INFLUENCE OF POLISHER SURFACE STRUCTURE ON POLISHER LIFE IN ULTRA-SMOOTHNESS POLISHING OF NiP PLATED ALUMINUM MAGNETIC DISK SUBSTRATE

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INTRODUCTION

To produce the low cost compact magnetic disk of high storage capacity, the high removal rate and ultra-smoothness polishing technique of the magnetic disk substrate has been strongly required. In our previous researches[1], ultra-high pressure and ultra-high speed polishing is effective for getting high removal rate in polishing of electroless nickel phosphorus (NiP) plated aluminum substrate. The polisher life in ultra-high pressure and ultra-high speed polishing, however, has not been adequately examined yet although it is one of the most important factors from the standpoint of the manufacturing cost. In the previous research, the polisher life is examined by pursuing the change of the removal rate with the polishing process using the suede type of polisher of the single layer in the surface structure.

The present report is extended to the investigation of the change of the removal rate in polishing process for the polisher surface structure of double layer. From the results, the remarkable difference between the polishers of single and double layer structure is found for the change of removal rate with polishing process.

EXPERIMENTS

The appearance of the polishing machine is shown in Fig. 1. The machine is available for polishing speed up to 9.0m/s and polishing pressure up to 60kPa. However, the maximum polishing pressure and speed generally used in the present polishing operations, are about 10kPa and 1.5m/s. The main experimental conditions are listed in Table 1. The aluminum substrate used is 3.5inch type. Supply flux is 20ml/min. The polisher surface is observed with a differential interference microscope and SEM. Surface structure of single layer and double layer polisher is shown Fig.2. From the figure polisher surfaces consist of large macroscopic holes and wall films having a lot of micro-pores.

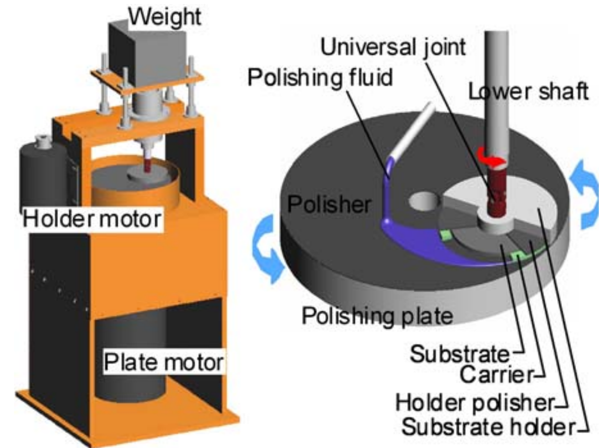
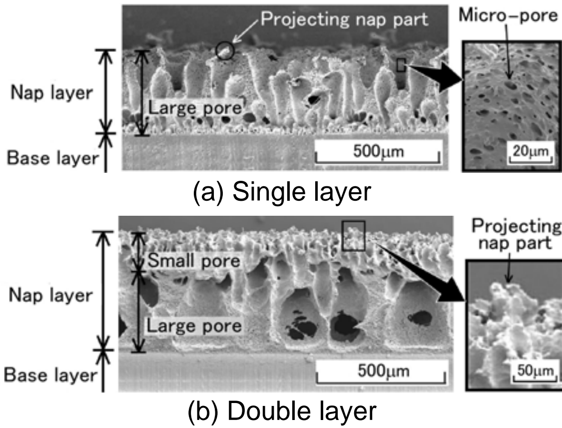


FIGURE 1. Schematic view of the polishing machine

TABLE 1. Experimental conditions

Work piece	NiP plated aluminum magnetic disk substrate (3.5inch type: $\phi 95\times\phi 25\times 1.27$mm)
Polisher	Suede type
Polishing fluid	Abrasives : Colloidal silica Content of abrasives Cg:5wt% Supply flux Lg : 20ml/min
Polishing conditions	Polishing pressure P :10,60kPa Polishing speed Va :1.5m/s

Moreover, the top of films consists of projecting nap part. The substrate smoothness is evaluated from the standpoint of the slight undulation Hwa(Ra), and the surface roughness Hra(Ra), which are obtained from the surface profiles of 4mm length and 256μm length measured with a interferometric surface profiler (WYKO), respectively. The data are obtained by averaging the values of two-dimensional profiles at five random positions on the three-dimensional WYKO images measured at four locations of substrate surface.



