MAGNETIC PROPERTIES OF NANO-SCALE FePtCr-SiN THIN FILMS

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Introduction

FePt alloy thin film is suitable for the magnetic recording media due to its high magnetocrystalline anisotropy (Ku ~ 7×10^7 erg/cm^3). However, it still has some disadvantages to be improved for high density recording media application, such as large grain size and high exchange coupling. High density recording media require ultrafine grain of about 10 nm or less. Previous investigations have shown that the grain size of the FePt can be reduced by adding Cr into FePt film [1] or dispersing magnetic FePt grains into an amorphous non-magnetic SiN matrix [2]. Although granular FePt–Si_3N_4 thin film has good magnetic properties for high density recording application, the magnetic grain size of FePt-SiN film is still larger than 10 nm. In this work we will add Cr into the FePt-SiN film to reduce its grain size and investigate the influences of Cr and SiN contents on the magnetic properties of the FePtCr-SiN thin film.

Experiment

$[(FePt)_{100-x}-Cr_x]_{100-\delta}-(SiN)_\delta$ nanocomposite films (where x = 0 ~ 25 at.% and δ = 0 ~ 30 vol.%) with thicknesses of 10 nm were produced on silicon wafer substrates at room temperature by co-sputtering $Fe_{50}Pt_{50}$, Cr and Si_3N_4 targets. The as-deposited film was annealed in vacuum at various annealing temperature T_{an} for 30 minutes then quenched in ice-water in order to get ordered FePt $L1_0$ phase. Magnetic properties were measured by vibrating sample magnetometer (VSM) and superconducting quantum interference device (SQUID) with maximum applied fields of 13 kOe and 50 kOe, respectively. Average grain size of the film was observed by transmission electron microscopy (TEM). The film thickness was measured by atomic force microscope (AFM).

Results and discussion

Fig. 1(a) and 1(b) show the relationships among in-plane coercivity $Hc_{//}$, out-plane coercivity $Hc_\perp$ and T_{an} of various annealed $[(FePt)_{90}Cr_{10}]_{100-\delta}-[SiN]_\delta$ films with different Si_3N_4 volume fractions. When T_{an} > 350 ℃, $Hc_{//}$ value of the $[(FePt)_{90}Cr_{10}]_{100-\delta}-[SiN]_\delta$ film will step up rapidly. The rapid decrease of $Hc_{//}$ for T_{an}> 650 ℃ is due to the grain growth and the reaction of FePtCr with the silicon substrate. $Hc_\perp$ value also has the same tendency as that of $Hc_{//}$ as shown in Fig.1(b). The maximum $Hc_\perp$ value is about 3.6 kOe, which is much smaller than that of $Hc_{//}$. The magnetic anisotropy of these films are parallel to the film plane. From Fig.1, we also see that the increase of SiN content in the film will increase the annealing temperature required for highest coercivity. This is due to the fact that the amorphous SiN phase is a poor heat-conductor, and postpones the initial temperature, which transforms the fcc γ-FePt phase to the ordered FePt $L1_0$ phase. Fig. 2 shows the relationship between the $Hc_{//}$ value and Cr content of various $[(FePt)_{100-x}Cr_x]_{100-\delta}-[SiN]_\delta$ films with different SiN contents. The annealing temperature is 600 ℃. The result shows the $Hc_{//}$ value decreased with increasing Cr and SiN contents.

We find the $[(FePt)_{90}-Cr_{10}]_{85}-(SiN)_{15}$ film which annealed at 600℃ for 30 minutes is suitable for high-density magnetic recording application. Average grain size of the FePtCr in this film is about 9 nm. Its $Hc_{//}$ is about 3.7 kOe, Ms is about 450 emu/cm^3, and its in-plane squareness $S_{//}$ is about 0.75.

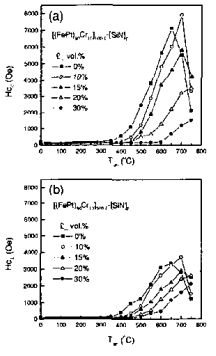

Fig. 1. The relationships among (a) $Hc_{//}$, (b) $Hc_\perp$, and T_{an} of the annealed $[(FePt)_{90}Cr_{10}]_{100-\delta}-[SiN]_\delta$ films.

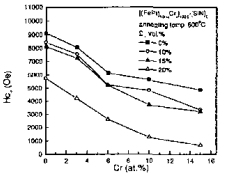

Fig. 2. Relationships between $Hc_{//}$ and the Cr content of the $[(FePt)_{100-x}Cr_x]_{100-\delta}-[SiN]_\delta$ *films.*

Reference

[1] P. C. Kuo, Y. D. Yao, C. M. Kuo, and H. C. Wu, J. Appl. Phys., vol. 87, 6146 (2000).
[2] Chih-Ming Kuo and P. C. Kuo, J. Appl. Phys., vol. 87, 1 (2000).

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