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CONTRIBUTED PAPERS

STRUCTURAL CHARACTERIZATION OF MAGNETIC RECORDING MEDIA BY USING GRADING INCIDENT AND CONVENTIONAL X-RAY DIFFRACTION

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Introduction

In recent years, the microstructure of Co-based alloy magnetic thin film disks has been studied extensively by using a conventional X-ray diffraction (XRD) technique [1-4]. Efforts to understand the relationship between the microstructure and the magnetic properties of disk had been limited due to the lack of depth resolution in the conventional theta-2theta scanning technique. In this paper, a fixed 0.5 degree of grazing incidence [5] 2-theta scan X-ray diffraction (GIXRD) technique was used to characterize the thin film disk microstructure and therefore to correlate with the magnetic properties.

Experimental Setup

An 18 kW Rigaku rotating anode (Cu Kα) X-ray generator, Geigerflex D/Max-B goniometer with a 43-sample holder attachment and Graphite (002) flat crystal as monochromator were used to collect the diffraction patterns of the film disks. A half degree divergence incident slit and 0.3 mm receiving slit were used in this setup.

The static magnetic properties of the film disks along the circumferential textured direction were measured by Vibration Sample Magnetometer with the 10 K saturation inplane field.

Results and Discussion

The XRD pattern (Fig. 1a) of a DC magnetron sputtered magnetic thin film disk composed of a Cr underlayer, a Co-based alloy magnetic layer and a protective overcoat of carbon, had been obtained by using a regular conventional XRD with a theta-2theta scan. As shown in the Figure, the sharp peaks are due to the crystal diffraction planes of the Al-4%Mg substrate and the broad hump background is produced by the plated amorphous NiP layer. Only the magnetic layer Co(110) diffraction peak is observed at higher diffraction angle. Due to the NiP background and Al diffraction peaks, many of the thin film microstructural features are obstructed by using a conventional theta-2theta XRD. The Co diffraction peaks (100), (002), (101) and Cr(110) are superimposed on a NiP amorphous background in the 2-

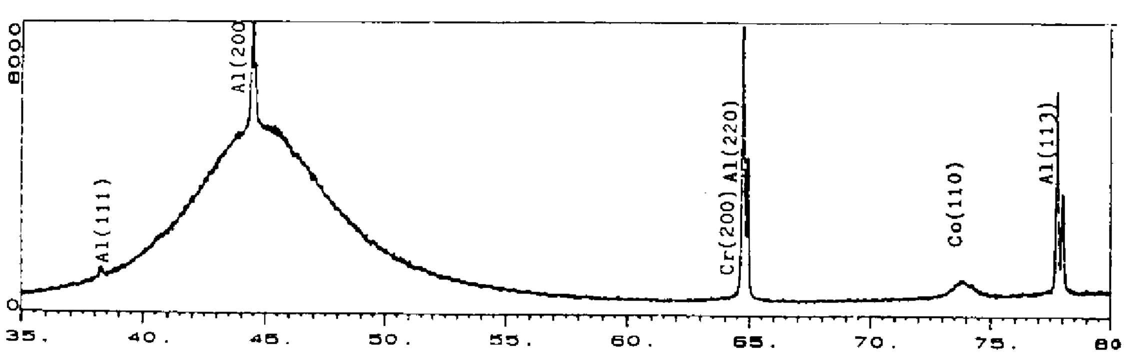

Fig. 1a. A conventional XRD pattern of Co-based alloy film disk.

