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The Role of Microstructural Phenomena in Magnetic Thin Films

Year II Progress Report

Year III Continuation Proposal

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Submitted to

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DISCLAIMER

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Introduction

Our program "The Role of Microstructural Phenomena in Magnetic Thin Films" started in August of 1990. Herein we report on the progress to date and summarize future research plans. In addition we include various supplementary material. This document includes:

I. Progress Report on Work Performed August 1990 to December 1991.
II. Listing of Papers Submitted for Publication
III. Personnel
IV. Proposed Research for Year III (August 1992 - July 1993)
V. Year III Budget
VI. Current Federal Support

Removed

I. Progress of Work to Date

We have pursued two lines of research during the first year and a half of this work. In the main portion of the project we have performed fundamental investigations of the microstructure and crystallographic texture of Co based alloys deposited on Cr underlayers. This has included atomic resolution electron microscopy of the cross-sections of CoNiCr on Cr thin films, as well as studies of the microstructures and properties of magnetic thin films produced with *interlayers* of Cr. The other portion of our work has centered on understanding the crystallography and crystal structure of CoSm/Cr thin films. These CoSm films have the potential of being utilized as high density media, but their structure is not yet understood.

1. CoNiCr and CoCrTa Thin Films

Multilayer magnetic recording films, which have thin nonmagnetic isolation layers, are reported to have both low noise and high signal to noise ratios (SNR).[1,2,3] A large amount of work has been done to investigate the effect of the interlayer from the point of view of magnetic interaction. However, all the explanations were phenomenological in nature. Furthermore it was assumed that each magnetic layer was identical. No studies on the microstructures of the multilayer magnetic thin films have been reported. In this project, we are investigating the role of microstructure in multilayered CoCrTa thin films. The goal is to understand the relationship between sputtering processes and film microstructures and the relationship between these microstructures and the magnetic properties.

It is well known that Cr thin films deposited on either glass or NiP/Al substrates have either a {110} or {002} crystallographic texture and that Co-based alloys deposited on such Cr underlayers usually have the $\{10\bar{1}1\}$ or $\{11\bar{2}0\}$ texture respectively.[4,5,6] However, the texture of Cr that develops when it is deposited onto $\{10\bar{1}1\}$ or $\{11\bar{2}0\}$ textured Co-based alloys has not been investigated. The texture developed in Cr deposited onto Co based alloys is important in understanding the development of the crystallographic texture in multilayer thin film media. In this work, we investigated the texture of Cr layers deposited on $\{10\bar{1}1\}$ and on $\{11\bar{2}0\}$ textured CoCrTa thin films.

Our multilayers were constructed as shown in Figure 1. The second layer of CoCrTa was not deposited in this investigation, as we wanted to study the structure of the Cr interlayer as deposited on the first CoCrTa layer. The Cr interlayer is thicker than normal to improve the x-ray diffraction signal to background noise. Our samples had thicknesses shown in Table I.

Table1

	Cr underlayer	CoCrTa layer	Cr interlayer	temperature
sample A	500Å	330Å	No	room temp.
sample B	500Å	330Å	200Å	room temp.
sample C	500Å	330Å	No	260°C
sample D	500Å	330Å	200Å	260°C
sample E	500Å	150Å	200Å	260°C

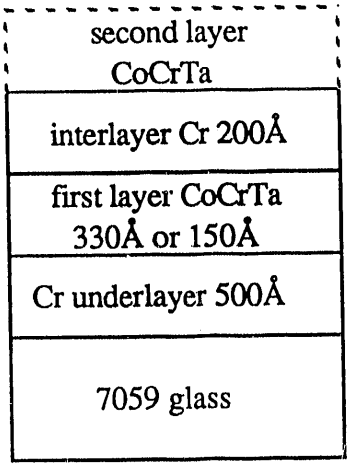

FIG.1 The film structure

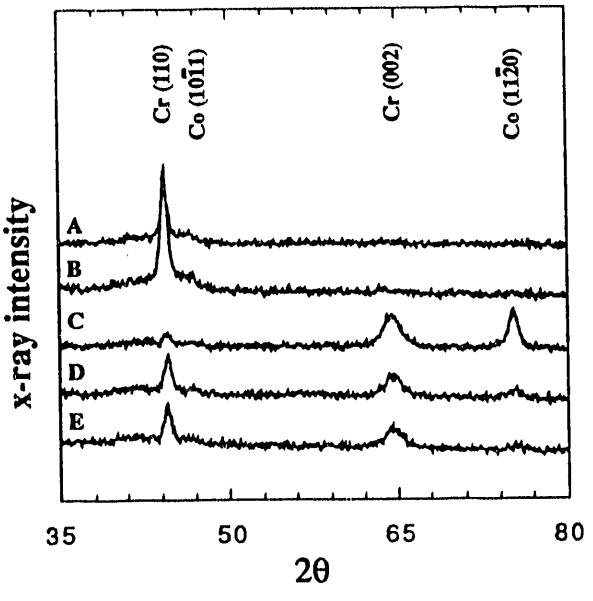

FIG.2 X-ray diffraction spectra

It might be expected that the Cr interlayer should have the same orientation relationship (OR) with the CoCrTa layer as the CoCrTa layer has with the Cr underlayer. This is true for the samples prepared at room temperature. The x-ray spectra shown in Figure 2A and 2B show that samples A and B have similar crystallographic textures. The OR between the CoCrTa and the Cr underlayer is $\{10\bar{1}1\}//\{110\}$.[5] Hence, the OR between the Cr interlayer and CoCrTa film is $\{110\}//\{10\bar{1}1\}$. The Cr interlayer has the same texture as the Cr underlayer. Thus, if CoCrTa were sputtered onto the Cr interlayer, it should have the same texture as the first CoCrTa layer.

