PASS WEAR DURABILITY OF CoCrTa PERPENDICULAR FLEXIBLE DISKS

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Abstract-- Pass wear durability for sputtered CoCrTa perpendicular magnetic flexible disks has been studied from the CoCrTa film preparation condition standpoint. Pass wear durability strongly depends on a sputtering pressure P_{Ar} . In the low P_{Ar} region, high pass wear durability, more than 30 million passes, is obtained. However, in the high $P_{Ar} > 7$ mTorr, the durability decreases by 1/100. Scratch resistance was examined to clarify the dependence of pass wear durability on P_{Ar} , using a sapphire scratch needle. The scratch resistance is found to be determined by Young's modulus value for CoCrTa films. CoCrTa film flexible disk with high Young's modulus value has high pass wear durability. As the result of flexible disk environment tests, pass wear durabilities, more than 10 million passes, are confirmed under high temperature (60°C) and high humidity (80%RH) condition, as well as low temperature (5°C) condition.

INTRODUCTION

Sputtered CoCr perpendicular magnetic films have been intensely investigated for use as very high density flexible media [1]. A key factor in technologies to realize a perpendicular flexible disk using CoCr film is pass wear durability. To assure the desired durability, many efforts have been made. Main factors determining the durability are base film, lubricant, protective layer and head material [2,3]. In addition, CoCr film mechanical property is also an important factor [4,5].

Pass wear deterioration for a thin film media is caused by media surface scratch with a magnetic head for double-sided flexible disk drive (FDD) [5,6], and by the variation in environment conditions.

This paper reports on pass wear durability of CoCrTa perpendicular flexible disks for double-sided FDDs.

EXPERIMENT

A flexible disk was composed of a heat resistant base film on which a CoCrTa film, an overcoat layer and lubricant were

formed. Perpendicular CoCrTa films [7,8] were deposited by r.f. magnetron sputtering under several sputtering pressures. The base film, CoCrTa film and overcoat layer thickness were 30 μm , 0.3 μm and 0.02 μm , respectively.

Pass wear resistances for the disks were evaluated by using a double-sided FDD (600 rpm) under some environment conditions. The media scratch depths were measured by a scratch test apparatus, using a sapphire needle [5]. Needle point radius was $R=0.025$ mm. Young's modulus of CoCrTa films was measured by a tensile tester.

RESULTS AND DISCUSSION

PASS WEAR DURABILITY FOR CoCrTa FILM FLEXIBLE DISK

Pass wear tests were carried out under 25°C and 60-70% RH. Pass wear durability is defined by pass number at which outputs decrease by 70% of the initial value.

Figure 1 shows the disk pass wear durability versus sputtering pressure P_{Ar} for CoCrTa film depositions. The pass number is normalized by the maximum pass wear durability value. The disk with the maximum value has a pass wear durability

>30 million passes [5]. The media pass wear resistance strongly depends on P_{Ar} and decreases by 1/100 in the $P_{Ar} > 6$ mTorr region. In order to clarify dependences of wear resistance on film sputtering pressure, scratch resistance for CoCrTa films and for disks were examined.

CoCrTa FILM SCRATCH RESISTANCE

Figure 2 shows scratch depths SD versus load force LF for CoCrTa films. In the low load force region, Scratch depth coefficient (SD/LF) values [5] for CoCrTa films prepared in $P_{Ar} < 6$ mTorr, are smaller than those for CoCrTa film, prepared at $P_{Ar} = 8$ mTorr.

Figure 3 shows photo-micrographs for regions of CoCrTa films prepared at $P_{Ar} = 1$ mTorr and at 8 mTorr, after scouring by scratch needle. In the CoCrTa film disk prepared at $P_{Ar} = 8$ mTorr, CoCrTa films were separated from the base film with the load force > 20 gf. On the contrary, the base film was not observed in the scoured regions for CoCrTa film disk prepared at $P_{Ar} = 1$ mTorr, even above LF 40 gf.

Figures 4(a) and (b) show average scratch force and scratch force variation (

Fig. 2 Scratch depth SD versus load force LF for CoCrTa films.

Fig. 1 Disk pass wear durability versus argon pressure P_{Ar} for CoCrTa film deposition.

(a) $P_{Ar} = 1$ mTorr

(b) $P_{Ar} = 8$ mTorr

Fig. 3 Photo-micrographs showing CoCrTa films scoured by scratch needle.

amplitude) versus load force for CoCrTa films on base film. The scratch force increases with increasing the needle load force. In the scratch force variation, a load force threshold value, above which the variation steeply increases, exists for individual CoCrTa films. The load force threshold values for CoCrTa films prepared in the low P_{Ar} < 4 mTorr are almost the same and larger than that of CoCrTa films prepared in the high P_{Ar} region. The load force threshold values increase with increasing P_{Ar} in the high P_{Ar} region. The scratch force variation amplitude for CoCrTa film prepared at P_{Ar} = 8 mTorr is larger than that for CoCrTa film prepared at P_{Ar} = 1 mTorr, as shown in Figs. 5(a) and (b). The large friction force variation is due to ploughing CoCrTa film from base

film. These results, that the CoCrTa film scratch resistance strongly depends on P_{Ar} and is large in the low P_{Ar} region, show that the pass wear durability is determined by the scratch resistance.

