A TRIBOLOGICAL STUDY OF NEW HEAD-PAD SLIDERS FOR A Co-Cr LAYERED FLEXIBLE DISK SYSTEM

S. Kadokura, K. Kinoshita, K. Kamei, K. Honjyo, and S. Sobajima

Advanced Film Products Lab., Teijin Ltd., Hino, Tokyo 191, Japan

Abstracts— Both axial runout and signal durability of a Co-Cr/Permalloy flexible disk with diameter 3.5", were studied using a disk drive with a pair of pads arranged in series relative to the disk radial direction, and with a single-pole type head.

In the drive, the radial position of the head was 35 mm at disk revolution rates ranging from 600 to 1200 rpm, to evaluate the effect of the pad configuration on the runout characteristics and read-write properties. The runout of the disk were suppressed less than 10 μm , and frequency spectra of the suppressed runout were observed up to 2 KHz. Stable read-write characteristics of the disk were observed in the high-density region over 70 kfc/i under a head pressure of about 3 mN and runout of less than 10 μm .

An out-put signal loss over 70 kfc/i was less than 1 dB after 7 million times of the head passes. No scratches were observed on the disk surface and the head-pad sliders after the durability test.

INTRODUCTION

The tribological behaviour of Co-Cr layered disks was clearly characterized by properties of solids (deformation and fracture of thin metal layers) and frictional conditions of the Co-Cr layered disk system [1,2].

Then, we have been studying novel head-pad models for the Co-Cr layered flexible disk, having a structure of relaxing the excess stress interactions for the improvement in signal durability as well as the steady read-write characteristics [3,4]. Stress interactions are due to the combined action of head load forces and frictional force with the sliding surface of a flexible disk.

In this paper, an effect of suppression in runout of a Co-Cr layered flexible disk of 3.5" diameter, was studied using a disk drive with a model of new head-pad sliders. Dynamic head positioning was studied under conditions of suppression in runout of the disk and head load of 3 mN. Finally, signal durability was evaluated for the new head-pad sliders.

EXPERIMENTAL

Outline of the test drive

Figure 1 is an external view of the test drive. As the jacket, we used a pair

Fig. 1. A photograph of the test drive.

of carbon ring plates, 150 μm apart, positioned on both sides of the outer periphery of a hard jacket for 3.5" disks [4]. Positions of the head and pads were adjusted by micrometers shown in Fig. 1.

The relative velocity of the disk and head was adjusted in the range from 2.2 to 4.4 m/s (revolution rate; $n = 600 \sim 1200$ rpm, disk radius; $r = 35$ mm) and the head load was set at 3 mN. A photometric position sensor was installed to measure axial runout of the disk and position changes of the head slider as shown in Fig. 1. We have evaluated the maximum amplitude R_m and frequency spectrum of disk runout. Signal durability was measured at carrier frequency of about 6 MHz at 1200 rpm.

New head-pad sliders

Figure 2 shows an arrangement of the new head-pad sliders in Fig. 1. Fiducial point $P_d = 0$ for the position P_d of the surfaces of two pads was set at nearly the same level as the surface of the carbon plate on the down part of the jacket as shown in Fig. 3.

Fig. 2. An arrangement of the new head-pad sliders.

Fig. 3. A configuration between pads and a carbon plate on the down part of the jacket.

This fiducial point was computed from the micrometer positions at which a surface of the pads came into contact with the glass surface when the slide glass was placed directly against the carbon plate. The two pads are of carbon, in a spherical shape with a radius of curvature of about 10 mm and 1.5 mm $\square$ in size. These pads were set 5 mm apart in the radial direction as shown in Fig. 2.

Either a dummy head or a single pole type (SPT) head was positioned so that its slider lied at the center of the two pads, on the opposite side of the disk. Table 1 shows parameter values of a SPT head [5]. The head with the head holder is 3~4 mN in weight, can be smoothly moved to its vertical direction, and is constrained in parallel direction to the disk plane.

Dynamic positioning of the head was measured in corresponding to the stress interactions between the disk and the new head-pad sliders.

Table 1. Parameter values of the SPT head

Slider size & material	Contour	Main pole	
		width	thickness
~ 1.0 mm $\square$	Spherical	70 μm	0.7 μm
$\text{Al}_2\text{O}_3\cdot\text{TiC}$	10 mmR		

3.5" disks

Double layer flexible media with a protective layer were prepared by a continuous vacuum coater with opposing targets for sputtering [6]. The media consist of an in-plane magnetization layer (Mo-Fe-Ni), a perpendicular magnetization layer (Co-Cr-Ta) and a carbide protective layer on the both sides of polyethylene naphthalate (PEN) substrate film. Media were stamped into 3.5" disks and used as samples. A lubricant was finished on both surfaces of the samples [7]. The sample dimensions and properties are listed in Table 2.

