Development of alternative abrasives of cerium oxide for glass polishing

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Abstract

Zirconium oxide (ZrO_2) abrasives were proposed as the alternative abrasives of cerium oxide (CeO_2) abrasives to reduce the use of CeO_2 abrasives in glass polishing. In polishing, a larger number of effective abrasives between work and polishing pad can be realized to the good polishing performances during processing. Two methods have developed to increase the number of effective abrasives on the polishing pad. As the first method to increase the effective abrasives, we used the cohering phenomenon at the isoelectric point of ZrO_2 abrasives. The cohered ZrO_2 abrasives were obtained the better surface roughness from 1.12nmRa to 0.86nmRa in a shorter time (10min.) compared with CeO_2 abrasives. And the next method to increase the number of effective abrasives was adding some additives such as NiO, WO_3, and CuO to the ZrO_2 abrasives. The role of added additives was to limit the behavior of the ZrO_2 abrasives on the pad, and this could increase the effective abrasives to improve the stagnation state of ZrO_2 abrasives between the work and polishing pad. The removal rate of work using CuO additives was 25% higher than that of ZrO_2 abrasives.

1 Introduction

In glass polishing process, the CeO_2 abrasives are widely used because a high removal rate and high-quality glass surfaces can be easily obtained. The metal component cerium (Ce), however, is the one of rare earth elements. Recently, because of supply risk of the rare earth materials, the price of CeO_2 abrasives has rapidly increased. Thus, development of alternative materials and technologies to reduce the use of rare earth materials including CeO_2, are strongly requested. We have developed alternative abrasives to reduce the use of CeO_2 abrasives for glass polishing as a Japan national project for rare metal substitute materials development.

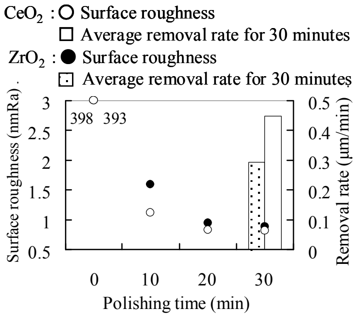

Fig. 1 Polishing characteristics of CeO_2 and ZrO_2 abrasives

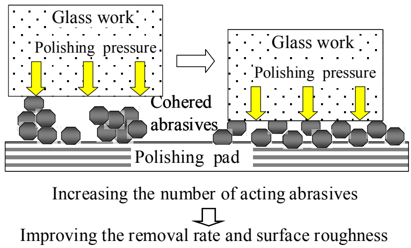

Fig.2 Schematic of improving the polishing characteristics by means of formation of cohered abrasives

We have previously developed the technology to reduce the use of CeO_2 abrasives [1]. However, from another point of view, this paper describes the improved polishing performance of glass by using the ZrO_2 abrasives with several types of additives and chemical medicines to reduce the use of CeO_2 abrasives.

2 Increasing effective abrasives using cohering phenomenon of ZrO_2 slurries with chemical medicines.

A series of tests have performed to investigated the polishing characteristics of abrasives with CeO_2 and ZrO_2 abrasives. Figure 1 shows the test results of removal rate and surface roughness of CeO_2 and ZrO_2 abrasives. In order to improve the polishing characteristics of ZrO_2 abrasives, we proposed light-cohesion phenomenon among the abrasives to increase the numeber of effective abrasives as shown in figure 2. The authors examined the pH dependence of zeta-potential and mean diameter of the ZrO_2 abrasives with the pH value. Figure 3 shows the cohesion region of ZrO_2 abrasives starts from pH 4 to pH5.5. However the pH value of ZrO_2 abrasives slurry was around 7. Therefore, two types of chemical medicine, acetic acid (CH_3COOH) and ferrous sulfate ($FeSO_4$) , were prepared to adjust the pH value of ZrO_2 slurry. The slurry of ZrO_2 abrasives was adjusted as pH4.5 with the chemical medicines and figure 4 shows the polishing test results of the glass work. For the comparison, the results of polishing characteristics of CeO_2 and ZrO_2 slurries were also displayed in the figure 4. From the figure 4, in case of adjusted by $FeSO_4$, the polishing characteristics were improved remarkably compared with ZrO_2 abrasives only. However, in case of adjusted by CH_3COOH, the surface roughness of work was bad