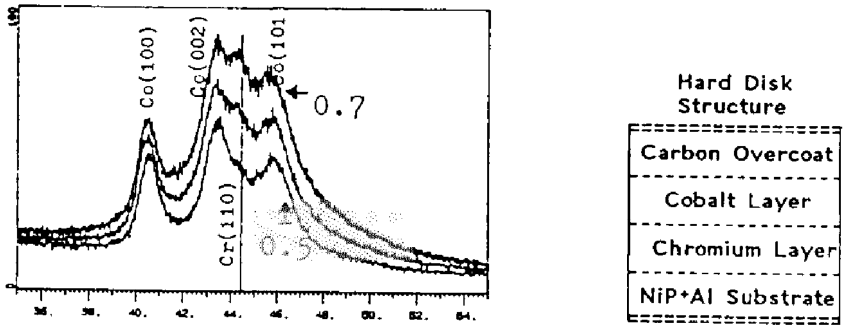

Fig. 1b GIXRD at 0.5, 0.6 and 0.7 incidence angle.

theta 35-55 degree region. To investigate the film microstructure without the interference from the substrate and NiP background, the grazing incidence X-ray diffraction technique was used to analyze the thin film characteristics.

With theta fixed at a 0.5 degree grazing incidence angle and a highly collimated X-ray path with Graphite (002) flat crystal as monochromator, the diffraction peaks of the Co magnetic layer and the Cr underlayer are free of interference from the NiP amorphous layer and AlMg substrate. As shown in Fig. 1b with a fixed 0.5 degree of theta grazing incidence angle, the Co(100), Co(002), Cr(110) and Co(101) have been clearly separated from the amorphous NiP and substrate background. Figure 1b also shows the interference increasing in the diffraction patterns due to the amorphous NiP layer as the theta increases from 0.5 to 0.6 and 0.7. Namely, the X-ray beam had penetrated more into the Cr underlayer and the NiP amorphous layer.

The grazing incidence XRD technique is useful for determining the film's lattice constants, preferred orientation, strain and grain size which are all strongly related to the static magnetic properties and disk performance. The grazing angle can be selected appropriately if the disk target composition and physical thickness are known.

In the disk coating procedure, several parameters such as process temperature, film thickness and gas pressure [1-3], strongly influence the magnetic film properties. With a grazing incidence XRD measurement, a better understanding of film magnetic characteristics correlated with the crystal microstructure has been achieved.

As shown in Fig. 2a, the thickness of the Cr and Co layers is constant, but a higher pre-sputter temperature increased the Body Center Cubic Cr(200) diffraction intensity. The increment of Cr(200) intensity also enhanced the Co(110) growth due to better d-

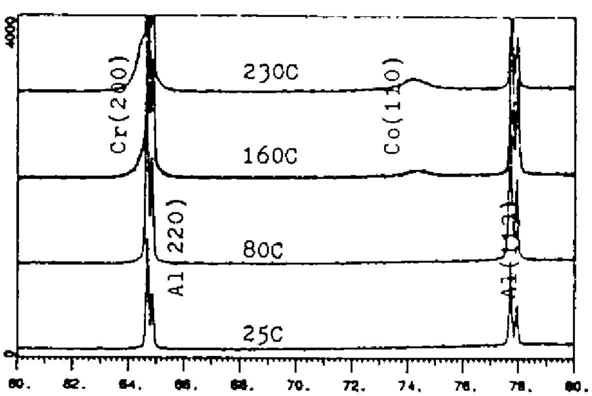

Fig. 2a XRD of disks deposited at various temperatures.

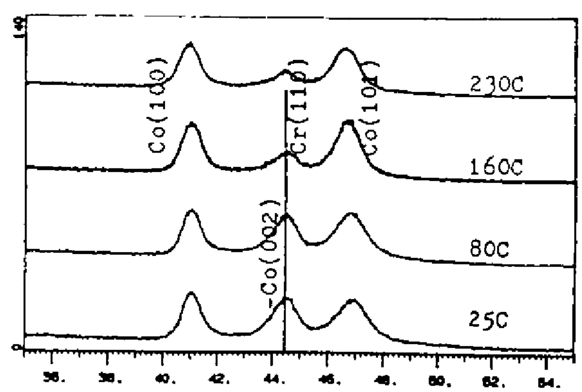

Fig. 2b GIXRD of disk deposited at various temperatures

value matching. The higher temperature produced larger Cr grain size based on the Cr(200) peak shape. The shift of the Co(110) peak indicates the change in thermal strain. The intensity reduction of Co(002) and Cr(110) implies more c-axis Co orientation in the film plane as Cr(200) formed. This results in a disk with higher coercivity (Hc) and remanent magnetization thickness product (Mrt) as shown in Fig. 2b/c.

