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Magnetic Properties of FePt:C Nanocomposite Film

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Equiatomic FePt and CoPt alloy thin films have received considerable attention as possible magnetic and magneto-optic recording because of their high magnetic anisotropy energy and high coercivity. The high coercivity in these thin films is due to the presence of finely dispersed ordered FePt phase mixed with disordered FePt phase [1]. However, a high temperature treatment, either substrate heating during deposition or post annealing, is needed to obtain the ordered $L1_0$ phase with high value of magneto-crystalline anisotropy. Recent microstructural studies on these films suggest that the average grain size ranges from 10-50 nm and the grains are magnetically coupled between each other [2]. On the other hand, the ultrahigh-density magnetic recording media with low media noise imposes the need of a material, which consists of magnetically isolated grains with size below 10 nm [3]. The magnetic grain isolation can be controlled by the amount of additional non-magnetic element in the system, which determines the interparticle separation and therefore the interparticle interactions. Recently, much research work has been done on various non-magnetic matrices. Preliminary studies showed that the samples prepared in B_2O_3 and Carbon matrices have shown strong perpendicular anisotropy and fine grain size down to 4nm, which suggest these nanocomposite films are very promising and may lead to the realization of a magnetic medium capable of recording densities beyond 1Tb/in^2. So, in this work, the effect of Carbon doping on the magnetic properties of FePt nanoparticles were investgated.

Thin film samples of $(Fe_{50}Pt_{50})_{1-x}C_x$ ($0 < x < 50$, x represents the volume fraction) were fabricated directly on MgO (100) substrates using dc magnetron cosputtering with a base pressure of better than 8×10^{-7} Torr and the sputtering Ar gas pressure of 5 mTorr. A composite FePt target was made by putting some Pt (99.99 % purity) chips on the Fe (99.99 % purity) target. The crystal structure of the films was characterized by Rigaku x-ray diffractometer. Room-temperature magnetic characterizations were carried out by a vibrating sample magnetometer (VSM) with an applied field of up to ± 20 kOe and a torque magnetometer with an applied field of 10 kOe.

Fig.1 shows the XRD pattern of $(Fe_{50}Pt_{50})_{1-x}C_x$ films prepared at 400 °C substrate temperature with various amount of Carbon doping. In addition to the fundamental peaks, the superlattice peaks of the face centered tetragonal (fct) phase have clearly been observed. It is clear from the figure that the intensity of the $L1_0$ superlattice peaks is predominant initially then reduced with increasing C, indicating the reduction in the degree of chemical ordering.

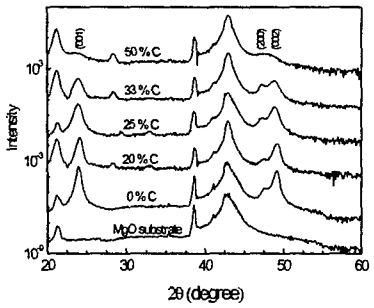

Fig.1. XRD patterns of $(Fe_{50}Pt_{50})_{1-x}C_x$ films prepared at 400 °C substrate temperature with various amount of C doping.

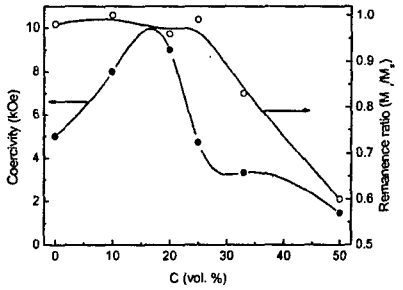

Fig.2. The dependence of coercivity and remanence ratio of the FePt-C films prepared at 400 °C substrate temperature on the concentration of carbon.

The room temperature magnetic properties of the samples were characterized by VSM and torque magnetometer.. The determined easy axis is close to 90° and the determined value of magnetic anisotropy energy (K_U) decreases from 2.82×10^7ergs/cm^3 for the FePt film with zero Carbon addition to 1.04×10^7ergs/cm^3 for $(FePt)_{0.75}C_{0.25}$ sample.. Fig.2 shows the values of coercivity and remanence ratio for various Carbon doped FePt samples. The coercivity increases up to $x \leq 20$ vol % and then decreases drastically with increasing C content. Moreover, the saturation magnetization (M_s) also decreases with increasing Carbon. the coercivity of the film is not only affected directly by the ordered volume fraction, but also by the microstructural factor [4]. In the present case, the small amount of Carbon doping shows almost no change in the XRD peak positions. So, the initial increament in the coercivity for small amount of Carbon doping can be explained by a diminution in the growth of the particle size and thus represent a higher pinning density for the magnetic domain walls. On the other hand, the density if the FePt fct(001) peak drops and FePt fct(002) peak shifts to the lower angles with increasing Carbon concentration indicates that the texture of the fct FePt phase has been changed slightly. This change in peak position may results from the defects. These defects are serving as pinning sites in the smaller amount(<20 vol %) of Carbon-doped films and nucleation sites in the higher amount(>20 vol %) of Carbon doped films.

The FePt:C nanocomposite thin films with perpendicular magnetic anisotropy have fine grains of about 5 nm, adjustable coercivity, and $L1_0$ ordering phase with lower Carbon doping suggest that this system might be applicable to ultrahigh-density magnetic recording media.

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