However, in samples deposited at 260°C, we found that the Cr interlayer texture was not the same as the Cr underlayer texture. Spectrum C in Figure 2, obtained from sample C, shows only the (002) Cr peak, whereas spectrum D, taken from sample D, shows both the (110) and (200) Cr peaks. The (110) Cr peak must come from the interlayer Cr. This means that the OR between the interlayer Cr and CoCrTa is not the same as that between the CoCrTa and the underlayer Cr. Hence, if we sputtered CoCrTa onto the Cr interlayer we would obtain a different crystallographic texture for it than for the first CoCrTa film that was sputtered on the Cr underlayer.

We also produced specimens with only 150Å of CoCrTa to see if the change in the Cr interlayer texture depended on the thickness of the CoCrTa film. As shown in Figure 2E, the same Cr texture is obtained for the interlayer.

To summarize: When deposited at room temperature, the Cr *interlayer* has the (110) texture, the same as the texture of the Cr underlayer. When deposited at 260°C, the texture of Cr interlayer is different from that of Cr underlayer. Hence, the magnetic properties of the second layer of CoCrTa should be different from those of the first layer.

2. CoSm/Cr Thin Films

Current research activities in high density longitudinal magnetic recording media are concerned with reducing medium noise and transition width. To lower the medium noise it is necessary to obtain thin films with magnetically non-interacting grains a few nm in size, and to minimize the transition width, a thin medium possessing a high coercivity is essential. To date we have obtained CoSm/Cr thin films with in plane coercivities approaching 3000 Oe. This portion of the work has involved investigating the microstructure and crystal structure of the CoSm alloy. The grains have been seen to be smaller than 10 nm. It has not been possible yet to identify the phases present but we believe both Co_5Sm and $Co_{17}Sm_2$ are present. Cross section work continues in our attempt to characterize the structure of the films.

References

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2. S. E. Lambert, J. K. Howard and I. L. Sanders, "Reduction of media noise in thin film metal media by lamination," IEEE Trans. Magn., **MAG-26**, 2706 (1990).

3. H. Hata, T. Fukuichi, K. Yabushita, M. Umesaki and H. Shibata, "Low noise media using double layer CoNiCr thin films for longitudinal recording," J. Appl. Phys. **67**(9), 4692 (1990).

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5. T. Ohno, Y. Shiroishi, S. Hishiyama, H. Suzuki and Y. Matsuda, "Modulation and crystallographic orientation of sputtered CoNi/Cr disks for longitudinal recording," IEEE Trans. Magn. **MAG-23**, 2809 (1987).

6. S. L. Duan, J. O. Artman, B. Wong and D. E. Laughlin," Study of the growth characteristics of sputtered Cr thin films, "J. Appl. Phys. **67**(9), 4913 (1990).

II. Listing of Publications

Papers Published

B.Y. Wong, D.E. Laughlin and D.N. Lambeth, "Investigation of CoNiCr thin films deposited on [100] and [110] Cr single crystals," *IEEE Trans. Mag.* 27(6), 1991.

D.E. Laughlin and B.Y. Wong, "The crystallography and texture of Co-based thin film deposited on Cr underlayers," *IEEE Trans. Mag.* 27(6), 1991.

B.Y. Wong and D.E. Laughlin, "A high resolution transmission electron microscopy investigation of the interfacial structure of CoNiCr/Cr bi-layer thin films," Proc. of 49th Annual Meeting of the Electron Microscopy Society of America (EMSA), San Francisco Press, San Francisco, CA, 1991.

Papers Submitted

Y.C. Feng, D.E. Laughlin and D.N. Lambeth, "Texture of Cr interlayer in double CoCrTa thin films," submitted to IEEE INTERMAG 1992.

E.M.T. Velu and D.N. Lambeth, "High density recording on CoSm/Cr thin film media, submitted to IEEE INTERMAG 1992.

III. Personnel

We now have one graduate student currently supported on the project, Mr. Y.C. Feng from the People's Republic of China. Mr. Feng was accepted as a student in the Metallurgical Engineering and Materials Science Department in January of 1991. He has expertise in electron microscopy and magnetic materials.

During the Fall 1990, Prof. Lambeth had one of his post-doctoral associates (Dr. E.M.T. Velu) spend a portion of his time on the project. Prof. Laughlin had one of his more senior graduate students (Mr. B. Wong) pursue atomic resolution electron microscopy of the thin films.

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