Development of Novel CMP Abrasives with Nano-dispersed Microstructure for Glass Precise Polishing by Spray Pyrolysis

Koichi Kawahara¹, Seiichi Suda², Toshimasa Suzuki¹

¹Materials Research and Development Laboratory, Japan Fine Ceramics Center, Nagoya, 456-8587, Japan
²Department of Engineering, Shizuoka University, Hamamatsu 432-8561, Japan

Glass precise polishing is one of the important technology, because precisely polished glasses are widely used for HDD substrates and flat panel displays. Generally, the glasses with extremely smooth surface less than 1 nm in Ra are achieved by chemical mechanical polishing (CMP) using ceria-based abrasives. During polishing process, glass surface would be softened by chemical reaction with abrasives, then mechanically removed by the abrasives. Ozawa et al. have reported that the trivalent cation doping in ceria would enhance the chemical reactivity with glasses[1], so that La doped commercial ceria-based abrasives are considered to have both adequate chemical reactivity and suitable mechanical strength. Therefore, the high performance CMP abrasives should have both chemical reactivity and mechanical strength.

In this study, in order to develop high performance CMP abrasives for glass precisely polishing, glass polishing properties were studied using the composite particles with paying particular attention to a synergetic effect of two materials. One is the material which has high chemical reactivity with glasses and the other is the material which has suitable mechanical strength. SrZrO₃ is considered to have relatively high chemical reactivity with glasses[2], thus, we focused on polishing properties of SrZrO₃/ZrO₂[2] and SrZrO₃/CeO₂ composite abrasives.

The polishing properties are well-known to be affected not only by material composition but also by the particle shape and size. Thus, we synthesized different abrasive particles with almost the same morphology by spray pyrolysis technique.

Figure 1 shows SEM images of synthesized abrasives of SrZrO₃/CeO₂ composite particles. The particle shape and size was found to be almost the same, irrespective of composition. The primary grain size was less than 100 nm except for pure CeO₂, indicating that the synthesized particles were nano-composite particles.

Figure 2 shows (a) removal rate and (b) surface roughness as a function of SrZrO₃/CeO₂ composition rate. The removal rate increased with increasing the SrZrO₃ rates up to the composition rate of 30 mol%, then the removal rate decreased with further increasing SrZrO₃ rate of 70 mol%. On the other hand, the surface roughness of polished glasses decreased with increasing SrZrO₃ rates up to SrZrO₃ rate of 30 mol%, then the surface roughness increased with further increasing SrZrO₃ more than 70 mol%. These results indicated that SrZrO₃/CeO₂ nano-composite abrasives showed a synergetic effect because the removal rate of CeO₂ and SrZrO₃ were lower than that of composite abrasives, and the surface roughness of CeO₂ and SrZrO₃ were larger than that of composite abrasives. Furthermore, experimental results indicated that the optimum composition rates of SrZrO₃/CeO₂ composite abrasives would be 30 – 70 mol% SrZrO₃. Using these composition rate, the removal rates were almost comparable to commercial ceria abrasives with La doping. Furthermore, smoother
polishing surface was obtained by using SrZrO$_3$/CeO$_2$ composite abrasives with 30 – 70 mol% SrZrO$_3$ composition rates than the polishing surface using commercial ceria-based abrasives.

Acknowledgement: This work was supported by New Energy and Industrial Technology Development Organization (NEDO), Japan as part of the Rare Metal Substitute Materials Development Project.

References


Fig. 1. SEM images of CeO$_2$/SrZrO$_3$ composite particles synthesized by spray pyrolysis technique, and particle size and primary grain size measured from SEM images.

Fig. 2. Removal rate (a) and surface roughness as a function of SrZrO$_3$/CeO$_2$ composition rate.