

POLISHER LIFE IN ULTRA-SMOOTHNESS POLISHING OF MAGNETIC DISK SUBSTRATE USING NEW DOUBLE SIDE SURFACE POLISHING MACHINE

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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. By using one side surface polishing machine, in the previous research, higher speed and/or higher pressure polishing than the present polishing condition is found effective for ultra-smoothness and high removal rate polishing of the substrate. The high speed and high pressure polishing, however, is considered difficult to be applied to double side surface polishing with the conventional polishing machine driven by gear mechanism because the carrier holding the substrate which is rotated by gear mechanism can not endure high polishing force generated from high polishing pressure and/or high speed drive. From the point of view, in the previous research [1], the gearless double side surface polishing machine in which the carrier is fixed during polishing is devised and manufactured on trial.

Using the new double side surface polishing machine, in the research, the polisher life which is one of the most important factors from the standpoint of the manufacturing cost is examined by polishing the electro-less nickel phosphorus plated aluminum substrate with colloidal silica abrasives.

GEARLESS DOUBLE SIDE SURFACE POLISHING MACHINE

In the conventional polishing machine, as shown in Fig.1, the carrier holding the substrate is rotated by sun gear and internal gear. Polishing is executed by the rotation of magnetic disk substrate accompanied with the carrier. The carrier can not endure high polishing force

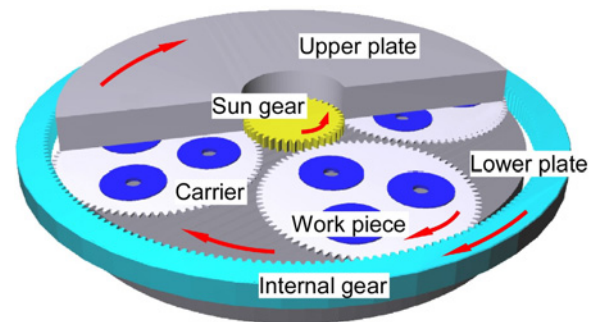


FIGURE 1. Schematic view of the mechanism in the conventional polishing machine

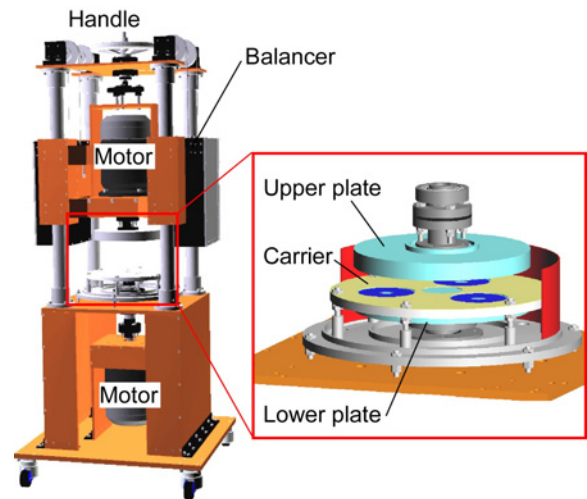


FIGURE 2. Appearance of new concept double side surface polishing machine

generated from high polishing pressure and/or high polishing speed drive because it is thin and weak.

To resolve the problem, the gearless double side surface polishing machine is devised. Appearance of double side surface polishing

