High-Coercivity CoPt Alloy Films Grown by Sputtering

J.-P. Hu and P. Lin

Institute of Materials Science and Engineering, National Chiao Tung University,

Hsinchu, Taiwan, Republic of China

Abstract -- **Co_xPt_{1-x} alloy films (x=0.2~0.4) were prepared by rf sputtering at substrate temperatures 150~300°C without Pt underlayer and post annealing. The magnetic properties of the films showed strong dependence on the composition and substrate temperature. High coerivity (~ 191 KA/m) and saturated remanence were achieved at conditions x=0.25 and 200°C. In contrast to the previous observations, the high perpendicular magnetic anisotropy, in the current case, appeared not associated with the good CoPt (111) texture. An interpretation based on minor composition modulation in the films was proposed.**

I. Introduction

CoPt alloy films have been investigated in the past years for potential application to high-density magneto-optical recording media because of their enhanced Kerr effect at shorter optical wavelengths. Evaporation and sputtering have been used to prepare these films[1-3]. It was found that the perpendicular coercivity and squareness ratio were very low for the $Co_{0.5}Pt_{0.5}$ alloy films sputtered at ambient temperature[1], and those magnetic properties could be improved after postdeposition annealing at 300°C in air while the magnetic moment was reduced and cobalt oxide was formed[4]. However, large perpendicular coercivity (maximum Hc~159 KA/m) and saturated remanence were obtained in the alloy films ($CoPt_3$) directly deposited by e-beam evaporation onto substrates with Pt underlayers at 200°C[2]. The strong perpendicular magnetic anisotropy of the films was correlated to the good CoPt (111) texture which was strongly influenced by the underlayers and increased with deposition temperatures[2].

From the viewpoint of practical application, it is desirable to attain CoPt alloy films of high perpendicular anisotropy by sputtering method. In this study, we demonstrate that CoPt alloy films with large coercivity and squareness can be prepared, without Pt underlayer, by sputtering on heated substrates without subsequent annealing. Also, the high perpendicular anisotropy in the films appeared to be independent of the (111) texture and probably to be related to the interfacial effect arising from small, undetected Co-rich and Pt-rich regions formed in the alloy films.

II. Experiment

The Co_xPt_{1-x} alloy films were deposited by rf magnetron cosputtering (3" pure Pt and Co targets) at various growth temperatures (T_G=150~ 300°C) and compositions (Co mole ratio, X=20~40%), on Corning 7059 glass without buffer layer. The individual deposition rate (for Co and Pt) or film composition was controlled by a precalibrated rf power and total deposition rate was fixed at ~0.5Å/s to prepare all the films of thickness 300Å. High purity argon was used as working gas and an operating pressure of 14 mTorr was maintained in the chamber during deposition.

The magneto-optic and magnetic properties of the samples were measured by Kerr hysteresis loop and vibrating-sample magnetometer(VSM). The crystallinity of CoPt alloy films were characterized by Siemens D5000 XRD with Cu Kα radiation.

III. Results and Discussion

The perpendicular coercivity Hc of the as-deposited CoPt alloy films (Fig. 1) showed a strong variation with T_G and X. The highest coercivity (~191 KA/m) occurred at T_G=200°C and X=0.25, and Hc reduced quickly to below 50 KA/m as

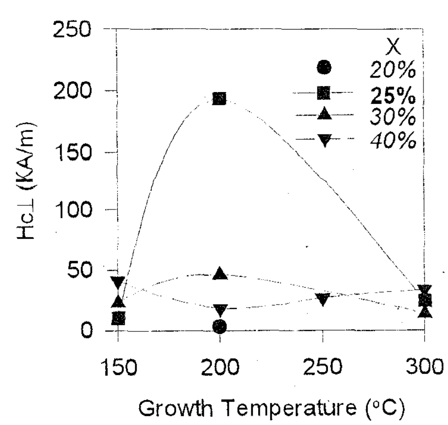

Fig. 1. The perpendicular coercivity of Co_xPt_{1-x} alloy films at varied growth temperature.

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J. -P. Hu, u8018512@cc.nctu.edu.tw, phone 886-35-712121 ext 55344; P. Lin, phone 011-886-35-731848, fax 011-886-35-724727

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the deposition condition deviated from the optimized point. The coercivity and normalized magnetization as functions of temperature for CoPt films grown at the optimized condition are shown in Fig. 2, indicating a Curie temperature of the films at around 250°C which is lower by around 50°C compared with the corresponding Co/Pt multilayers[5].

