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Observations on Flash Sintering of Uranium Dioxide

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The recent prioritization on development of nuclear fuels with enhanced accident tolerance has led the community to consider fuel systems that offer improvements in certain performance characteristics such as fission gas retention, oxidation resistance and thermal conduction. Advanced fuels being studied for enhanced accident tolerance often have unique characteristics that make conventional sintering routes undesirable for or incapable of yielding the required fuel pellet characteristics. For illustration, UO_2-composite fuels with second phases for increased thermal conductivity, such as SiC, can have deleterious reactions with the UO_2 fuel above operating temperatures but below temperatures required to sinter a high quality fuel pellet. In such cases, field assisted sintering techniques can enable these compositions to be considered for application as nuclear fuel in addition to offering more efficient and economical fuel pellet fabrication.

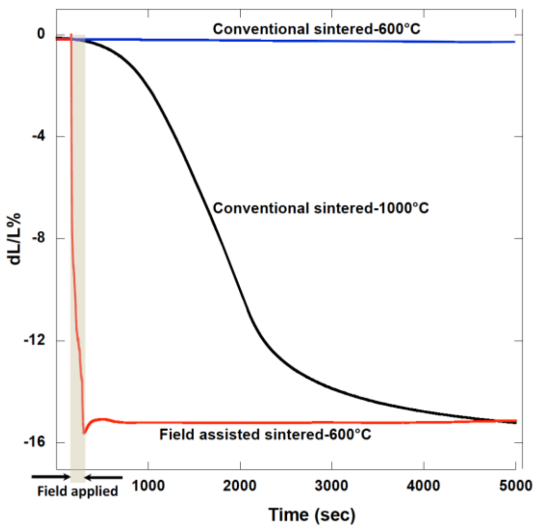

Figure 1 – Sintering strain (dL/L$_o$%) obtained from $UO_{2.16}$ comparing flash sintering at 600°C to conventional sintering at 600°C and 1000°C. Samples were sintered under gettered argon.

As indicated above, urania-based composite fuels are being considered for these enhanced fuels, and field assisted sintering, particularly spark plasma sintering, has been used recently to both process UO_2 and UO_2-SiC [1] fuel pellets and as a method to fabricate UO_2 with volatile fission products [2]. As a potential approach to employ the benefits of field assisted sintering for "enhanced UO_2" while mitigating changes from the existing nuclear fuel fabrication infrastructure, we have examined flash sintering in UO_2 and UO_2-UB_x composites with second-phase contents up to ~10 vol%.

Early studies on uranium dioxide showed that flash sintering of cylindrical compacts resulting in relative densities as high as 94% could be achieved in seconds as opposed to several hours at temperatures hundreds of degrees lower than necessary under conventional sintering (Fig. 1). The critical parameters governing flash sintering of urania were examined, such as, oxygen-to-metal ratio, applied field, temperature, current and hold times. The flash event was observed in hyperstoichiometric urania at room temperature with applied fields as low as 25 V/cm with incubation times of several minutes.

Results of the parametric studies will be presented along with early data from in-situ x-ray diffraction studies. The role of electric field on defect behavior in this semiconducting compound will be discussed.

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