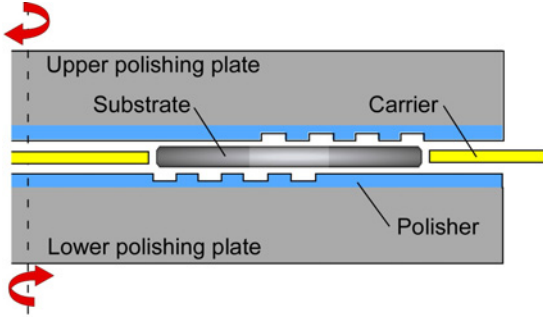


FIGURE 3. Schematic view of the rotating mechanism in the new concept machine

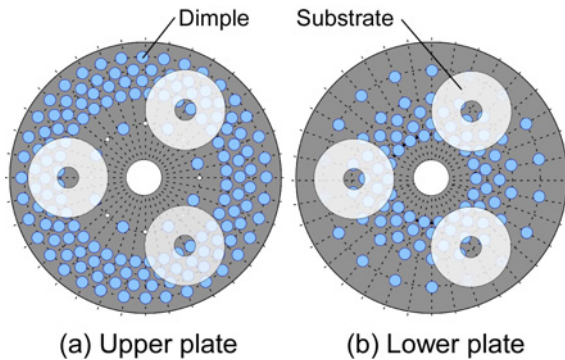


FIGURE 4. Schematic view of the polisher surface

machine is shown in Fig.2. In the gearless machine, the carrier is fixed and does not move the substrate set in the carrier. The rotating mechanism of the substrate depends on the couple of forces generated by the friction forces which are caused from the contact between the substrate and upper or lower polishing plate. Figure 3 shows the schematic view of the rotating mechanism of the new concept machine. The upper and the lower plate are rotated to reverse direction. In the upper plate side, the friction force between the substrate and polisher surface becomes larger at the outside of plate than the inside of plate because the contact area between the substrate and the polisher at the outside of plate is closer than the inside of plate. In the lower plate side, on the other hand, the friction force between the substrate and polisher surface becomes oppositely larger at the inside of plate than the outside of plate. As those results, the couple of forces which rotates the substrate operate to the substrate. Figure4 shows the schematic view of the polisher surface. A lot of circular dents are found on the polisher surface. The dents called "dimple"

TABLE 1. Experimental conditions

Work piece	NiP plated aluminum magnetic disk substrate (3.5inch type: $\phi 95 \times \phi 25 \times 1.27\text{mm}$)
Polisher	Suede -Type (Single layer)
Polishing fluid	Abrasives : Colloidal silica Supply flux L_g : 50g/min
Polishing conditions	Polishing pressure P : 10kPa Polishing speed V_a : 1.5m/s

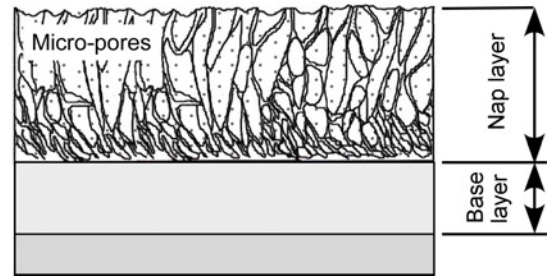


FIGURE 5. Schematic view of the polisher section

decrease the contact area between the polisher and substrate. The number of dimple in the upper plate side is more at the outside of plate than the inside of plate. The number in the lower plate side is more at the inside of plate than the outside of plate. The difference between the contact area due to the location of the substrate gives the large couple of forces to the substrate. As the result, high pressure and/or high speed double side surface polishing is possible.

EXPERIMENTS

To compare with the results obtained previously in the one side polishing experiments [2], in the research, the experiments are executed at polishing speed of 1.5m/s and polishing pressure of 10kPa which corresponds to the maximum ordinal polishing conditions. However the machine is available for the experiment up to polishing pressure of 60kPa and polishing speed of 18m/s in the specification of the design. The main experimental conditions are listed in Table 1. The aluminum substrate used is 3.5inch type. Supply flux is 50g/min. The polisher surface is observed with a differential interference microscope and SEM. Schematic view of the