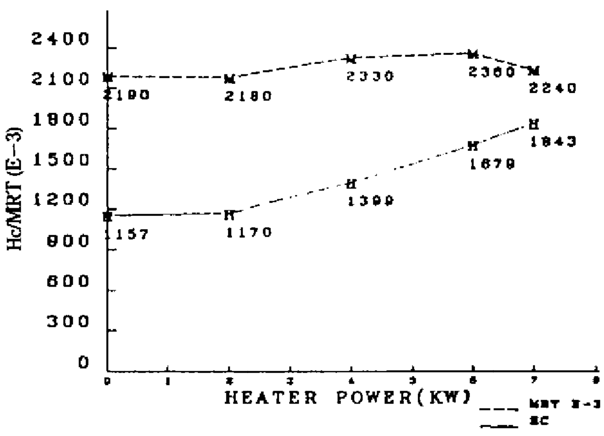

Fig. 2c Temperature vs coercivity (Hc) and remanent magnetization (Mrt).

In Fig. 3a/b the variation of the Mrt and Hc with magnetic film thickness is shown as the Cr with constant thickness. For an ultra thin magnetic layer, the coercivity is extremely low. This is a result of the film's non-crystallinity and discontinuity. When the film grows thicker than 140 Å, the coercivity reaches a steady state. However for thicker films, the Co(002) intensity increases due to the low potential energy of hexagonal close packing and the coercivity will decrease again. As seen in Fig. 3d, the strain of Co(110) is inversely related to the Cobalt film magnetic thickness (Mrt) and the stress is approaching the bulk value as the Cobalt film thickness increases.

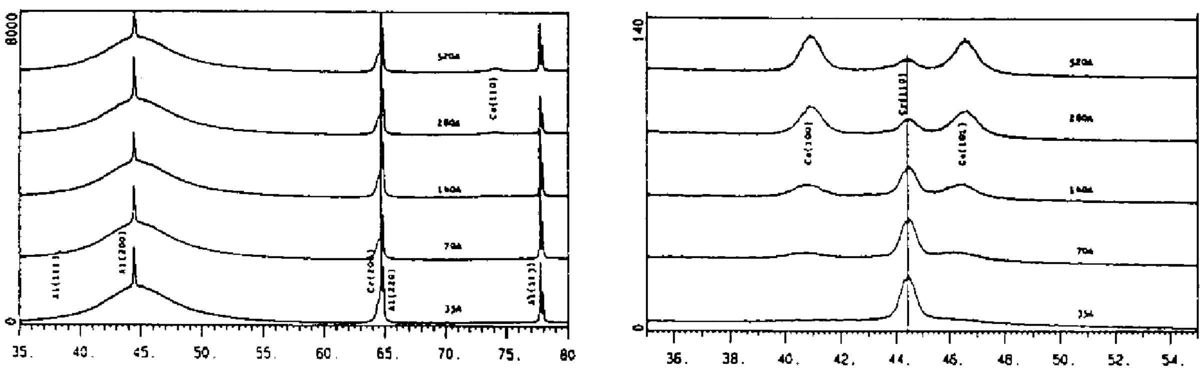

Fig. 3a/b XRD/GIXRD of disks with different thicknesses of cobalt.

