

Sintering of oxides: the significant impact of carbon on densification kinetics

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Advanced manufacturing processes for ceramics, such as non-conventional sintering techniques and additive manufacturing, frequently introduce carbonaceous contamination into oxide-based samples. In this study, we investigate how carbon affects the densification kinetics of Al_2O_3 and Y_2O_3 -stabilized ZrO_2 ceramics, focusing on both the underlying mechanisms and the quantitative impact. The impact of carbon on the densification of these oxide ceramics through both free sintering and Spark Plasma Sintering (SPS) is discussed. While carbon's influence may be limited in pressure-assisted densification processes, its effect is significant in pressureless sintering. In fact, it can delay consolidation by hundreds of degrees Celsius, resulting in a reduction in the consolidation rate by several orders of magnitude. This suggests that carbon adsorption on the oxide surface significantly decreases the driving force for densification - specifically the surface excess energy. This conclusion is further supported by the observation that, when sintering is driven by an external force (such as uniaxial pressure in SPS), the influence of carbon is significantly reduced. Beyond densification, microstructural features, such as grain growth, are also impacted. These findings are particularly relevant in light of the increasing prevalence of carbon sources in ceramic processing, including additive manufacturing with high binder volumes and the use of unconventional sintering tools.

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