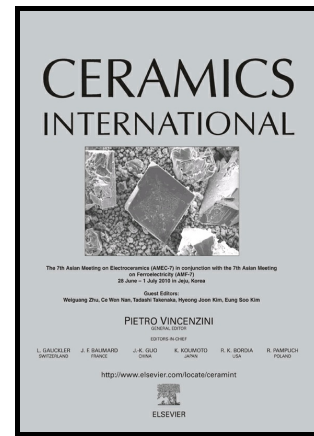


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In-situ observation of oxygen mobility and abnormal lattice expansion in ceria during flash sintering

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Abstract

Flash sintering has been shown to be an effective method of sintering for many types of ceramics. However, the characteristics of flash sintering for each type of ceramic varies. When ionically conducting ceramics are sintered under a DC electric field, a strong dependence of densification with respect to position is observed. Microstructural analysis of the effect of electric field on oxygen ion conductors shows non-stoichiometry (oxygen deficiency) at the cathode which continues to build up over time under flash. In oxygen ion conductors, dominant charge carriers during flash are oxygen ions and the final density of the specimen is related to the availability of oxygen. This effect is no longer evident when using an AC power supply. Thus, use of AC instead of DC electric field is preferable for flash sintering of ionically conducting ceramics.

Introduction

Sintering is the prime method in manufacturing ceramic components, wherein powders are compacted and heated to a suitably high temperature for solid state diffusion of particles along the grain boundaries, which results in densification. Although sintering polycrystalline materials has provided a cheaper alternative to single crystal ceramics at the expense of somewhat deteriorated properties, it is still a slow and energy intensive process. In addition, problems arise due to grain growth, chemical decomposition, and impurity segregation, among other issues. Many methods of sintering, such as spark plasma sintering (SPS), hot pressing (HP), and microwave sintering (MW) were developed to alleviate these problems. Flash sintering is one of the latest sintering techniques, [1] which lowers the sintering temperature and enhances the kinetics of densification. A wide range of ceramic materials, including insulators and high dielectric materials [2-8], semiconductors [9-15], electronic conductors [16] and ionic conductors [1, 16-25] have been sintered using this technique. The enhanced kinetics at lower temperatures have given rise to a debate about the mechanism(s) responsible for flash sintering. Recent papers have proposed mechanisms such as local Joule heating [26-31], pore migration [27, 32, 33], liquid phase sintering [34-36], fast heating rates [37, 38] and defect generation [2, 3, 39-47].

Flash sintering has found applications in co-sintering of composites [18, 39, 40, 42, 48-53] and difficult-to-sinter ceramics [54-58]. While presently studied ceramics seem to make the transition into the flash state at comparable electrical power densities of 10 – 50 W/cm³ [44], it is notable that the contribution

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