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Publication Date

1989-07-01

Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

Materials & Chemical Sciences Division

Presented at the Magnetic Recording Media Conference,
Rimini, Italy, September 4-6, 1989, and
to be published in IEEE Transactions on Magnetics

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EFFECT OF MEDIA PROPERTIES ON SIDE ERASE BANDS

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Abstract - The erase bands on CoNiCr/Cr longitudinal media with coercivities ranging from 176 to 1390 Oe have been studied using a two-frequency, triple-track profile method. In this method, the two side tracks are recorded at 10 kFCI and the central track ranges from 0 to 40 kFCI. The write and the erase widths are measured by the Bitter method. Media properties such as coercivity, coercivity squareness and remanence-thickness product are correlated with the total write width. It is shown that media with high coercivity squareness contribute to a reduction in the width of a side erase band. In addition, the magnetic structure of the triple-track profile has been characterized by high resolution Bitter patterns using scanning electron microscopy, which show domain structures within bit cells and along track edges. Finally, the relationship of the erase band to the magnetic structure is discussed.

Introduction

In the quest for higher areal density per recording surface, many efforts have been devoted to improve the linear density by optimizing the media extrinsic properties such as coercivity and squareness ratio. Yet another option, theoretically better, for higher density recording is the improvement of track density. Indeed, the issue of limitations on track density with respect to recorded media has received a great deal of attention.^{1,2,3}

One of the concerns in attaining higher track densities is the existence of a side erase band on the media which limits the closest distance that two adjacent tracks can be written. One way to enhance the track density for a given recording configuration is to reduce or even eliminate the necessity of the safety guard band between recorded tracks, i.e., diminishing the widths of erase bands. Recently, in a systematic investigation to study the effect of writing current and frequency on the erase band width, it was found that the observed frequency-dependent erase width is a media-related effect.^{3,4}

The objective of this study is to extend the previous work³ to include other longitudinal recording media and to establish the role of media parameters which may affect resolution and bit shift in the formation and width of the erase band. In addition, issues concerning the track density achievable in the emerging narrow-track magnetoresistive (MR) head technology will be addressed.

Experimental

DC magnetron sputtered CoNiCr media with a Cr underlayer of thickness ranging from 10 to 200 nm and an experimental narrow-track MR head (top pole width = 5 μm , bottom pole width = 100 μm , head gap = 0.45 μm) were used in this study. The magnetic properties of CoNiCr disks were varied by different Cr underlayer thicknesses. The coercivities (H_c), coercivity squariness (S^*) and remanence-thickness product ($M_r \cdot t$) for these disks are listed in Table I. The recording configuration used in this study is a two-frequency, three-track profile, in which two 10.25 kFCI tracks are written at 150mA adjacent to each other, then a third track, with frequencies ranging from 10^{-5} to 40 kFCI, is written at 150 mA in the center of the two side-by-side tracks. The write and erase widths of these tracks were measured by both optical and SEM (higher resolution) Bitter techniques. The changes in the write and erase widths of the tracks are correlated with media properties, i.e., H_c , S^* , and $M_r \cdot t$.

Results and Discussion

The resultant written tracks under different recording schemes can be easily decorated by the Bitter ferrofluid method except for those written at very high frequencies. Figure 1 illustrates typical decorated tracks for CoNiCr thin film media with different coercivities, (a) 276 Oe, (b) 856 Oe, (c) 1140 Oe, (d) 1390 Oe, in which all were written at a linear density of 40 kFCI and a writing current of 150 mA. Many of the tracks, especially those written by the MR head, show asymmetric side-by-side background tracks, as seen in Figure 1. This phenomenon is mainly due to minor errors in head positioning and the servo system.

The difference in contrast in the Bitter patterns is due to the fact that some disks had been ashed prior to ferrofluid decoration, but the presence of thin carbon overlayer should not affect the magnetic flux on the surface of the disk. Note that at low H_c , the self demagnetizing field dominates and high frequency recording becomes difficult. Thus the resulting flux gradient is weak and the magnetite particles are loosely decorated.

In Figure 2, the write (W), erase (R) and total data widths (W') for the narrow-track MR head are plotted as a function of the medium coercivity. The total data width is comprised of the write width (W) and two side erase widths (R) (i.e., $W' = W + 2R$). Though the side erase width is seen as large as 6 μm on each side for low H_c media, the measurement of the track widths on the low H_c media was difficult due to the poor writing signal. As shown in the figure, both the total data width and side erase width decrease significantly as the coercivity increases, while the write width is relatively independent of the coercivity. Also, as expected, the write width of single tracks (non-overwrite) were very similar to those of the central tracks in the two-frequency, triple-track overwrite profiles.

The effect of coercivity on the width of the total data width can be qualitatively explained as follows: During writing, the total data width can be estimated based upon the effective region confined by the field contour where the head field is equal to the saturation field H_s . The saturation field is about 1.5 times the coercivity of the medium.³ When the coercivity of the medium increases, the H_s needed increases, and a higher percentage of the maximum head field

falls in the medium surface and causes the shape of the field contour to be smaller, and thereby the total data width decreases.

