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PASS WEAR RESISTANCE FOR PERPENDICULAR RECORDING MEDIA

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Abstract - Pass wear resistance for sputtered CoCr perpendicular flexible disks has been investigated. The flexible disk was composed of CoCr film on heat resistant base film , protection layer and lubricant. The disk pass wear durabilities were evaluated by conventional double-sided 3.5 inch flexible disk drive. Pass wear strongly depends on CoCr film preparation conditions. As a result of film scratch test using a sapphire needle, it was found that the scratch depth SD (μm) per load force LF(g) depends on preparation conditions ,and that the CoCr film hardness relates to pass wear durability. SD/LF values range from 0.2 to 0.3 for CoCr films without a protection layer. By forming the protection layer and adding a lubricant, the range in SD/LF values vary from 0.2 - 0.3 to 0.1 - 0.3. The disk hardness, especially for small SD/LF media, is improved. A pass wear durability of 30 million passes was attained for the disk having SD/LF=0.1. It is shown that the media hardness for a disk using flexible film is a very important factor which determines pass wear durability.

1. INTRODUCTION

Sputtered CoCr perpendicular anisotropy films have been intensely investigated for use as very high density flexible disk media [1]. A key factor in technologies to realize CoCr perpendicular recording is pass wear durabilities. Many efforts have been made to improve the durability. As factors determining the pass wear durability, there are pass wear base films, lubricant, protective layer, head material and so on [2,3,4,5]. In addition, CoCr film mechanical property also is a important factor[6,7].

In these pass wear tests single sided spherical heads have been widely used [1,4,5,6,7]. However, pass wear durability [3] for a double-sided flexible disk drive is needed from the disk memory capacity points of view. The pass wear deterioration of the thin film media is caused by scratching with wear particles and head sliders [8] in flexible disk drive (FDD).

This paper reports on the correlation between media mechanical property and pass wear resistance of a CoCr flexible disk for double-sided FDD .

2. SAMPLE PREPARATION AND EXPERIMENTAL

A flexible disk was composed of lubricant, protection layer and CoCr film (0.3 μm thick) on heat resistant base film (30 μm thick). Figure 1 shows 3 dimensional surface roughness for a base film. The average roughness of base film was 24 A. Preparation conditions for the Disks A, B and C are shown in Table 1. The substrate rotation for intermittent sputtering was 6 rpm. CoCr films were deposited by r.f. magnetron sputtering . Sputtering pressure was 1 m torr. The lubricant and protective layers (0.02 μm) were liquid and inorganic material, respectively . The lubricant and protective layers were prepared for all flexible disks under the same conditions.

To investigate wear characteristics on flexible disks, specimens subject to wear tests were formed into 3.5 inch diameter flexible disks. The pass wear number for disks was measured under the following conditions: 1) 3.5 inch double-sided FDD (1 MB). 2)Rotational speed: 600 rpm. 3) Head slider: calcium titanate. 4)Head pressure: 20 g. 5)Track: 20, 7)Environment:20-30 ℃, 30-70 % RH.

In order to examine flexible disk strength resistance to scratching by head slider and wear particles the disk scratching strength was investigated using a scratching needle. Figure 2 shows the configuration of the scratching test apparatus. The scratching needle was sapphire with 0.025 mm radius. The needle travel velocity was 50 mm/min. In the scratching test, scratching depth and scratching force were both measured under temperature 25 ℃ and 50-60 % RH. The scratch depths were calculated from the scratch width and the radius of the spherical tip of the sapphire needle.

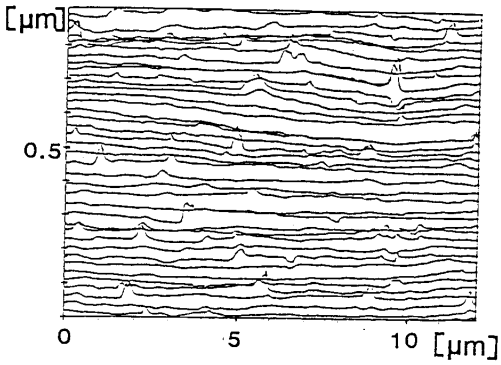

Fig. 1 Three dimensional surface roughness for a flexible disk.

