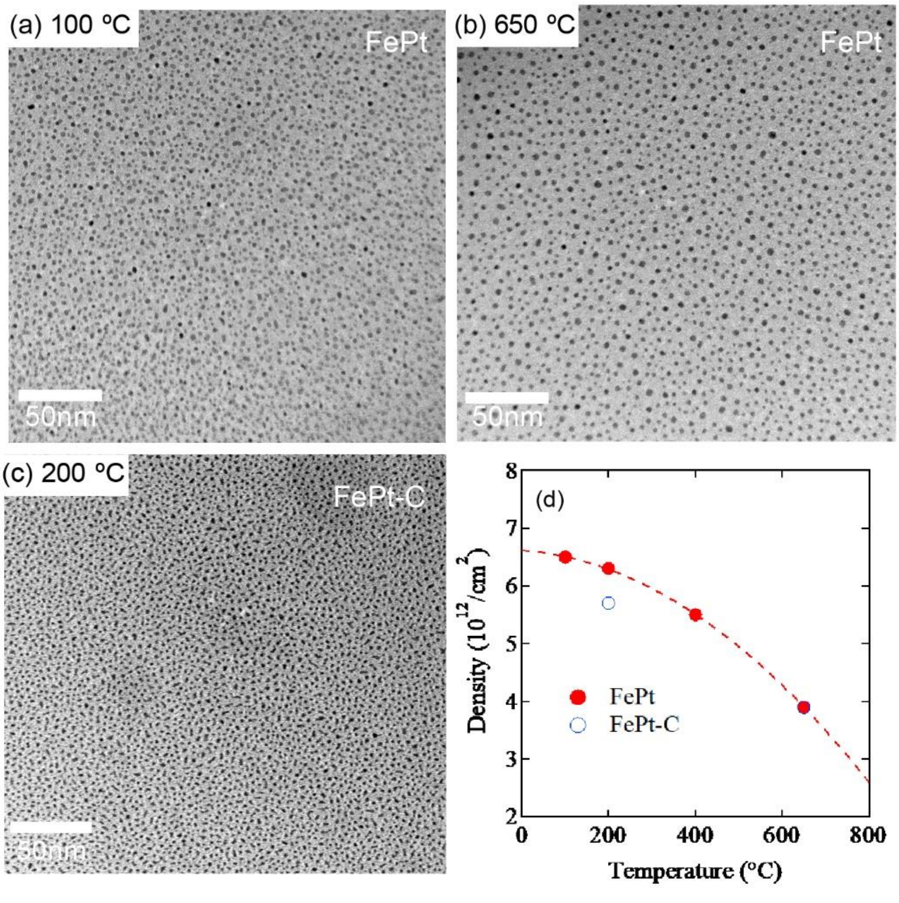

Fig.1 Bright-field plane-view TEM images of 0.5-nm-thick FePt grown at (a) 100 ℃, (b) 650 ℃ and (c) 0.5-nm-thick FePt-C at 200 ℃. (d) Grain density of 0.5-nm-thick FePt and FePt-C as a function of growth temperature.