PROTECTIVE LAYER EFFECT ON SCRATCH RESISTANCE

Furthermore, disk scratch tests were carried to examine the disk protective layer effect on scratch resistance.

Figure 6 shows scratch depth versus load force for disks used for the pass wear test shown in Fig.1. By forming a protective layer, SD/LF values decrease for every disk in the small load force region, and the scratch resistance is improved.

Fig. 4(a) Average scratch forces versus needle load force LF for CoCrTa films.

Fig. 4(b) Scratch force variations versus needle load force LF for CoCrTa films.

Fig. 5 Scratch force versus scratching time for CoCrTa films.

Fig. 6 Scratch depth SD versus needle load force LF for disks.

However, scratch depth steeply increases above a load force threshold value for each disk. The threshold value increases with decreasing P_{Ar} . Figure 7 shows the scratch force variation (amplitude) versus the load force for disks. The disks with CoCrTa films prepared at $P_{Ar} < 6\text{ mTorr}$ have almost the same dependence of scratch force variation on load force, unlike that dependence for CoCrTa films shown in Fig.

4 (b). However, disks with CoCrTa film prepared at $P_{Ar} = 8\text{ mTorr}$, have large scratch force variations, though protective layers are formed on the CoCrTa films.

Figure 8 shows photo-micrographs of disks scratched by the needle. As shown in

Fig. 7 Scratch force variation versus needle load force LF for disks.

Fig. 8 Photo-micrographs of disks scratched by scratch needle.

Figs. 3 and 8, scratch width for the disk with a protective layer is larger than that for CoCrTa film at $P_{Ar} = 8$ mTorr. This is attributed to the fact that the degree of ploughing with the needle increases by covering a rather low strength CoCrTa film with a hard protective layer.

YOUNG'S MODULUS FOR CoCrTa FILMS

As mentioned above, pass wear durability corresponds with the scratch resistance. The load force threshold value, above which the degree of ploughing steeply increases, determines the scratch resistance margin against scratch forces. Since the scratch resistance may vary with film mechanical strength, the Young's modulus value was examined.

Figure 9 shows Young's modulus versus P_{Ar} for CoCrTa films used in the experiment. As shown in the figure, Young's modulus values strongly depend on the

Fig. 9 Young's modulus versus sputtering pressure P_{Ar} for CoCrTa films.

sputtering pressure [4,9]. The values were about $2.2 \times 10^4 \text{ Kg/mm}^2$ in the P_{Ar} range from 0.6 mTorr to 2 mTorr. The Young's modulus value begins to decrease from 4 mTorr P_{Ar} and becomes one-half of that in the low P_{Ar} range.

The sputtering pressure dependence of Young's modulus corresponds with that of the disk pass wear durability shown in Fig.1. Since the CoCrTa film mechanical strength decreases with decreasing Young's modulus, low Young's modulus in the high P_{Ar} region leads to low film scratch resistance. High pass wear durability in the low P_{Ar} is due to high Young's modulus for a CoCrTa film. Therefore, to obtain high pass wear durability, it is very important to increase film strength.

ENVIRONMENT TEST FOR CoCrTa FILM DISK

The pass wear was examined for an appropriate disk, with a CoCrTa film deposited at low P_{Ar} , under FDD operation

conditions.

Figure 10 shows normalized output for disks versus pass number under 60°C (80 % RH) and 5°C. As shown in the figure, pass wear durabilities, for more than 10 million passes, were obtained under high temperature and low temperature. Furthermore, pass wear for more than 50 million passes as the top data was confirmed at ordinary room temperature conditions (25°C, 60 - 70 %RH).

Fig. 10 Normalized output voltage versus pass number.

CONCLUSION

Pass wear durability for a CoCrTa flexible disk strongly depends on sputtering pressure P_{Ar} in CoCrTa film preparation conditions. In the low P_{Ar} region, high pass wear durability was obtained. However, in the high $P_{Ar} > 7$ mTorr, the durability decreased by $1/100$. The scratch resistance was examined to clarify the dependence of pass wear durability on P_{Ar} , using a sapphire scratch needle. Scratch depth coefficient SD/LF values for CoCrTa films are large in the low pass wear durability region. By forming a protective layer on the CoCrTa film, SD/LF values decrease and scratch resistance is improved. It is clarified that the scratch resistance is determined by Young's modulus value for CoCrTa film. Pass wear durability, more than 10 million

passes, was confirmed under high temperature (60°C) and high humidity (80 % RH), as well as low temperature (5°C).

ACKNOWLEDGMENT

The authors would like to thank to Drs. S. Esho and H. Gokan for their encouragement and Mrs. T. Takeda and Y. Motomura for discussions and suggestions.

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