Table 1. Flexible disk preparation conditions

Disk No.	CoCr film No.	CoCr sputtering	Temperature
A	A	Intermittent(Batch)	20 ℃
B	B	Intermittent(Batch)	100℃
C	C	Continuous (heat can roll)	100℃

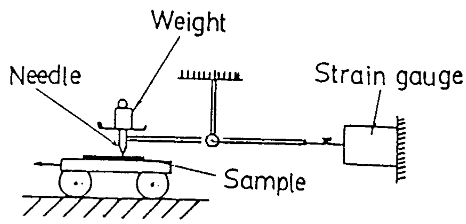

Fig. 2 Configuration of scratching test apparatus.

3. RESULTS AND DISCUSSION

3.1 CoCr films strength effect on pass wear durability

Figure 3 shows relative outputs for flexible disks A, B and C (table 1) versus pass number. As shown in Fig. 3, the pass wear strongly depends on CoCr film preparation conditions, under the same lubricant and protective layer conditions. The pass wear durability for Disks A, B and C are < 10^4 passes, 1.1×10^5 passes and > 3×10^7 passes, respectively.

In order to clarify the causes, scratching resistant strengths for CoCr films used in flexible disks were examined. Figure 4 shows photo-micrographs

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for regions scoured by scratching needle on CoCr films A and C. The scratching width increases with increasing needle load. The scratching width for CoCr film A is greater than that for the CoCr film C. A part of CoCr film A was removed from the base film at 20g needle load.

Figure 5 shows scratching depth SD versus needle load force LF for CoCr films A, B and C. SD is proportional to LF in the low LF region. The coefficients (= SD/LF) are 0.3, 0.25 and 0.2 for CoCr A, B and C, respectively. CoCr films,prepared by continuous sputtering and high heat treatment have greater film strength than that prepared by intermittent sputtering . The film surface temperature for continuous sputtering is higher than that for intermittent sputtering. Therefore, the magnitude order of film surface temperature for CoCr films A, B and C is as follows,

CoCr C > CoCr B > CoCr A

These results show that the heat applied during sputtering promotes sputtering particle migrations on the film and improves the film strength. The pass wear durability of the disk increases with the decrease of SD/LF value. In the large LF region, the larger SD/LF value is, the larger SD becomes. This means that wear resistances for CoCr films with large SD/LF values deteriorate, even for small impact forces.

Figure 6 shows friction force versus scratching distance t for CoCr films A and C. The friction force for CoCr film A, with large SD/LF value, is greater than that of CoCr film C with small SD/LF value. Figure 7 shows friction force variation versus LF. The friction force variation is due to scratching depth variation and begins with a smaller LF values (10 g) for CoCr film A , as compared with CoCr film C. Figure 8 shows the friction force of scratching needle versus LF for CoCr films A, B and C. The friction forces also increase with increasing LF, as previously shown for SD versus LF in Fig. 5.

3.2 Effect of protective layer on pass wear durability

Furthermore, to clarify the factor of pass wear durability in 3.1, Scratching resistance was examined from protective layer points of view.

Figure 9 shows scratching depth versus LF for Disks A, B and C in Table 1, after coating with protective layer and lubrication. Figure 10 shows photo-micrographs of regions scratched by the needle for Disks A and C. By forming protective layer on CoCr films, SD/LF values for Disks B and C change from 0.2-0.24 to 0.1-0.17. Media hardness is improved as CoCr film hardness becomes large. However, the SD/LF values for disk A does not change from SD/LF 0.3 of the CoCr film without protective layer. Figure 11 shows scratching force variation for Disk A and C. As shown in Figs. 10 and 11, abrasive wear for Disk A increases after forming a protective layer on the low hardness CoCr film. Therefore, these results show that media strength is a very important factor, which determines pass wear resistance margin, and that a pass wear resistance of 30 million passes can be attained by using appropriate conditions during media preparation.

