THE CHARACTERISTICS OF HIGH COERCIVITY RIGID DISK WITH PARTICULATE BA-FERRITE AND α -FE

Akinori NISHIZAWA, Tsuneo KAGOTANI, Junichi SATOH, Kenji YOKOYAMA,
Keiji KOGA and Yasumichi TOKUOKA
R&D Center, TDK Corp.
113, Nenei, Saku, Nagano, 385, Japan

ABSTRACT— The objective of this study is to develop rigid disks which have higher recording density and are more reliability by using barium ferrite or α -Fe particles. The produced disks had more than 1000 Oe of the coercivity and the thicknesses of the magnetic layers were less than 0.2 μ m. The surface roughness of the produced disks were more smooth than those of conventional rigid disks. The head flying height could be reduced less than 0.1 μ m, and the disks had high recording density more than 30 kFCI. CSS (Contact-Start-Stop) durability of the disks performed more than 20,000 cycles. Moreover, the produced disks had low friction coefficients.

INTRODUCTION

In recent years, digital magnetic recording drive systems have been developed rapidly. Therefore, larger capacity, faster access time and smaller drive size have been actively studied. In magnetic recording media, old products have been replaced by new ones with additional values.

In small magnetic recording media, the particulate disks with oxide powders, for example Co- γ -Fe₂O₃, have been replaced by thin film types produced by sputtering or plating methods, and these show excellent characteristics in read/write properties. In the recording heads, MIG (Metal In Gap) and thin film head have been used with the higher coercivity media. The spacing between a flying head and the media has become shorter. Therefore, the reliability of media should be more important.

The particulate rigid disks with Co- γ -Fe₂O₃ powder are excellent in durability, but have relatively lower recording density because of its lower coercivity and the surface roughness. Magnetic particles with high coercivity, such as barium ferrite or α -Fe particles, have not prevailed in rigid media market, yet.

In this paper, the possibility of the rigid disks with barium ferrite or α -Fe particles for high density recording media are described.

EXPERIMENT

The properties of used hexagonal barium ferrite and α -Fe ferromagnetic powders prepared are shown in Table 1. The easy axis of barium ferrite is perpendicular to the plane of the particle [1].

These particles were dispersed in a resin binder with several additives. 3.5" diamond turned Al-Mg alloy substrates exposed by chromate treatment were

used. The magnetic paints with barium ferrite or α -Fe were coated on the substrates by spin coating method. The easy axes of the magnetic particles were oriented to the circumferential direction in the disk plane by a magnetic field. After that, disks were cured by heat treatment and the disk polishing was carried out. Finally, lubricant was coated on the disk surfaces.

Table 2 shows the magnetic properties of the disks. The coercivity of our specimen exhibited 1310–1360 Oe and the thickness was 0.18–0.20 μ m. Moreover, in table 2, the magnetic properties of the particulate disk with Co- γ -Fe₂O₃ powder and the thin film media with Co-Pt-Ni, Co-Ni-Cr and Co-Ni-P alloys are shown in comparison. The thin film

Table 1. The properties of magnetic particles

Magnetic Material	H _c (Oe)	σ_s (emu/g)	BET (m ² /g)
Barium Ferrite	941	52.9	31.9
α -Fe	1408	136.7	42.5

Table 2. The magnetic properties of the disks

Sample	H _c (Oe)	S	S*	B _m (G)	δ (μ m)
Barium Ferrite	1360	0.81	0.85	1280	0.200
α -Fe	1310	0.84	0.72	2100	0.180
Co- γ -Fe ₂ O ₃	650	0.83	0.64	1480	0.480
Co-Pt-Ni	1435	0.78	0.87	10660	0.050
Co-Ni-Cr	850	0.87	0.74	10180	0.049
Co-Ni-P	945	0.76	0.86	12000	0.044

disks have large B_m because of the magnetic layer produced with only magnetic materials. S^* of the disks produced in this work and thin film media are much higher than that of the $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ disk.