(a) Single layer

(b) Double layer

FIGURE 2. *Comparison of surface structure of single layer with double layer in the polisher surface*

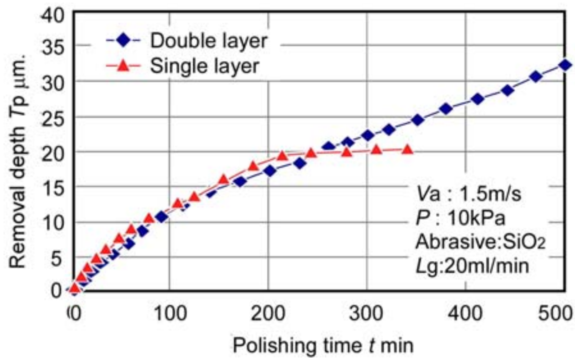


FIGURE 3. Comparison of the change of removal depth with polishing time using the single layer polisher and double layer polisher

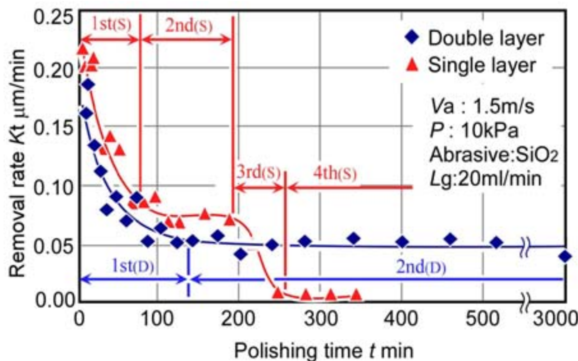
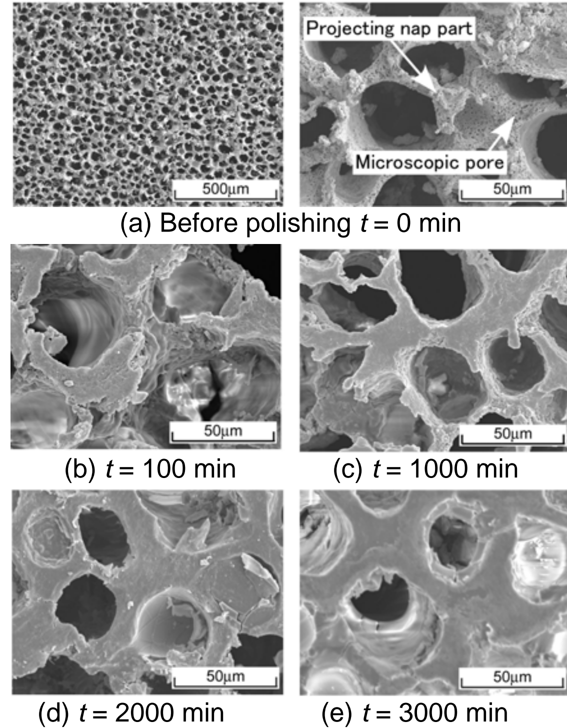


FIGURE 4. Comparison of the change of removal rate with polishing time using the single layer polisher and double layer polisher

EXPERIMENTAL RESULTS AND DISSCUTIONS

Change of removal rate with polishing time

Figure 3 shows the comparison of the change of removal depth with polishing time using the



(a) Before polishing $t = 0$ min

(b) $t = 100$ min (c) $t = 1000$ min

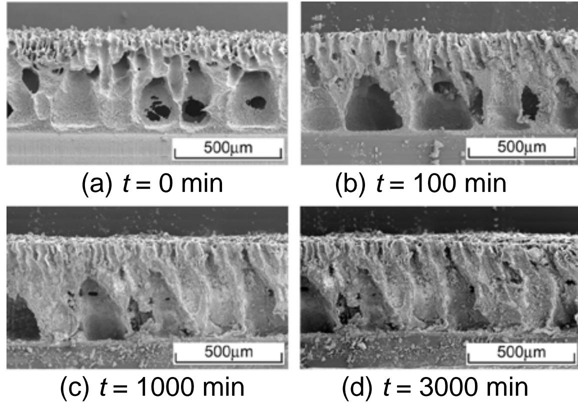
(d) $t = 2000$ min (e) $t = 3000$ min

FIGURE 5. Change of polisher surface with polishing time in the double layer type polisher

[Polisher: Suede type , Abrasive :SiO2, Lg=20ml/min , P=10kPa , Va=1.5m/s]

single layer polisher and the double layer polisher. Polishing pressure and speed used are 10kPa and 1.5m/s, respectively. In the case of the single layer polisher, the removal depth increases steeply in the initial polishing process. Afterward the increasing rate of the removal depth increases linearly. From the polishing time of 220 minutes, the increasing rate of removal depth begins to become small again and finally converge to a extremely small value. In the case of the double layer polisher, on the contrary, removal depth still increases linearly up to the polishing time of 500 minutes.