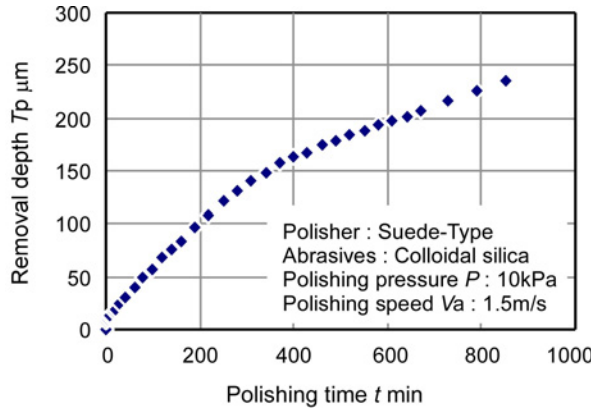


FIGURE 6. Change of removal rate with removal depth

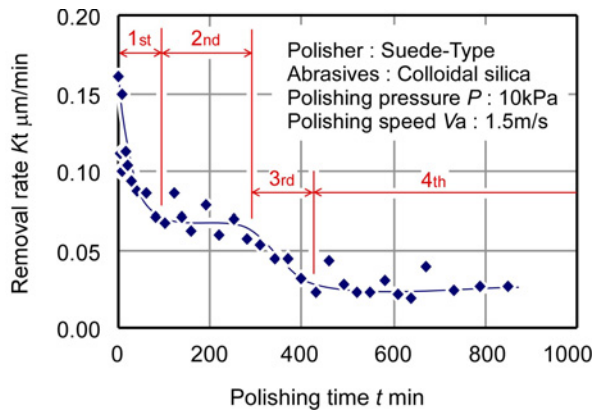


FIGURE 7. Change of removal rate with polishing time

polisher section is shown Fig.5. From the figure the polisher surface consists of large macroscopic holes and wall films having a lot of micro-pores. The substrate smoothness is evaluated from the standpoint of the average surface roughness $H_{ra}(Ra)$, which is obtained from the surface profiles of 256 micro-meter length measured with an interferometric surface profiler (WYKO). The data is 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.

EXPERIMENTAL RESULTS AND DISCUSSIONS

FIGURE 6 shows the change of removal depth with polishing time. Polishing pressure and speed used are 10kPa and 1.5m/s, respectively. The removal depth increases steeply in the initial polishing process. Afterward the

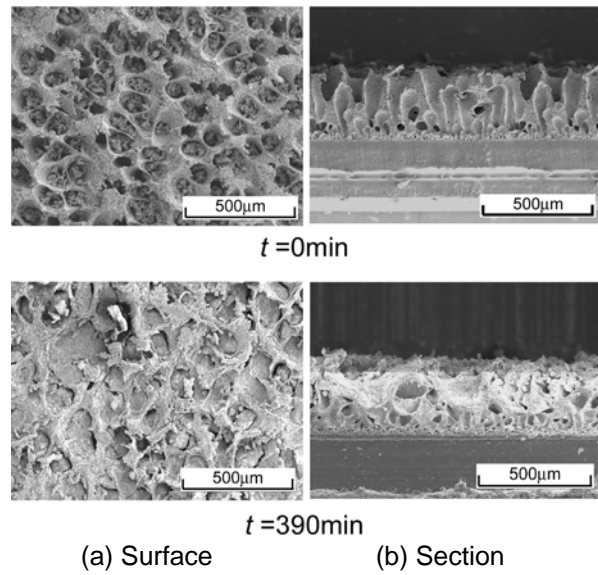


FIGURE 8. Comparison of the new polisher surface with that after polishing for 390min

[Colloidal Silica, Suede-type, $V_a=1.5\text{m/s}$, $P=10\text{kPa}$, $L_g=50\text{g}/\text{min}$]

increasing rate decreases gradually. However the removal depth increases linearly from the polishing time of about 100 minutes to about 300minutes. From the polishing time of 300 minutes, the increasing rate of removal depth begins to become small again and finally converge to a extremely small value.

FIGURE 7 shows the change of removal rate with polishing time. The removal rate is high at the beginning of polishing. In the initial polishing process, however, the removal rate steeply decreases transiently with the increase of removal depth (1st stage). After the initial polishing process, the removal rate is kept steadily a constant value in the range of polishing time of about 200min (2nd stage). Over the range of steady state, the removal rate steeply decreases again (3rd stage). Finally the removal rate converges to extremely small values (Final 4th stage). The polisher life is defined when the removal rate comes to the final stage level. The change in the double side polishing machine is almost the same as that obtained previously in the one side polishing machine.

