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Flash sintering of stoichiometric and hyper-stoichiometric urania.

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Abstract

Flash sintering (FS), a novel fabrication technique belonging to the family of field assisted sintering (FAS) techniques, has been utilized in this study to fabricate uranium dioxide (UO_2) pellets. Stoichiometric ($UO_{2.00}$) and hyper-stoichiometric ($UO_{2.16}$) pellets were flash sintered at 600°C within a few (2-3) minutes. This is in sharp contrast to conventional sintering where temperatures hundreds of degrees higher are necessary and the sintering time extends to hours. Relating this in terms of the homologous temperature ratio (T_H) for both conditions shows that in the case of flash sintering at 600°C, T_H=0.3 versus T_H=0.6 for conventional sintering at 1600°C. The highest density achieved for a $UO_{2.00}$ pellet was 81% theoretical density (TD) when flash sintered at 600°C for 184 seconds at a field of 188 V/cm and a current density of 442 mA/mm^2. For the $UO_{2.16}$ pellet, the highest achieved density was 92% TD when flash sintered at 600°C for 140 seconds at a field of 188 V/cm and a current density of 632 mA/mm^2. X-ray diffraction (XRD) characterization of the sintered pellets showed the final sintered material to be single cubic fluorite phase. Scanning electron microscopy (SEM) of longitudinal sections revealed non-uniform microstructures with regions of high density where the grain size ranged from 1-15 µm. Comparisons between conventionally and flash sintered pellets that achieved equivalent shrinkage strains were also conducted. In all cases, the flash sintered pellets achieved similar densification to the conventionally sintered pellets at much lower furnace temperatures and shorter times.

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1. Introduction

Field assisted sintering (FAS) techniques describe a group of novel sintering methods that use electric field and/or current to provide powder densification in very short time periods (minutes compared to hours) and at lower temperatures compared to conventional sintering [1]. Spark plasma sintering (SPS) [2]–[6] and flash sintering (FS) [7]–[20] are FAS methods that have received a lot of attention in recent years due to their potential significant economic impact. SPS uses a combination of temperature, pressure, and electric current to sinter powder compacts at lower temperatures and at shorter times but with better mechanical properties. In SPS, powder is loaded into a graphite die and heated by a