Table 2. Properties of disk sample

Substrate	Permalloy	Co-Cr-Ta	Protective layer
Material & thickness	thick-ness	thick-ness	Material & thickness
PEN	0.5 μ m	10e	0.1 μ m
30 μ m		1100oe	Carbide
			0.02 μ m

RESULTS AND DISCUSSION

Suppression in disk runout by the jacket and pads

Without the pads, the maximum amplitude R_m of disk runout was over 50 μ m.

Figure 4 shows examples of axial disk runout with the pads. Patterns of the disk runout did not change in the range from 600 to 1200 rpm, and values of R_m decreased slightly when n increased as shown in Fig. 5.

When P_d was adjusted to support tightly the disk plane by the pads, values of R_m decreased clearly from 10 μ m to few μ m as shown in Fig. 6.

Fig. 4. Examples of axial disk runout

Fig. 5. Properties of R_m depending on n .

Fig. 6. Properties of R_m depending on P_d .

Frequency spectra of the disk runout is typically shown in Fig. 7. All of the samples showed similar distributions of the frequency spectrum. Judging from these test results, we can conclude that values of R_m can be easily suppressed less

Fig. 7. An example of the frequency spectrum with the disk runout

than 10 μm , but vibration of the disk runout extends its frequency more than 2 KHz in the combination of the disk sample and the new head-pad sliders without a head.

Head positioning under suppression in disk runout

Dynamic variations of the head positioning were measured under the same conditions as suppression of disk runout by the jacket and pads. Variations of the head positioning were less than 1 μm and almost the same value as the system noise of the photometric position sensor.

The spectrum analysis indicated that vertical movement of the head at 3 mN of the head load, responds slightly to the fundamental frequency of the disk angular velocity when R_m is suppressed less than 10 μm by the jacket and pads.

Signal durability

Read-write characteristics were measured on out-put signal envelopes at recording frequency of 3.2 MHz under conditions of $P_d = 50 \mu\text{m}$, $r = 35 \text{ mm}$, $n = 600 \text{ rpm}$. Spacing variations between the head and the disk were evaluated from output signal envelopes in the range from 600 to 1200 rpm.

Figure 8 shows a typical out-put signal envelope at $n = 1200 \text{ rpm}$. Maximum and minimum levels in Fig. 8 were measured and converted to normalized signal level E_n . E_n of maximum level in Fig. 8 was 12 $\text{nVo-p/T} \cdot \mu\text{m} \cdot \text{m/s}$ at recording density $D = 72 \text{ kfc/i}$. No changes of spacing in the range from 600 to 1200 rpm were observed as shown in Fig. 9.

Figure 10 shows an example of signal durability test under similar atmosphere in an office. Signal envelopes except a position of minimum level (in Fig. 8), show level changes less than 1 dB in the range from start to the end of test, 7 million passes.

Another out-put signal envelope after 5 million passes is shown in Fig. 11.

Out-put signal envelopes in Fig. 8 and Fig. 11 are almost same in the envelope levels and their variations except portions around minimum levels.

Fig. 8. A typical out-put signal envelope (start).

Fig.10. Properties of out-put signal levels E_n depending on the head passes.

Fig. 9. Dependence of E_n on n.

Fig.11. Another out-put signal envelope (5 million passes).

Judging from our experiments for the new head-pad sliders, variations in output signal envelopes depends mainly on changes of the sliding area between the head and the disk.

After the end of test, both sliding portions between the head slider and the disk were observed by a microscope. There were no detectable changes on both the sliding portions. But, a dirty zone around 70 μm in diameter was observed on the SPT head slider about 150 μm apart, at the rear position from the line of the main pole to the disk running direction. A ZrO_2 composite slider of a dummy head showed same superior performance on durability as the SPT head of $\text{Al}_2\text{O}_3\cdot\text{TiC}$ slider.

These test results indicate that characteristics of no wear and little change of spacing can be expected in the combination of the Co-Cr layered flexible disk and the new head-pad sliders when the disk surfaces are kept to be clean by removing contaminations from an environmental atmosphere.

CONCLUSION

Better results on both signal durability and tribological behaviour for a Co-Cr layered flexible disk system, can be expected from the following test results by the new head-pad sliders.

- 1) Negligible changes of spacing were obtained under the head load of 3 mN, when disk runout was suppressed less than 10 μm by the pads and the jacket.
- 2) Variations of the head positioning were less than 1 μm when the thickness of the disk substrate was 30 μm .
- 3) After 7 million times of the head passes, little wear was observed on a carbide protective layer of the disk and on either a ZrO_2 composite or an $\text{Al}_2\text{O}_3\cdot\text{TiC}$ slider of the SPT head [8].

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