Mirror Grinding of Optical Glass by EPD Pellets

Hideo SHIBUTANI¹, Jun-ichi IKENO² and Akihiko SUZUKI

¹Graduate School of Science and Engineering, Saitama University,

255 Shimo-Okubo, Sakura-ku, Saitama City, Saitama 338-8570, Japan, Shibutani@mech.saitama-u.ac.jp

²Graduate School of Science and Engineering, Saitama University, ikeno@mech.saitama-u.ac.jp

³Graduate School of Science and Engineering, Saitama University, akihiko_suzuki@mech.saitama-u.ac.jp

Abstract:

Mirror grinding wheels composed of a cerium oxide abrasive and sodium alginate binding-agent were developed using electrophoretic deposition phenomenon. And disk-shaped optical glass samples with a diameter of 3 inches were ground on an ultra-precise surface grinder. As the results, the mirror surface was obtained in a few minutes and the roughness was 1nmRa and 9nmRz. This grinding technique have possibilities of high-speed mirror grinding for an optical glass.

Keywords: Mirror grinding, Optical glass, Surface roughness, EPD pellet

1. Introduction

With the increasing production of digital consumer electronics such as personal computer, portable music player, digital still cameras, glass parts like an optical lens and a platter for hard disk drive are in great demand. These parts need an ultra smooth surface and finished by polishing with loose abrasives. But, polishing process is real slow and time-consuming. Solving these problems, mirror grinding technique is very promising.

We have been working on the mirror grinding wheel for silicon wafers ⁽¹⁾⁻⁽³⁾. In this study, mirror grinding wheels for the optical-glass were fabricated and the grinding tests were carried out. Purpose of this study is to investigate the feasibility of high-speed mirror grinding of an optical glass.

2. Mirror Grinding Wheel

2.1 Fabrication process

Fine particles are negatively charged in an alkaline solution in which they get an electric double layer so that they are dispersed homogeneously in the solution due to the repulsion force acting between the particles. When an electric field is applied, the particles are attached to an anode electrode and deposit on it, which is called electrophoretic deposition

phenomenon.

The phenomenon is effective for the fabrication of fine abrasive pellet which is called EPD pellet. In this study, fine cerium oxide was used as abrasives for EPD pellet because it is generally using in a polishing of optical glass. When the fine abrasives deposited on an anode and became dry, the outer surface of the deposition layer was cracked. Thus it is necessary to include a bonding agent in EPD pellet in order to use the pellet as a grinding wheel.

Sodium alginate, one of the hydrophilic electrolytes, was use as the bonding agent. The polymers adhere to each of fine particles and form a hydrophilic colloid as show in Fig. 1. Consequently, electrophoretic deposition of the fine abrasives, which wrapped by bonding agents, occurs around an anode.

The fabrication process was as follows.

Fig.1 Fabrication of fine abrasive pellet applying electrophoretic deposition

1. Mix fine cerium oxide abrasives, sodium alginate and pure water uniformly in a vessel.
2. Apply to DC power in the above mixture for forming the deposition layer by electrophoretic deposition.
3. Cutting the deposition layer to suitable size.
4. Dry it more than 24h at room temperature.

2.2 Characteristic of cerium oxide EPD pellet

Optical glass polishing with cerium oxide abrasives are generally done in a wet condition. But, EPD grinding for the silicon wafer is done in a dry conditions. Therefore, characteristic of cerium oxide EPD pellet in the wet conditions. In this study, swelling characteristic when there are waterdrop on the EPD pellet and vickers hardness when the EPD pellet was soaked in water was investigated.

EPD pellet was sudden expanded just after drop waterdrop of 0.2cc and swelling reached about 60 μ m as shown in Fig.2, and vickers hardness was decrease with soak time as show in Fig.3. This result shows that wet grinding with EPD pellet is difficult because of there characteristics. Therefore, water mist spray as a grinding fluid was attempted to mirror grinding of optical glass with cerium oxide EPD pellet.

