Hidehiro Yoshida et al., Madridge J Nanotechnol Nanosci. 2017
http://dx.doi.org/10.18689/2638-2075.a2.002

Field-assisted and flash-sintering of yttria ceramics: Grain boundary nanostructure and mass transport phenomena

Hidehiro Yoshida[1,2], **Koji Morita**[1], **Byung-Nam Kim**[1], **Yoshio Sakka**[1] and **Takahisa Yamamoto**[3]
[1]National Institute for Materials Science, Japan
[2]Tokyo University of Science, Japan
[3]Nagoya University, Japan

Electric field-assisted sintering (FAST) is gaining interest in recent years due to the accelerated consolidation compared to conventional, pressure less sintering. In particular, flash-sintering, where densification occurs almost immediately (typically <5 seconds) under high DC electric field, has attracted extensive attention as an innovative sintering technique. The flash-sintering has been demonstrated in various ceramics, and nearly full density has been achieved at relatively low furnace temperature for very short time.

Y_2O_3 has special chemical and physical properties such as high resistance to halogen-plasma corrosion and thermal stability, and is therefore known as a promising environment-resistant or optical material. However, Y_2O_3 is difficult to sinter. Dense, polycrystalline Y_2O_3 ceramics have been developed by pressure less sintering in vacuum or hydrogen atmosphere at high temperature (typically >1600°C), by hot press sintering, and by hot isostatic pressing process.We have demonstrated that high-purity, undoped Y_2O_3 can be fully densified by pulsed electric current-assisted sintering; ECAS (or spark plasma sintering; SPS), where a green compact is directly heated by pulsed DC electric current under compressive stress, at a sintering temperature of around 1000°C. Translucent Y_2O_3 with a relative density of 99% was produced by ECAS at a sintering temperature of 1050°C under a compressive stress of 80MPa. In addition, transparent Y_2O_3 polycrystals have been obtained by ECAS technique with a combination of sintering temperature and compressive stress of 1050°C-300MPa or 1300°C-100MPa. More recently, almost instantaneous and full densification can be achieved in Y_2O_3 by flash-sintering, where densification occurs in a few seconds under a threshold condition of temperature and applied field. For instance, full densification is achieved at 1133°C under a field of 500 V/cm. The single-phase nature of ECASed and flash-sintered Y_2O_3bodies was confirmed by high-resolution transmission electron microscopy (HRTEM). The FAST and flash-sintering techniques are very effective to produce dense Y_2O_3 ceramics at relatively low sintering temperatures and short sintering times. It is postulated that densification and grain growth were enhanced by accelerated solid-state diffusion, resulting from both Joule heating and the generation of defects under the applied field. The present paper aims to briefly summarize the recent results on the densification of Y_2O_3 through the electric current/field-assisted sintering, and to discuss the effect of electric field/current on the grain boundary nanostructure and mass transport in Y_2O_3.

Biography:

Hidehiro Yoshida is a principal researcher in the National Institute for Materials Science (NIMS), and also serves as a visiting associate professor at Department of Materials Science and Technology, Tokyo University of Science. He received his doctoral degree in material science in 2001 from The University of Tokyo; the doctoral thesis dealt with high temperature creep resistance of ceramics. His research addresses high temperature mass transport phenomena such as sintering, creep deformation, super plasticity, ionic conduction, and phase-transformation in structural/functional oxide ceramics. Special attention is placed on the relationship between the high temperature mass transport and grain boundary nanostructure. His research achievements cover a broad range of topics, from scholarly research to practical application of engineering ceramics. He has also contributed to the field of geoscience; superplastic flow and microstructural development in the earth's mantle.