Figure 4 shows the change of removal rate with polishing time for both polishers. Using the single layer polisher, reported in the previous report, the removal rate in the polishing process is found from the figure to be classified by four steps. The first polishing step is the former transient process in which the removal rate changes from the extremely high removal rate at the beginning polishing process to steady removal rate at the second polishing step. The third polishing step is the latter transient process in which the removal rate changes from the



(a) $t = 0$ min (b) $t = 100$ min
(c) $t = 1000$ min (d) $t = 3000$ min

FIGURE 6. Change of polisher section with polishing time in the double layer type polisher

[Polisher: Suede type , Abrasive: SiO_2, Lg=20ml/min , P=10kPa , Va=1.5m/s]

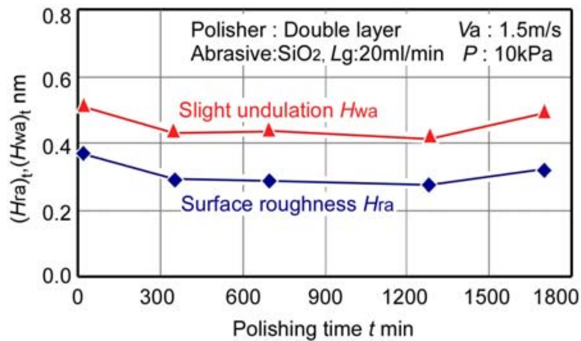


FIGURE 7. Change of the terminal surface smoothness with polishing time

steady removal rate to the extremely low removal rate at the fourth polishing step, that is, the lifetime. At the lifetime, the polisher surface layer is embedded mostly with colloidal silica abrasives. On the other hand, using the double layer polisher, it is found that only the first two steps, that is the former transient polishing step and the steady polishing step are ascertained and polisher life is not found until long polishing time.

FIGURE 5 and FIGURE 6 show the change of surface and section of polisher with polishing time for the double layer polisher, respectively. Compared with the new polisher surface, the polisher surface at t=100 min becomes flat because the projecting nap part is scrapped off. The polisher surface at t=3000 min, is not embedded with colloidal silica abrasives. The result is large different from the case of the single layer polisher. As the result, the same removal rate is kept until long polishing process.

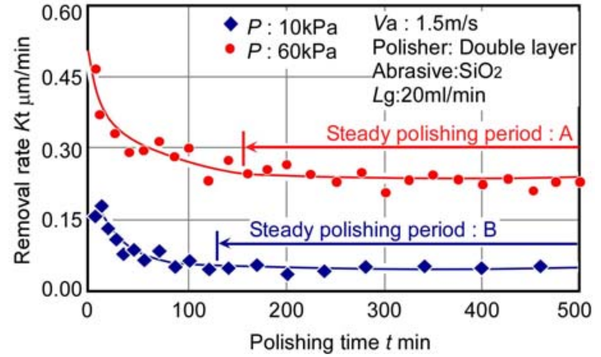


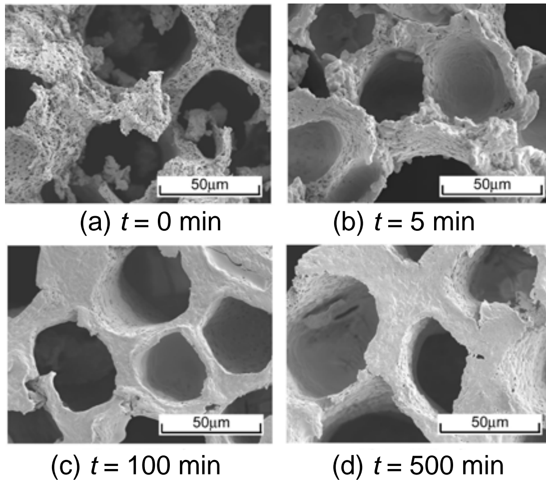
FIGURE 8. Influence of polishing pressure on the change of removal rate with polishing time

FIGURE 7 shows the change of terminal surface smoothness with polishing time for the double layer polisher. However the terminal surface roughness means that the substrate smoothness converges finally to a value related to a given polishing condition after being improved by polishing. From the figure, both of slight undulation and surface roughness are somewhat worse in the former transient polishing step and attains the smallest in the second stage. After the polishing time of 1500 min, the surface smoothness tends to increase slight with the increase of polishing time again. It is inferred why the colloidal silica abrasives, which are piled up in the shallow cave found partially on the flat surface of polisher, groove somewhat deep on the substrate. Thus the polisher surface condition is referred to influence a little on polished substrate surface smoothness.