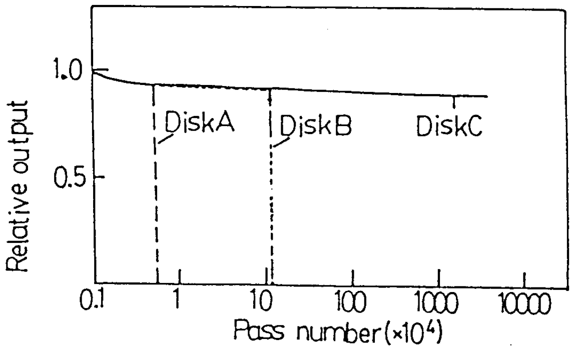

Fig. 3 Relative output versus pass number for flexible disks A, B and C.

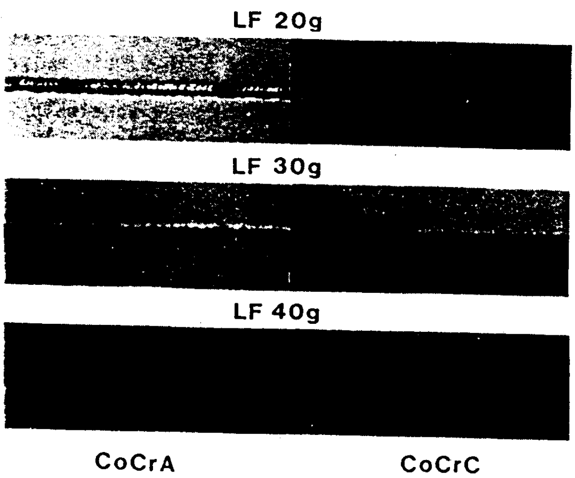

Fig. 4 Photo-micrographs of scoured regions for CoCr films A and C.

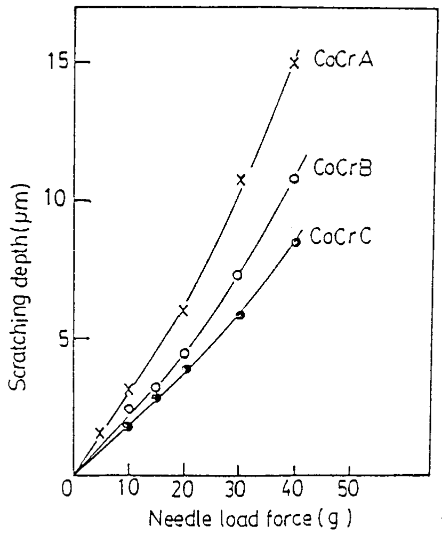

Fig. 5 Scratching depth SD versus needle load force LF for CoCr films A, B and C .

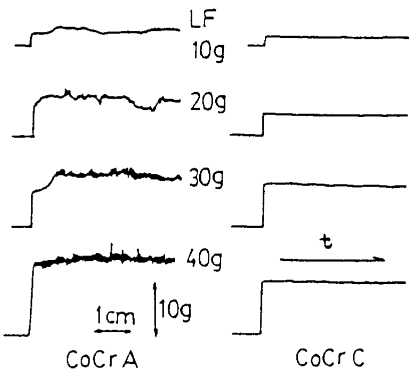

Fig. 6 Friction forces versus scratching distance t for CoCr films A and C. LF values =10, 20, 30 and 40g.

CONCLUSION

Pass wear strongly depends on CoCr film preparation conditions. As a result of film scratch tests using a sapphire needle, it was found that the scratch depth SD (μm) per load force LF(g) relates to pass wear durability. SD/LF values range from 0.2 to 0.3 for CoCr films. By forming the protective layer and adding a lubricant, the SD/LF values vary from 0.2-0.3 to 0.1-0.3. The media hardness is improved, especially for small SD/LF media. The disk pass wear resistance of 30 million passes was attained for a disk with SD/LF 0.1

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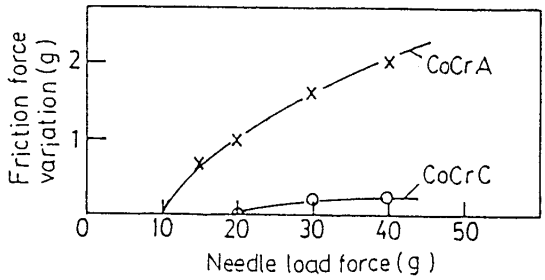

Fig. 7 Friction force variation versus needle load force for CoCr films A and C.

