INVESTIGATION OF THE MECHANISMS OF FLASH SINTERING IN CERAMIC MATERIALS

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Flash Sintering (FS) has been the subject of intense study by the ceramics community in recent years. Discovered by Cologna, Rishi Raj, et al. in 2010, flash sintering utilizes the non-equilibrium rise in current under applied electric field to densify ceramic green body compacts in seconds. The model materials used in this study were ZnO, TiO_2, and CeO_2 as they are simple binary oxides which avoids the complication of atomic segregation of multi-cation compositions such as 3 and 8 mol% yttria stabilized zirconia (3YSZ and 8YSZ). This work, which analyzes the proposed mechanisms for the onset of the flash, the cause of the enhanced sintering kinetics during FS, and the temperature approximation methods used as supporting evidence for each theory, will be presented. A series of TiO_2 ceramics, manufactured at Rutgers FS Laboratory at stage III Steady State, compressed to greater than 10% strain in room temperature (RT) without noticeable crack formation. The mechanisms and evidence for each have been explored in depth by a serious of publications including a Science Advances paper. In situ micropillar compression tests, developed by our Purdue Collaborators, show that FS TiO_2 exhibits unexpected substantial plasticity at RT. The high-density of preexisting defects and O vacancies introduced during the non-equilibrium flash-sintering process facilitates the nucleation of dislocations will be also discussed. In situ Synchrotron studies of FS nano-B_4C demonstrates an anomalous lattice expansion accompanied by a maximum current draw with an increase in density of 99%. Applications of the B_4C ceramics in this flash sintering processing, exhibiting small grain size including, but not limited to ballistic armor will be discussed. The effectiveness of the flash sintering method, which relies on the understanding of the conductivity mechanism for several oxide and non-oxide ceramics, will be shown.