Polisher Life in High Speed Ultra-Smoothness Polishing of NiP Plated Aluminum Magnetic Disk Substrate

Heiji YASUI*, Shoji KURIBAYASHI*, Seiji MATSUHASHI*, Yutaka YAMASAKI* and Kanta YAMAGUCHI*
*:Dept. of Mechanical Engineering & Materials Science, Kumamoto University 2-39-1 Kurokami, Kumamoto 860-8555, JAPAN

1. Introduction

In manufacturing of the compact magnetic disk, reducing its cost together with realizing higher storage capacity has been steadily required. One of the methods for filling the requirement is to build the high productive ultra-smoothness polishing technique of the magnetic disk substrate. In our previous researches1),2) high speed polishing in excess of 5 times the usual polishing speed is attempted for getting high removal in polishing of electroless nickel phosphorus (NiP) plated aluminum magnetic disk substrate. From the result, high speed polishing is useful for getting high removal rate with ultra-smoothness substrate surface. Polisher life, however, is not examined yet although it is one of the most important factors from the standpoint of the manufacturing cost.

The research deals with the polisher life in the polishing of NiP plated aluminum magnetic disk substrate. In the report, the polisher life in the high speed polishing is examined.

2. Experiments

The appearance of the polishing machine is shown in Fig. 1. The machine is available for polishing speed up to 9m/s which is in excess of 5 times the maximum polishing speed executed by the conventional polishing machine. The main experimental conditions are listed in Table 1. The aluminum substrate used is 3.5inch type. Polishing speed is 9m/s. The polisher and abrasives used are suede type and colloidal silica, respectively. The polisher surface is observed with a differential interference microscope and SEM. The substrate smoothness is evaluated from the standpoint of the slight undulation $H_{wa}(Ra)$, and the surface roughness $H_{ra}(Ra)$, which are obtained from the surface profiles of 4mm length and 256µm length measured with a interferometric surface profiler (WYKO), respectively. The data of slight undulation and surface roughness are obtained by averaging the values of two-dimensional profiles at five random positions on the three-dimensional WYKO images measured at four substrate surface locations. AFM is also used to examine ultra-precisely the substrate surface roughness.

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4. Results and discussions

4.1 Change of removal rate with polishing process

Figure 2 shows the change of removal rate with removal depth. Polishing speed and pressure are 9m/s and 3.7kPa, respectively. 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 removal depth of about 8 µm (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 near zero (Final stage). The polisher life is defined when the removal rate comes to the final stage level.

4.2 Change of polisher surface due to polishing

The change of removal rate due to polishing is considered to depend on the state of the polisher surface. Figure 3 shows the polisher surfaces before polishing and after coming to polisher life. Polishing speed and pressure are 9m/s and 11.1kPa, respectively. The new polisher surface before polishing consists of large holes and wall layers having a lot of micro-pores. After coming to life, however, the micro-pore is vanished and observed little on the polisher surface. In addition, the large hole is filled up with the chip of polisher formed by polishing. As the result, the polisher surface becomes nearly flat. The colloidal silica abrasives are difficult to stay on such a flat polisher surface. Thus the removal rate in polisher life is considered to become extremely small value near zero.

Figure 4 shows the change of polisher cross-section profile due to polishing. The cross-section profile before polishing is rough. The roughness is about 70µm. After coming to the final stage, however, the roughness becomes small and about 30µm.
Figure 5 shows the change of polisher surface roughness with polishing time. From the figure, the surface roughness decreases steeply from about 70 µm to about 30 µm in the short polishing time. Thus the polisher used is considered soft for high polishing speed and pressure. It is referred important to select the suitable polisher for effective polishing of long life though dressing technique is additionally one of the most important subjects.

4.3 Effect of flow rate of polishing fluid
The effect of flow rate of polishing fluid on polisher life time is shown in Fig.6. The experiments are carried out in two supplying methods in which the flow rates are 6g/min with one nozzle and 14g/min with two nozzles. From the result, the change of removal rate with removal depth is almost the same curve for both those methods. For high flow rate of 14g/min, however, the removal depth in the region of the steady polishing state is larger than low flow rate of 6g/min. In high speed polishing with high polishing pressure, large heat generation occurs. Accordingly it is considered important to remove effectively the generated heat.

4.4 Influence of polisher surface condition on substrate surface smoothness
In Fig.7, the change of substrate surface smoothness with polishing time is shown for polishing pressures of 11.1kPa and 3.7kPa under polishing speed of 9m/s. It is found from the figure that both of slight undulation and surface roughness are almost the same values through whole polishing process from the beginning of polishing to final stage, which are about \( H_{wa}=0.4\text{nm}(Ra) \) and \( H_{ra}=0.3\text{nm}(Ra) \), respectively. The polishing pressure has little influence on slight undulation and surface roughness. Accordingly the polisher surface condition is referred to influence little on polished substrate surface smoothness measured with WYKO.

Figure 8 shows the three dimensional WYKO image for two polishing times. It is clear that the surface roughness in both of polishing time of 300min in the range of steady state and 510min in polisher life are almost the same.
Figure 9 shows an example of AFM image of substrate surface formed in the final polishing process. From the figure, some grooves with small particles are found on the polished substrate surface. As the surface roughness excluding the grooves is about 0.2nm(Ra), the surface is referred to be polished relatively smooth. When including the height of grooves, however, the surface roughness can not use as a product. Accordingly, it is considered important to exchange new polisher before coming to polisher life.

5. Summary

The main results obtained are as follows:
(1) The removal rate is high at the beginning of polishing. However, it decreases steeply in the initial polishing process transiently. In the second process after the initial process, the removal rate is kept a constant value. In the third process, the removal rate transiently decreases steeply and finally converges to a life value near the removal rate of zero.
(2) The polisher life occurs when the small hole with wall layer having micro-pores is mostly filled up with the chip of polisher, as the result, polisher surface becomes flat.
(3) The flow rate of polishing fluid influences on polishing life time.
(4) Both of slight undulation and surface roughness is almost the same values through whole polishing process from the beginning of polishing to final stage defined as polisher life, which are about \( H_{wa}=0.4\text{nm}(Ra) \) and \( H_{ra}=0.3\text{nm}(Ra) \), respectively.
(5) In the polisher life, some grooves with small particles are found on the polished substrate surface measured with AFM.

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References