FIGURE 8 shows the comparison of polisher surface and surface section before and after polishing time of 300 minutes corresponding to life time. On the new polisher surface, large

empty pores of several 100 micro-meters are found. Thin film like wall around the pores is observed and has minute empty hole of below 1 micro-meter inside it. And the top of the film is consisted of the salience of nap. Compared with the new polisher surface, the polisher surface at the life time of $t=390$ min, is embedded mostly with colloidal silica abrasives. As the result, the real polishing pressure that is related to the removal rate decreases drastically because the polishing loading is applied to the embedded abrasives in addition to the surface of the thin film like wall. Thus the removal rate in polisher life is considered to become extremely small value.

FIGURE 9 shows the change of the terminal surface roughness with polishing time. 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, the roughness, Hra , is the lowest in the 2nd stage and somewhat worse in the 1st stage. After the 3rd stage, the Hra tends to have extremely slight increase with the increase of polishing time. Accordingly the polisher surface condition is referred to influence little on polished substrate surface smoothness measured with WYKO.

FIGURE 10 shows the change of the three dimensional WYKO image with polishing time. The polishing time is found to have small influence on the surface smoothness.

CONCLUSIONS

The main conclusions obtained are as follows:

- (1) The removal rate with polishing process changes in the four stages, which are the initial removal rate reducing stage, the steady removal rate stage, the later removal rate reducing stage and the extremely small removal rate stage corresponding to the life time.
- (2) The terminal surface roughness is at almost the same from the beginning of polishing to polisher life.
- (3) The polisher life occurs when the small hole on the polisher surface is mostly embedded by colloidal silica abrasives.

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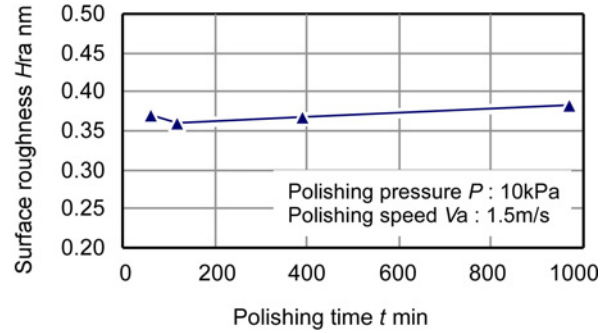


FIGURE 9. Change of the terminal surface roughness of substrate with polishing time [Polariser :Suede-type , Abrasive :SiO₂]

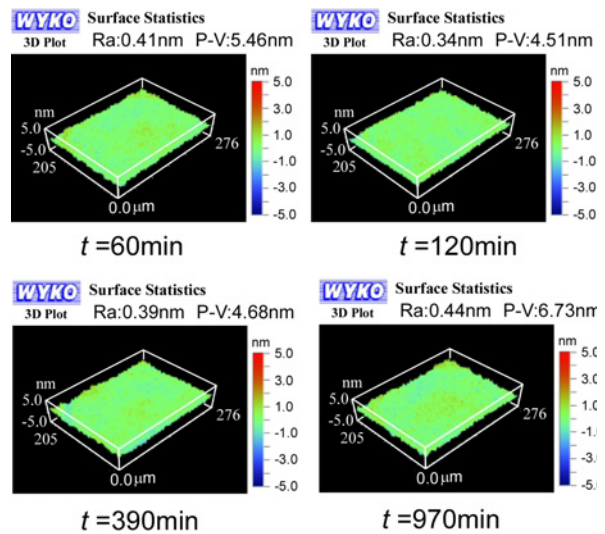


FIGURE 10. Change of WYKO image with polishing time [Polariser :Suede-type , Abrasive :SiO₂]

polishing fluid. A part of the research is supported by GRNT-IN-AID for Scientific Research (2005) [Project No. 17360065], in Japan

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