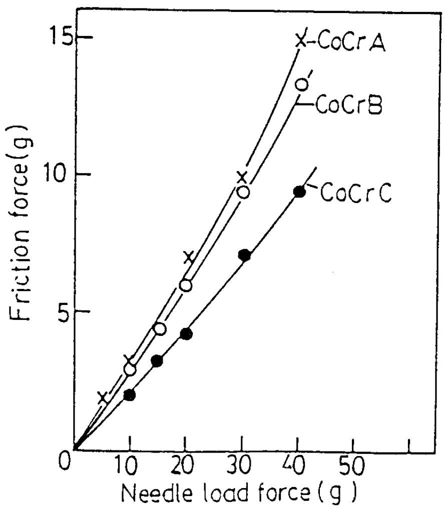

Fig. 8 Friction forces versus scratching needle load force for CoCr films A, B and C.

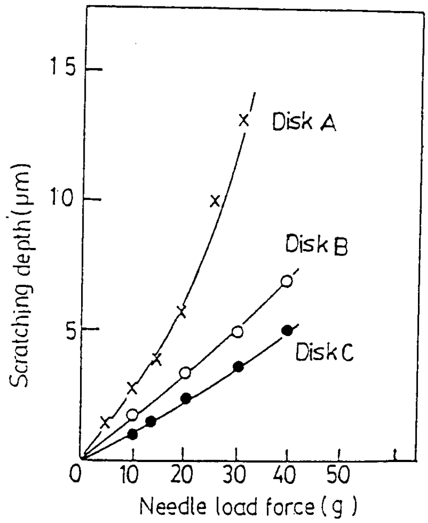

Fig. 9 Scratching depth versus needle load force for disks A, B and C with lubricant and protective overcoat .

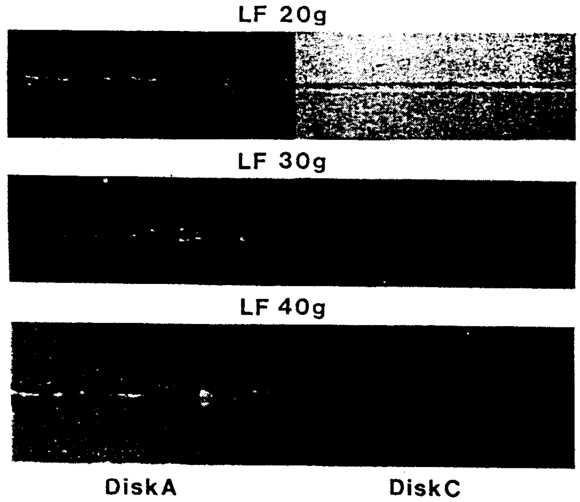

Fig.10 Photo-micrographs of scoured regions for disks A and C with lubricant and protective overcoat.

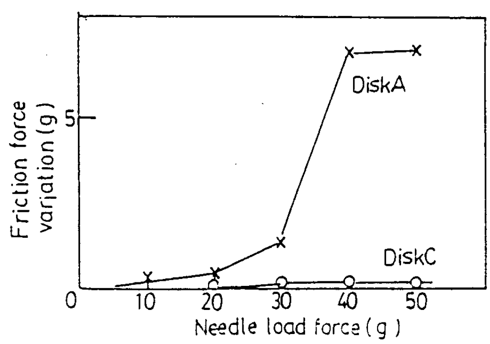

Fig.11 Friction force variation versus needle load force for disks A and C with lubricant and protective overcoat.