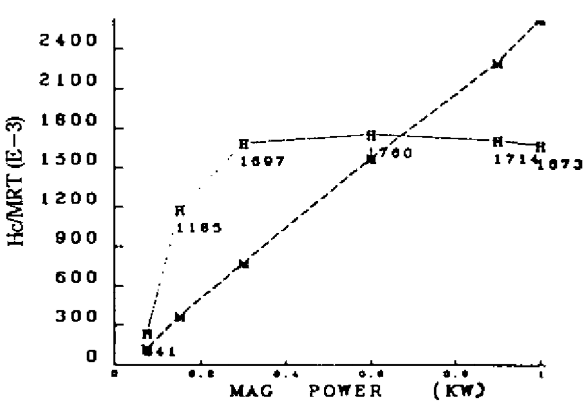

Fig. 3c Variation of Hc/Mrt with Co thickness as constant chromium.

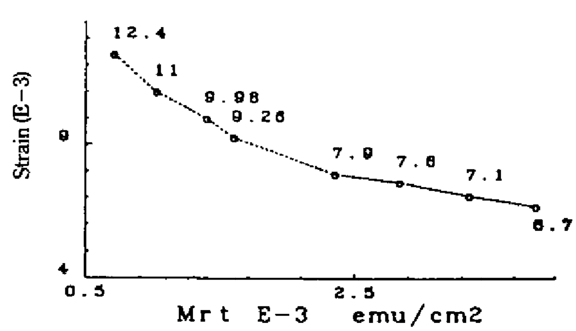

Fig. 3d Co(110) strain vs cobalt magnetic thickness (Mrt).

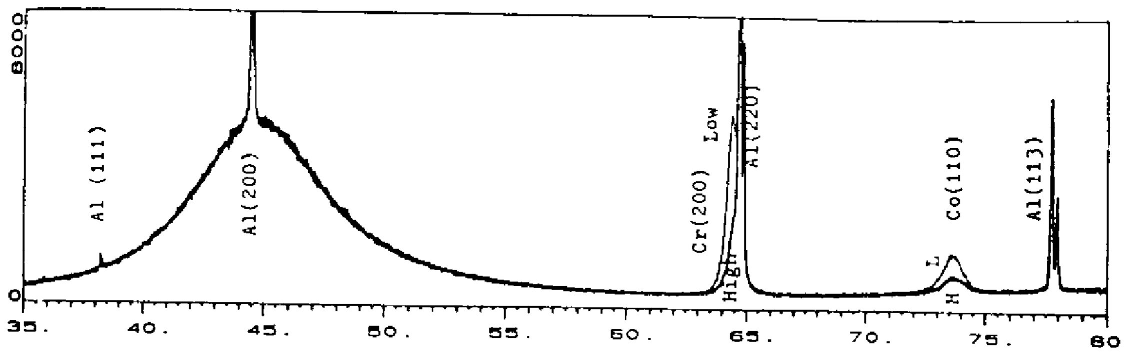

Fig. 4a XRD of disks with low and high Ar gas pressure during chromium deposition.

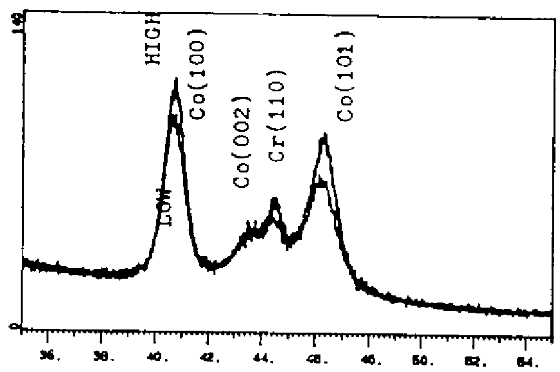

Fig. 4b GIXRD of disks with low/high Ar gas during Cr deposition.

