GRAIN GROWTH BEHAVIOR DURING SPARK PLASMA SINTERING OF CERAMICS

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During sintering, most of densification process proceeds in the intermediate stage where channel-like open pores and large isolated pores shrink by the movement of particles or grains towards the pores. The grain rearrangement without significant shape change, one of the characteristics of sintering, is a result of the grain-boundary sliding which is the most important mechanism for high-temperature deformation, such as superplastic deformation. The grain-boundary sliding is an essential process during densification.

During spark plasma sintering of alumina, the effects of heating rate, pressure and loading schedule on the grain size were examined. Usually, high heating rates results in small grain sizes because of short heating time. However, when alumina was densified at low temperatures, high heating rates accelerated grain growth, though the total heating time was reduced. The grain growth rate after full densification was also accelerated for high heating rates. The accelerated grain growth might result from the generation of defects during densification. The densification in the intermediate stage of sintering includes the deformation of powder particles, and the deformation occurs mainly by grain-boundary sliding or grain re-arrangement. The defects generated during grain-boundary sliding may enhance the grain-boundary mobility and accelerate the grain growth rate, that is the dynamic grain growth. It is considered, therefore, that the high deformation rate at high heating rates accelerated grain growth during sintering.

The accelerated grain growth also appeared for high-pressure sintering. The grain size after sintering increased with the applied pressure. High pressures lowered the deformation temperature and increased the deformation rate. As a result, the high deformation rate during heating may generate defects and enhance the grain-boundary mobility. Lastly, the loading schedule during heating also affected the deformation and the grain growth. Applying pressure at low temperatures or at high rates may generate more defects and resultantly accelerate the grain growth. These unusual grain growth behaviors during spark plasma sintering are explained by using a concept of dynamic grain growth [1]. Hence, one of our conclusions is that the deformation of grain-boundary sliding plays an important role in both densification and grain growth during sintering.

[1] BN Kim et al., Scripta Mater., 80 (2014) 29.