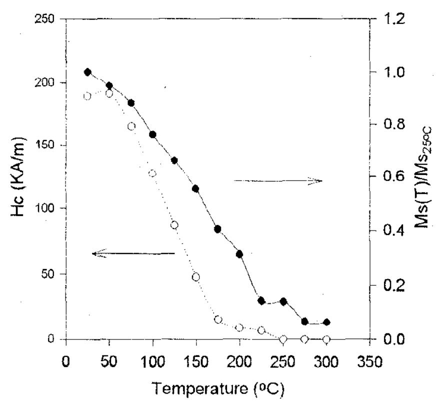

Fig. 2. The temperature dependence of the coercivity and the magnetization for $Co_{0.25}Pt_{0.75}$ alloy film grown at 200°C. $Ms_{25°C}$ indicate the staturated magnetization measured at 25°C.

For those films of composition X=25%, the X-ray diffraction patterns (Fig. 3) showed the preferred CoPt(111) peak intensity improving steadily with T_G up to 300°C at which the coercivity dropped to a quite low level. The strong perpendicular anisotropy present in the evaporated CoPt alloy films, as mentioned above, was considered closely associated with the good CoPt (111) texture from which a net perpendicular easy axis was obtained[2]. However, in the current case, the texture does not seem as the main factor determing Hc in sputtered CoPt alloy films.

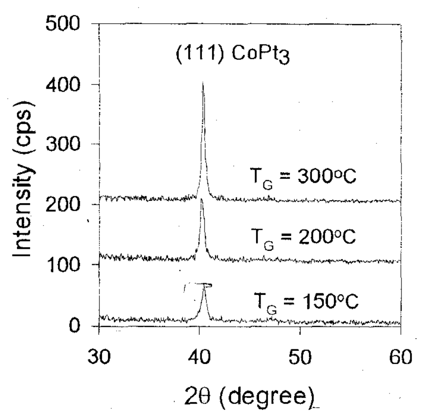

Fig 3. X-ray diffraction patterns of $Co_{0.25}Pt_{0.75}$ alloys films deposited at various growth temperature.

It is well recognized that the perpendicular anisotropy for Co/Pt multilayers or composition modulation film comes from Co/Pt interfacial anisotropy. For comparison, Co/Pt multilayers $[Co(2.5Å)/ Pt(10.5Å)]_{23}$ (average composition close to X=25%) were prepared under the same optimized conditions. The measured Kerr hysteresis loops for the multilayers and the optimized $Co_{0.25}Pt_{0.75}$ alloy films showed a remarkable similarity in both high coercivity and saturated remanence (Fig. 4). If the resemblance is not fortuitous, it may suggest that the perpendicular anisotropy for the alloy films is probably related to the interfacial effect. Some minor composition modulation presumably occurred in the apparently homogeneous films, which could not be revealed by the current XRD analysis.

In a recent study on epitaxial (100) and (111) $Co_{0.25}Pt_{0.75}$ alloy films[6], anomalous enhancement of perpendicular anisotropy was also observed in the films grown at around 400°C. The films deposited in the higher or lower temperature ranges exhibited a very low anisotropy. The variation could be interpreted based on the model of phase separation[6]. That is, near 400°C, in a presumed local surface equilibrium state, small Co-rich and Pt-rich regions may be found on the growth surface. The mixed regions are then trapped in the bulk by the further deposition of the film which induce a much higher perpendicular anisotropy than that true homogeneous alloy films could attain. Our lower optimized T_G (~200°C) compared with 400°C for the epitaxial films could be accounted for by the higher adatom mobility on the sputtered film surface.

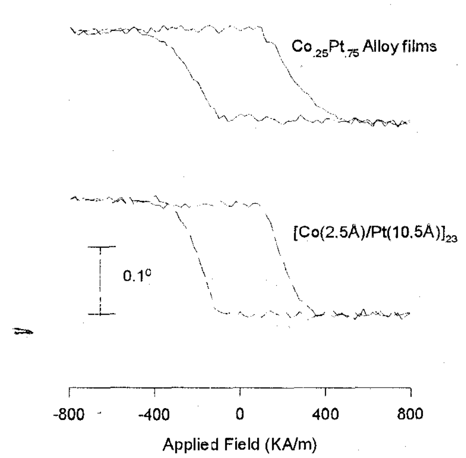

Fig. 4. The Kerr hysteresis loops of CoPt alloy (solid line) and $[Co(2.5Å)/ Pt(10.5Å)]_{23}$ multilayers films(broken line).

IV. Summary

We have prepared CoPt alloy films with high perpendicular coercivity and saturated remanence by rf sputtering without underlayer and post annealing. The magneto-optical properties of the films optimized at growth temperature 200°C and composition of 25% Co. The high perpendicular anisotropy does not appear to relate with the well-developed CoPt (111) texture and probably due to the interfacial effect arising from some minor, undetected composition modulation occurred in the alloy films.

Acknowledgment

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