Influence of polishing pressure

FIGURE 8 shows the Influence of polishing pressure on the change of removal rate with polishing time. From the result, the change of removal rate with polishing time is similar for both polishing pressure. It is found that the removal rate in polishing process is classified by two steps. In the second steady step, the removal rate at P=60kPa is about four times larger than that at P=15kPa.

FIGURE 9 and FIGURE 10 show the change of surface and section of polisher with polishing time in the double layer polisher for the polishing pressure of 60kPa. From the figure, it is found that the polisher surface is flattened out quickly by the short polishing time of 5min. The thickness of the polisher decreases several 10 microns. After the long polishing time of 500 min, however, the large pore on the bottom part of polisher surface is not embedded with colloidal

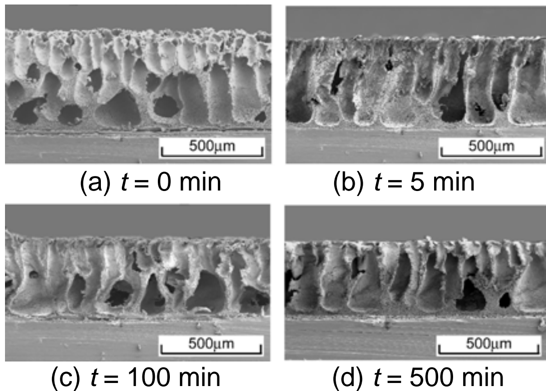


(a) t = 0 min (b) t = 5 min

(c) t = 100 min (d) t = 500 min

FIGURE 9. Change of polisher surface with polishing time in ultra-high pressure polishing condition

[Polisher: Double layer type, Abrasive:SIO_2 , Lg=20ml/min , P=60kPa , Va=1.5m/s]



(a) t = 0 min (b) t = 5 min

(c) t = 100 min (d) t = 500 min

FIGURE 10. Change of polisher section with polishing time in ultra-high pressure polishing condition

[Polisher: Double layer type, Abrasive:SIO_2 , Lg=20ml/min , P=60kPa , Va=1.5m/s]

silica abrasives. At that time, the large pore is left in the situation near the polisher before polishing.

FIGURE 11 shows the Influence of ultra-high polishing pressure on surface smoothness of polished substrate for the double layer polisher. The polishing time is found to have a little influence on the surface smoothness.

CONCLUSIONS

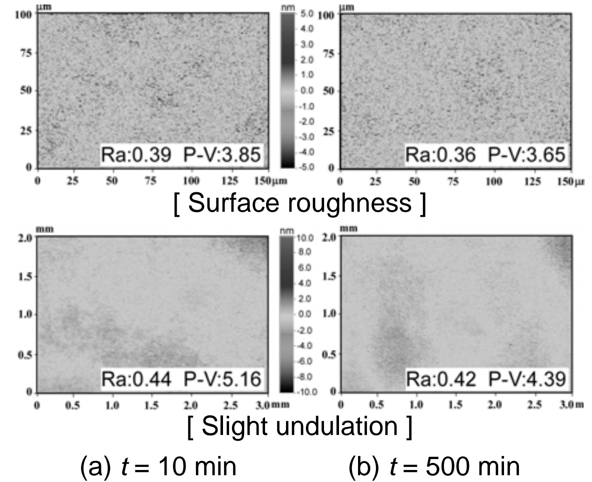
The main conclusions obtained are as follows:

(1) In the case of the double layer polisher, only the first two steps, that is, the former transitional polishing process and the steady polishing process among the four steps which are found in the change of removal rate with polishing process for the single layer polisher are ascertained.

(2) The surface structure of the double layer polisher is embedded difficult with colloidal silica abrasives.

(3) In the case of the double layer polisher, the removal rate at ultra-high pressure of 60kPa is about four times larger than the maximum rate in the usual polishing pressure of 10kPa under the polishing speed of 1.5m/s.

(4) The polishing pressure has little influence on surface smoothness.



(a) t = 10 min (b) t = 500 min

FIGURE 11. Influence of ultra-high polishing pressure on surface smoothness of polished substrate

[Polisher: Double layer type, Abrasive:SIO_2 , Lg=20ml/min , P=60kPa , Va=1.5m/s〕

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