RESULT

1. Head-Fly-Height Characteristics

1) Surface Roughness

To obtain high recording density, the spacing between a flying head and a disk must be reduced. Therefore, surface topography of the disk is very important.

Table 3 shows the surface roughness (R_a , R_{max}) of the produced disks and the others in comparison. Fig.1 indicates the profiles of the disk surfaces measured by a three dimensional stylus instrument. The radius of stylus was $0.5 \mu\text{m}$. As shown in these table and figure, the surface roughness (R_a) of the produced media were 33–35 Å, therefore, the surfaces of these disks are more smooth than those of the others.

Fig.2 shows the number of the peaks on the

Fig.1 Three-dimensional surface profiles of the disks (a) coated with barium ferrite, (b) coated with $\alpha\text{-Fe}$, (c) coated with $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$, (d) sputtered with Co-Pt-Ni , (e) sputtered with Co-Ni-Cr and (f) plated with Co-Ni-P .

Table 3. The surface roughness of the disks

	Barium Ferrite	α -Fe	Co- γ Fe ₂ O ₃	Co-Pt-Ni	Co-Ni-Cr	Co-Ni-P
	Coated			Sputtered		Plated
Ra (Å)	35	33	147	71	68	55
Rmax (Å)	638	525	4850	1150	1069	813

Fig.2 The number of the peaks on the plane with distance, h , above the mean plane for the disks coated with barium ferrite (—●—), coated with α -Fe (—■—), coated with Co- γ -Fe₂O₃ (—▲—), sputtered with Co-Pt-Ni (—○—), sputtered with Co-Ni-Cr (—□—) and plated with Co-Ni-P (—△—).

plane with the distance, h , above the mean plane. The peaks of the Co- γ -Fe₂O₃ disk is higher and much more than those of the others. As shown in fig.2, the number of the peaks of our specimen decreases more steeply compared with the thin film media.

In thin film media, the surfaces are affected by the shapes of the substrates which have texturing treatment. On the other hand, in case of the particulate media, the surface roughness of the magnetic layer can be more improved by the polishing treatment than that of the substrate. Therefore, the media with a much more smooth surface were obtained in this work.

Fig.3 Head-Fly-Height characteristics for the disks coated with barium ferrite (—●—), coated with α -Fe (—■—), coated with Co- γ -Fe₂O₃ (—▲—), sputtered with Co-Pt-Ni (—○—), sputtered with Co-Ni-Cr (—□—) and plated with Co-Ni-P (—△—).

Table 4. The value of D_{50} for the disks

	Barium Ferrite	α -Fe	Co- γ Fe ₂ O ₃	Co-Pt-Ni	Co-Ni-Cr	Co-Ni-P
	Coated			Sputtered		Plated
D_{50} (kFCI)	41.7	38.2	24.0	39.5	34.9	36.3

2) Head-Fly-Height Characteristics

Fig.3 shows Head-Fly-Height characteristics of the disks [2]. In this figure, the outputs from an AE-sensor (Acoustic Emission sensor) mounted on the head slider are plotted against the flying height. In the produced disks, the rapid increase of the AE-output was not observed over 0.07 μ m, which made flying height less than 0.1 μ m. The thin film media also have good Head-Fly-Height characteristics. While, the Co- γ -Fe₂O₃ can not be used less than 0.2 μ m of the flying height.

The result of Head-Fly-Height is consist with that of fig.2.

Fig.4A Recording density characteristics using MIG head for the disks (a) coated with barium ferrite (—●—), (b) coated with α -Fe (—■—), (c) coated with $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ (—▲—) and (d) sputtered with Co-Pt-Ni (—○—).

Fig.4B Recording density characteristics using thin film head for the disks (a) coated with barium ferrite (—●—), (b) sputtered with Co-Pt-Ni (—○—).

2. Recording Density

The measurement was carried out by a MIG head (Sendust, G/L; 0.52 μm , T/W; 12.0 μm and F/H; 0.13 μm) and a thin film head (Permalloy, G/L; 0.32 μm , T/W; 13.0 μm and F/H; 0.097 μm).