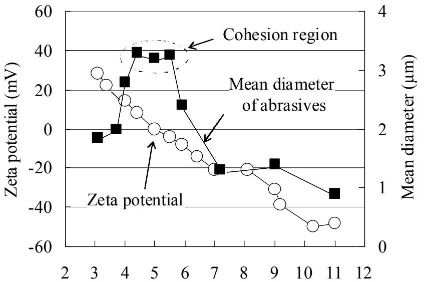

Fig.3 Change of zeta potential and mean diameter of ZrO_2 abrasives with pH value

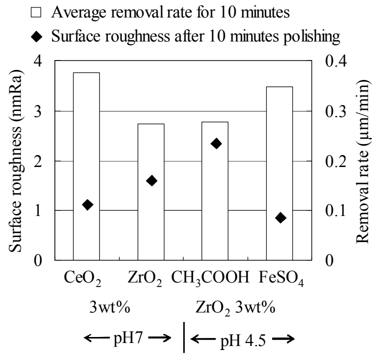

Fig.4 Polishing characteristics in addition of CH_3COOH and $FeSO_4$ to ZrO_2 abrasives

compared with ZrO_2 abrasives only. Because the CH_3COOH is a sort of acid, it is considered that CH_3COOH might be ocurred interaction to the glass as an etchant. From these results, it confirmed that by adjusting the pH value to the cohesion region of ZrO_2 abrasives to increas effective abrasives with a mild chemical medicine such as $FeSO_4$, the polishing characteristics of work could be improved.

3 Improvement for the polishing characteristics with heavy additives in ZrO_2 abrasives slurry

To increase effective abrasives on polisging pad as the stagnation state during process, we examined adding the heavier metal oxides than those of ZrO_2 abrasives as additives. The additives disturbed and limited the behavior of escape quickly from the polishing pad of ZrO_2 abrasives and then made the stagnation state which lead to increase the number of acting/effective abrasives during processing. Figure 5 shows the image of the role of the heavier additives in the slurry. The authors have examined the physical properties between the particle size and the specific gravity compare with the ZrO_2 abrasives. The physical properties ZrO_2 are specific gravity 5.4 and the mean diameter of abrasives 1.3μm repectively. From the reason, the heavier metal oxides than those of ZrO_2 abrasives were provided such as copper oxide (CuO: specific gravity 6.3, mean diameter of particles 3.2μm), nickel oxide (NiO: specific gravity 6.7, mean diameter of particles 1.4μm), silver oxide (AgO: specific gravity 7.1, mean diameter of particles 1.1μm), and tungsten oxide (WO_3: specific gravity 7.2, mean diameter of particles 0.7μm). Figure 6 shows a series of

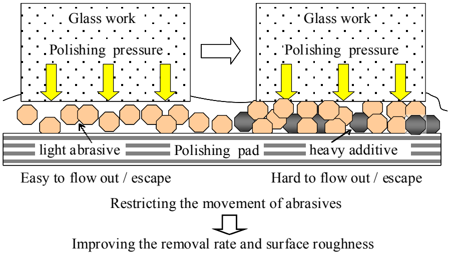

Fig.5 Schematic of improving the polishing characteristics adding the heavy additives

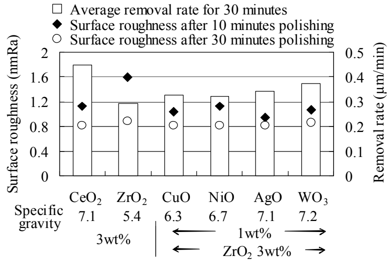

Fig.6 Polishing characteristics with heavy metal oxide additives using ZrO_2 abrasives

tests results by adding the heavier metal oxides as additives. From the figure 6, it confirmed that by adding the heavier metal oxides than those of ZrO_2 abrasives as additives, the polishing characteristics improved compared with ZrO_2 abrasives only.

4 Conclusion

Alternative abrasives of CeO_2 abrasives were developed with ZrO_2 abrasives. And in order to improve the polishing characteristics for the glass, we suggested to increase the effective abrasives on the polishing pad during processing. By using cohering phenomenon of ZrO_2 abrasives and adding heavier metal oxides than those of ZrO_2 abrasives as additives, the polishing characteristics were improved. From these results, it confirmed the possibility of alternative abrasives of CeO_2 abrasives and to reduce the use of CeO_2 abrasives for the glass polishing.

5 Acknowledgement

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[1] J. Murata, Y. Tani, M. Yamada, T. Yanagihara, N. Nomura, R. Hirokawa, Y. Zang and O. Kirino, "Development of composite abrasives and epoxy resin polishing pads to reduce the use of CeO_2 abrasives in glass polishing", Proc. of 11th Int. Conf. of EUSPEN (2011), 11(2), pp. 136-139.