Grazing Incidence X-ray Diffraction Study of $Co_{1-x}Pt_x$ Ultrathin films

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Introduction

The ordered $L1_0$ phase of $Co_{50}Pt_{50}$ is a candidate material for next-generation, patterned or nanostructured recording media [1]. It has a high magnetocrystalline anisotropy, which is desirable for minimizing self-demagnetization and thermal instability. However, it has a relatively low Curie temperature and low moment when compared with alloys having a higher Co content. To explore the potential of higher-Co-content alloys, we have studied the crystal structure and magnetic properties of $Co_{1-x}Pt_x$ (x = 0.0-0.2) discontinuous films. One difficulty in obtaining high coercivity is the tendency for fcc-Co formation in thin films [2]. The anisotropy field of fcc-Co is about 0.5 kOe, whereas the anisotropy field of hcp-Co is about 10 kOe. The anisotropy field represents the maximum coercivity (H_c) that one would expect for a small, single-domain particle. The Co-Pt phase diagram indicates that the addition of small amounts of Pt stabilize the hcp phase. Therefore, one might expect that the addition of Pt would increase the fraction of the hcp phase in the sample, thus increasing coercivity. The present study focused on determining the crystal structure of these discontinuous films.

Methods and Materials

$Co_{1-x}Pt_x$ thin films were sputtered by using a triode magnetron source (L. M. Simard Co.). A circular Co (99.99%) target was used, with various pieces of Pt foil spot-welded to the surface in order to obtain the range of compositions: x = 0.0-0.2. The deposition rate and composition were determined by using a combination of x-ray fluorescence and x-ray reflectivity spectra. The present study focuses on nominally 3.5-nm-thick films grown on Si wafers with native oxide. Transmission electron microscopy showed that they consist of ~10-nm-diameter metal islands. A reactively sputtered, amorphous Al_2O_3 layer (10-nm thick) was subsequently deposited to passivate the samples, preventing further oxidation upon exposure to air.

X-ray diffraction measurements on such thin, polycrystalline specimens required several measures to increase the diffracted intensity. We used 7700-eV radiation in a grazing incidence geometry, with a fixed incident angle of 0.6º. The scintillation detector was mounted behind Soller slits having an acceptance angle of 0.33º in order to define the scattering angle while accepting scattered radiation from the whole sample surface.

Results and Discussion

While the data are still being analyzed, preliminary conclusions are as follows. Magnetization data for samples grown at 230°C indicate a peak in coercivity of around x = 0.1. X-ray diffraction measurements on a sample of this composition showed multiple diffraction peaks consistent with a significant hcp component. Other compositions grown at 230°C showed either a single peak consistent with an fcc structure or a much smaller hcp peak than the sample with x = 0.1. The diffracted signal was weak enough that higher-order peaks were not detected.

This result is consistent with our magnetization data shown in Fig. 1, with about 10% Pt being near optimal for growth at 230°C. For growth at 520°C, the increase of coercivity with increasing Pt content is unknown but may be caused by some degree of chemical ordering. The x-ray diffraction data show no sign of an hcp phase (only a single peak) for 520°C growth, consistent with the bulk phase diagram, which indicates that the hcp phase is not stable above 422°C.

Acknowledgments

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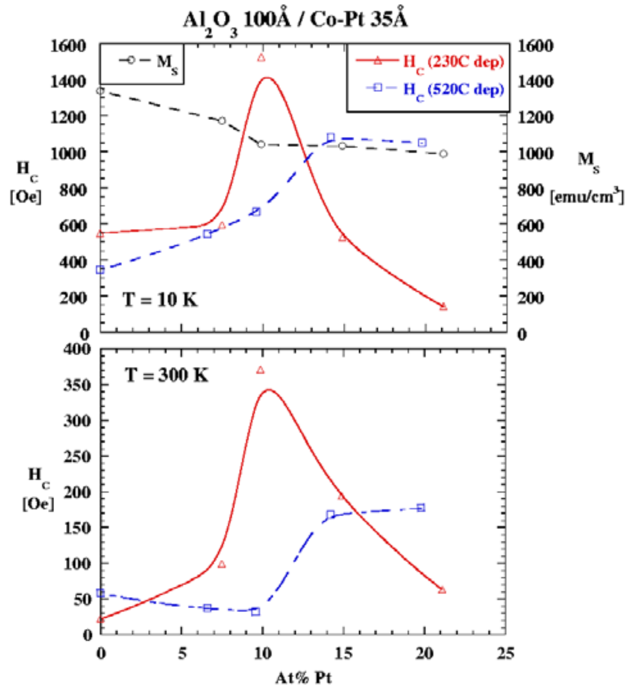

FIG. 1. Saturation magnetization (M_S) and coercive field (H_C) vs. composition for $Co_{1-x}Pt_x$ (x = 0.0-0.2) discontinuous films.