Table 4 shows the value of D_{50} . The barium ferrite disk and the Co-Pt-Ni disk had higher recording density. Both of the high coercivity and the high S^* of these media may contribute to these short wavelength recording properties.

The profiles of recording density characteristics are shown in fig.4A using the MIG head and in fig.4B using the thin film head. The barium ferrite disk, however, shows fairly low output than thin film media and α -Fe disk.

The $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ disk was measured by a higher flying height head (F/H=0.24 μm).

3. O/W, Noise and Bit-Shift Characteristics

O/W (Over Write), noise and bit-shift were measured by a head used in 2. The recording frequency (2F) was 5MHz.

Fig.5 shows the dependence of O/W on recording density. As shown in fig.5, these high coercivity disks had the bottoms at recording density about 40kFCI [3,4]. The barium ferrite and α -Fe particulate disks and thin film disks had sufficient O/W

Fig.5 The dependence of O/W on recording density using MIG head for the disks (a) coated with barium ferrite (—●—), (b) coated with α -Fe (—■—) and (c) sputtered with Co-Pt-Ni (—○—).

Table 5. The Bit-Shift of the disks

	Barium Ferrite Coated	Co-Pt-Ni Sputtered
BSFF (ns)	7.55	5.00
BSB8 (ns)	11.90	10.00

Fig.6 DC erased noise spectra using thin film head for the disks (a) coated with barium ferrite, (b) coated with α -Fe, (c) coated with $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ and (d) sputtered with Co-Pt-Ni.

characteristics at more than 30kFCI.

The DC erased noise spectra of each specimen is shown in fig.6. The noise level of the produced disk with barium ferrite is the same as that of a thin film type. And the α -Fe disk had higher noise level than the barium ferrite media. It is thought that the barium ferrite disk has higher S^* than the α -Fe disk.

The bit-shift of the disks coated with barium ferrite and sputtered thin film disk were measured. The results are shown in table 5. The FF pattern of the barium ferrite disk is large, owing to its low 2F output. The peak-shift of that disk, however, is smaller than that of thin film type.

4. Reliability

CSS (contact-start-stop) tests of the produced disks were carried out with a composite calcium titanate head. The rotational speed was 3600 rpm. And the loading weight of the head was 15 g and the flying height was $0.28 \mu\text{m}$ ($v=8.3\text{m/sec}$). The result is shown in fig.7. The particulate disks achieved lower friction and more cycles than thin film types. The friction coefficient of the produced disk was lower than that of a $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ disk, which was 0.24 after 20,000 cycles. On the other hand, the coefficients of the frictions of thin film disks with carbon protected layers increased in small counts of CSS cycles. And the thin film disk failed with the wear-out of the magnetic layer or stopped by sticking of the head to the disks.

Fig.7 CSS durability for the disks coated with barium ferrite (---●---), coated with $\text{Co-}\gamma\text{-Fe}_2\text{O}_3$ (---▲---), sputtered with Co-Pt-Ni (---○---), sputtered with Co-Ni-Cr (---□---) and plated with Co-Ni-P (---△---)

It is supposed that the particulate media could contain more lubricant in the porous structure of the magnetic layer than that of thin film disks. Therefore, the particulate disk must have shown more excellent durability.

CONCLUSION

We described the high smooth and high coercivity characteristics rigid disks with barium ferrite and α -Fe magnetic particles. The disks achieved low flying height less than $0.1 \mu\text{m}$ and high recording density more than 30kFCI was obtained. The characteristics of friction and CSS durability of the disks were much better than those of the other types and satisfied the fundamental characteristics of high density rigid disks.

REFERENCE

- [1] T.Ido, O.Kubo and H.Yokoyama, IEEE Trans. Magn., MAG-22, pp704,1986
- [2] Y.Hatamura et al., IEEE Trans. Magn., MAG-24, pp2638, 1988
- [3] K.Yokoyama et al., IEICE Technical Report (Japan), MR89-36, pp25,1989
- [4] D.Wachenschwanz and F.Jeffers, IEEE Trans. Magn., MAG-21, pp1380, 1985