The effect of remanence-thickness product ($Mr \cdot t$) on the side erase bands is seen not as significant as that of film coercivity. In general, $Mr \cdot t$ is affected mainly by the alloy composition and the effective packing density of the magnetic layer. This has been studied by other authors.⁵ Since these two parameters for the magnetic layer studied here are considered constants, hence, very little change is observed in $Mr \cdot t$.

Within the effective region, writing in the side erase band is significantly different from saturation recording in the region right under the physical width of pole tips. At the edge of the head, writing is not effective due to the sharp decrease in the head field gradient. In fact, it is the head field gradient coupled with the switching field distribution, which is related to the S^* of the medium, that takes part in the erasing mode of poor writing in this region. Therefore, S^* may play a dominant role in the determination of the erase band width. As the S^* decreases, the switching field distribution of the medium becomes broader, and the side erase band widens.

Experimentally, it has also been confirmed that in polished thin film hard disks, the CoCrTa film exhibits a wider erase band than that of the CoNiCr counterpart. Both media have the same coercivities except the latter has a higher coercivity squareness. Figure 3 shows Bitter patterns of the 40-kFCI tracks (recorded by thin film inductive head) on CoNiCr and CoCrTa disks, comparing the widths of the erase bands.

This side erase phenomenon is found to be quite consistent with the recent study by J. Su *et al.*⁶, on base-line shift (BLS) in the readback pulses of the tracks recorded by an magnetoresistive head. J. Su *et al.* report that a BLS occurs when the magnetoresistive head senses a line of dipole charges induced along each edge of the track, and that the width of the dipoles, which was measured to be as large as 2.5 μm , increases as the track width or the medium coercivity decreases. The concept of these induced dipoles is consistent with our observations of side erase bands in the MR recorded track.

The magnetic structure at the track edge is of particular significance since the ultimate track density attainable is constrained by its characteristics. We have found that high resolution SEM Bitter pattern microscopy is quite useful and informative in studying these effects. In Figure 4, magnetic structures of a 1-kFCI track overwritten on two side-by-side 10.25-kFCI tracks are outlined by the magnetite particles attracted to the stray fields. The figure also shows the nonuniform domain structure along the track edge and reveals a ripple-type magnetization distribution within the recorded bit. As shown from the figure, this technique is strongly influenced by the instrumental operating parameters. An optimal operating voltage of 10kV is found to give the best contrast. Further studies are needed in order to clarify the micromagnetic structure at the erase band and to correlate this with the recording parameters.

Conclusions

In this study, it was shown that a wide side erase band exists in the MR head aimed for high track density applications. This limits the track density as this band can erase the adjacent track, thus requiring a wider safety guard band for the track pitch.

The existence of side erase bands indicates that along the write track edge, there is a region where the head's fringing field approaches the coercivity but the field gradient is not high enough to write. The nonuniform domain structure at the edge of a track, observed by high resolution SEM Bitter patterns and by Lorentz microscopy of discrete tracks⁷, supports such hypothesis that the formation and the width of the erase bands are strongly influenced by media properties, since these properties are intimately related to the micromagnetics of the media.

The observed difference in the widths of the side erase bands between CoCrTa and CoNiCr thin film media can be attributed to their difference in the coercivity squareness. As S^* approaches unity, more uniform switching of the magnetization occurs in these films (also considering strong exchange interactions in these films), thus resulting in smaller side erase bands.

Acknowledgments

The authors would like to thank E. Simpson for preparation of the CoNiCr/Cr disks and Imprimis Technology Inc./Control Data Corp. for various research support. This work is also supported by National Science Foundation under contract No. DMR-8707241E (K.C.L.). We acknowledge the use of various facilities at Materials and Chemical Sciences Division, Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, California.

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Figure Captions

Figure 1. Optical Bitter patterns of 150mA, 40-kFCI tracks on CoNiCr/Cr disks with coercivities of (a) 276 Oe, (b) 856 Oe, (c) 1140 Oe, (d) 1390 Oe.

Figure 2. Write, erase, and total write widths plotted as a function of medium coercivity.

Figure 3. Optical Bitter patterns of 40-kFCI tracks on (a) CoNiCr/Cr disk and (b) CoCrTa/Cr disk with lower S^* .

Figure 4. Higher resolution SEM Bitter patterns of 1-kFCI tracks on CoNiCr/Cr disk, using accelerating voltage of (a) 25 kV and (b) 10 kV.

Table I. Magnetic properties of recording medium

Medium	Cr thickness (nm)	H _c (Oe)	S [★]	M _r t (memu/cm ²)
CoNiCr (60nm)	10	276	0.09	3.01
	30	856	0.88	3.11
	100	1140	0.84	3.13
	200	1390	0.89	2.93

Fig. 1

XBB894-3072

Fig. 2

XBB897-5564

Fig. 3

Fig. 4

XBB880-10111-B

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