3. EPD Grinding Test

Grinding test of optical glass with EPD pellet, EPD grinding, was carried out using a precision vertical surface grinder. After EPD grinding, observation of the ground surface, the surface roughness were investigated.

Precision vertical surface grinding machine (JTEKT : SG-30) and set up for EPD grinding were shown in Fig.4. The wheel spindle was held by a hydrostatic bearing. Cup-type EPD wheel, which its diameter is 200mm and adhered with 22 pellets as shown in Fig. 5, was mounted on the bottom of the spindle.

ϕ 3inches optical glass wafer, B270 soda glass ,with both polished were prepared and one side was ground by a conventional diamond wheel (#2000) before EPD grinding. And these wafers were mounted on the rotary table with the ϕ 3inches ceramic vacuum chuck held by hydrostatic bearing.

The grinding condition was shown in Table 1. The wheel rotated at 1000rpm, the work at 30rpm, the cutting speed was 10 μ m/min, the depth of cut was 200 μ m and an

Fig.2 Swelling characteristic of cerium oxide EPD pellet

Fig.3 softening characteristic of cerium oxide EPD pellet

Fig.4 Ultra precision vertical surface grinder and Set up for EPD grinding

infeed grinding was carried out with water mist spray.

4. Result and Discussion

In this study, grinding conditions were configured that EPD pellet and optical glass were contacted when grinding time was 600s. But, they were contacted grinding time was about 120s, and after that, grinding force was increased, an exponential increase was found grinding time was about 180s as shown in Fig.6. Then, infeed motion was forced stopped and observation of ground surface was carried out.

Fig. 7 show appearance of the optical glass wafer after EPD grinding. The wafer before EPD grinding resembled frosted glass in appearance because of grinding marks by a diamond wheel. But after EPD grinding, ground surface had a clear appearance and no scratch marks were also

found. But, there were some salient area in the roughness curve as shown in fig. 8. This result shows that there were adhesion substances on the ground surface, but mirror surface of 9nmRz was obtained in a short time. This grinding technique have possibilities of high-speed mirror grinding for optical glass.

In this grinding technique, it was considered that the exponential increase of grinding force as shown in fig.6 was very important phenomenon.

Next grinding test, infeed motion was forced stop before the exponential increase of grinding force was appeared, then the ground surface was observed. Fig. 9 and Fig.10 show the result. This result shows that any adhesion substances on the ground surface was found, but mirror surface was not obtained. This results shows that it is necessary to control and keep suitable grinding force to realize the high-speed mirror grinding of the optical glass.

Fig.5 Cup-type EPD wheel

Table 1 EPD grinding condition

Wheel rotation	1000min ⁻¹
Work rotation	30min ⁻¹
Infeed rate	1um min ⁻¹
Total depth of cut	20μm
Spark out	2min
Coolant	Water mist spray

Fig.6 Grinding forced during EPD grinding with water mist spray.

Fig.7 Appearance of ground surface.

5. Conclusions

In this study, mirror grinding wheel, EPD pellet, was fabricated and applied mirror grinding of optical glass.

1. Water mist spray technique was effective for mirror grinding of optical glass with cerium oxide EPD pellets.
2. Mirror surface of 9nmRz was obtained in a short time(about 2min).
3. This grinding technique have possibilities of high-speed mirror grinding for optical glass.

References

- [1] Fuwa N., Shibutani H., Horiuchi O., Suzuki H. and Ikeno J., 2001, *Proc. of the Forth International Symposium on Advances in Abrasive Technology*, Korea, Vol. 1, pp.295-302.
- [2] Fukazawa T., Fuwa N., Ikeno J., Shibutani H., Horiuchi O. and Suzuki H., 2001, *Proc. 10th ICPE*, Japan, Vol.1, pp.366-370.
- [3] Shibutani H., Ikeno J., Horiuchi O. and Yano K., 1998, *Proc. 9th ICPE*, Japan, Vol. 1, pp.98-102.

Fig.8 Surface roughness of ground surface

Fig.9 Grinding force in case of forced stop

Fig.10 Ground surface roughness in case of forced stop