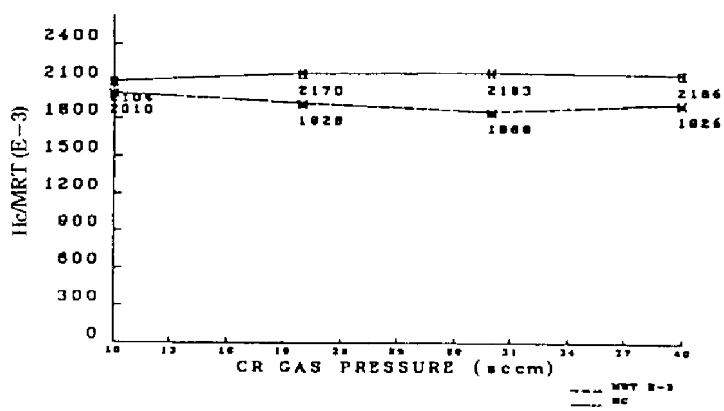

Fig. 4c Hc/Mrt variation with Ar gas pressure during Cr deposition.

As shown in Fig. 4a, when the Cr deposition with a high Ar gas pressure, the Cr(200) peak becomes broadly which indicates a finer grain size in comparison with the case of lower Ar gas pressure. The atomic mobility decreases as more Ar gas is used. The reduction of Co(110) but the enhancement of Co(100) and (101) in Fig. 4b/c produces a 70 Oe gain in the coercivity and a slight Mrt loss. The disk prepared at the high Cr gas pressure showed lower noise in magnetic performance (3) and it seems to function with a finer grain size in condensed packing of Cr(200) and the preferred orientation of Co(100).

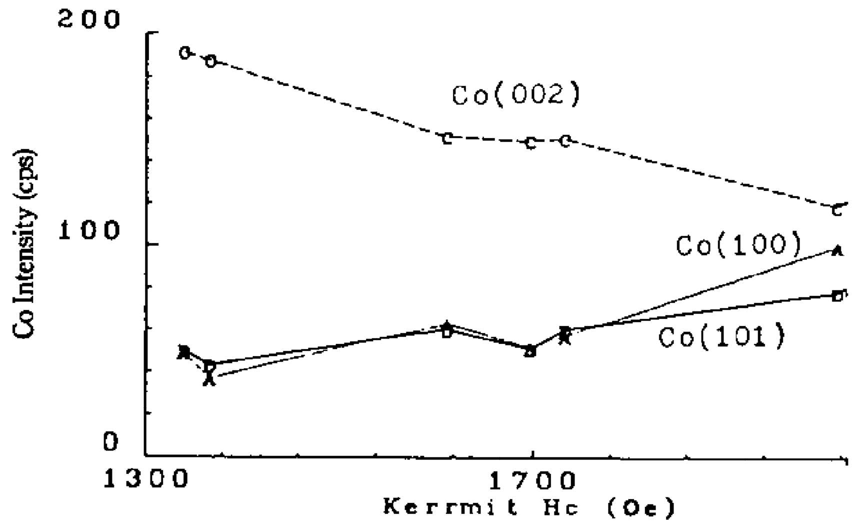

Fig. 5 Coercivity vs cobalt peaks intensities.

Six disks with the same magnetic thickness but different coercivity had been characterized by using GIXRD. Figure 5 shows that the Co(002) peak intensity decreases linearly but the Co(100) and Co(101) increase when the coercivity of the magnetic film increases. The increase in Co(100) is greater than Co(101) as the coercivity goes above 1700 Oe. Therefore, the lower coercivity is associated with more Co c-axis out of the film plane. The increment of Coercivity is correlated to the amount of Co(110) and the degree of Co c-axis into the film plane. The formation of Co(110) is nucleated by the conversion factor of Cr(110) into Cr(200). A finer grain size of Cr(200) is favorable for Co(100) growth and further reduction of Co(002) and Co(101). This results in a magnetic film even with a higher coercivity and superior the disk performance.

Conclusion

The results of lattice cell dimension and average strain as well as the process parameters influence of underlayer and magnetic layer were obtained by using the conventional and the grazing incidence XRD technique. Therefore clearly, the conventional and grazing incidence XRD are powerful tools for monitoring the process conditions and implementing the process parameters, as well as to identify the material phase, strain and grain size. With the grazing incidence XRD data for the Aluminum substrate thin film disks, we are able to reveal the mysteries of different characteristics in the disk.

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