Microstructure Evolution in Alumina during Two-Step Pulsed Electric Current Sintering

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Highlights

- Densification and grain growth are affected by heating rate even in two-step PECS.
- Faster heating rate causes faster grain growth.
- Decrease in grain size occurs at the middle point of sintering.

1. Introduction

Heating schedule as well as heating rate has strong influences for sintering behavior in pulsed electric current sintering (PECS). In order to produce transparent polycrystalline alumina with fine grain size, PECS with two-step heating schedule, two-step PECS, is proposed [1]. Microstructure evolution during two-step PECS is also affected by heating rate. Faster heating rate leads to larger grain size. Effects of two-step heating schedule and heating rate during PECS should be studied for understanding sintering mechanism of alumna to obtain higher transparency. In the present study, microstructure evolution of alumina during two-step PECS was investigated.

2. Methods

A commercial α-Al_2O_3 powder (TM-DAR, Taimei Chemical Co.) was sintered by two-step PECS under 100 MPa with the heating schedule shown in Fig. 1. A graphite die with 70 mm in outer diameter, 30.4 mm in inner diameter and 80 mm in height was used with a graphite sheet with 0.2 mm in thickness to be inserted between die/punch and sample. In each stop point, bulk density and grain size were measured.

3. Results and discussion

Figure 2 shows density and gran size change in the central part of sample. With progressing sintering process, bulk density is increased. At Stop 4, bulk density with 100ºC/min is higher than that with 10ºC/min. Figure 3 shows average grain size in the central part of sintered alumina at each stop point. In the early stages in TS-PECS, Stop 1 and 2, grain size with 100ºC/min is higher than that with 10ºC/min. After Stop 3, grain sizes at 100ºC/min are higher than these of 10ºC/min. Faster heating rate leads to faster grain growth. This phenomenon is caused by dynamic grain growth mechanism. Note that grain size at Stop 4 at 10ºC/min is smaller than that at Stop 3. Bulk density is increased from 76% at Stop 3 to 94% at Stop 4. These stop points correspond to the intermediate stage of densification. Stress around the neck parts between particles is much higher than apparent pressure during PECS. The decrease in grain size may be caused by dynamic recrystallization during pressure sintering.

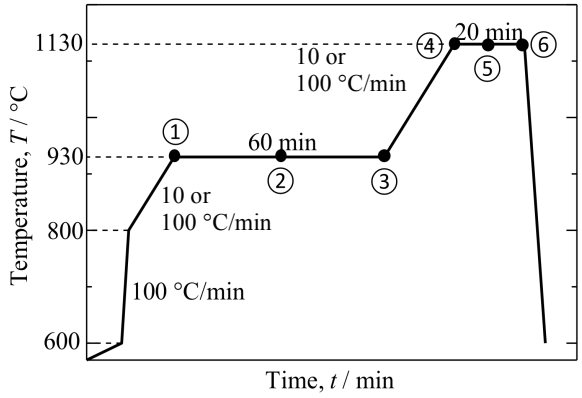

Figure 1. Heating profile of two-step PECS in the present study.

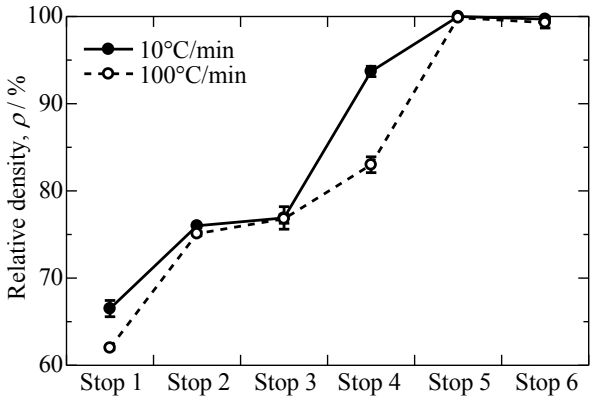

Figure 2. Bulk density of sintered alumina at each stop point.

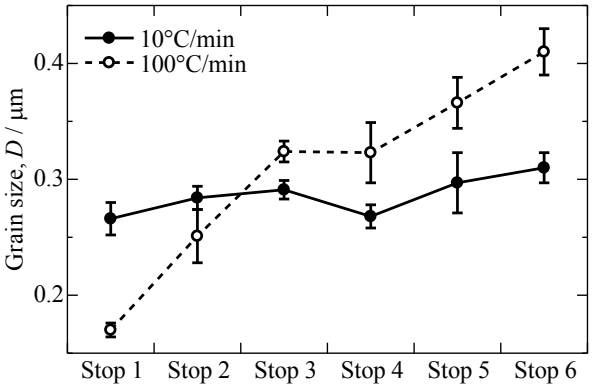

Figure 3. Grain size in the central part of sintered alumina at each stop point.

4. Conclusions

Bulk density and average grain size in the central part were investigated in two-step pulsed electric current sintering of alumina. Even in two-step pulsed electric current sintering, heating rate affects densification and microstructure evolution. Faster heating rate leads to faster grain growth. At slower heating rate, 10ºC/min, decrease in average grain size was observed in the intermediate stage of sintering.

References

[1] M. Nanko and K. Q. Dang, Adv. Appl. Ceram.,113 (2014) 80-84.

Keywords
two-step PECS, heating rate, alumina, grain size