Flash Sintering of 3YSZ scaffolds

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Flash Sintering (FS) is a novel technique that utilizes electric fields to assist sintering, combining short processing times and reduced energy consumption. This approach facilitates rapid densification of ceramic materials within seconds. A noteworthy pathway for exploring FS involves its application to 3D-printed porous structures, such as scaffolds. In this study, we present the application of FS to 3 mol% yttria-stabilized zirconia (3YSZ) scaffolds fabricated using direct ink writing (DIW) for potential biomedical applications. The scaffolds, with dimensions of 9 mm x 9 mm x 6 mm, were printed using an ink formulated with poly(ethylene glycol) (PEG-400) and 7.5% (w/w) Laponite® nanoclay as a rheological modifier, containing 70% (v/v) solid loading. DIW parameters encompassed 20 layers, a nozzle diameter of 0.58 mm, and a printing speed of 15 mm/s. Thermal debinding at 800 ºC for 2 hours was employed to remove the sacrificial ink. Subsequently, FS was applied employing an electric field of 80 V/cm and a current density of 150 mA/mm². Rheological properties of the ink were analyzed to assess its printability. Moreover, scaffold morphology was investigated across flat, radial, and core surfaces. Results highlighted the shear-thinning behavior of the inks, aligning well with the demands of the DIW process. Initial investigations indicated that the scaffolds exhibited typical behavior observed in FS experiments, characterized by a rapid increase in current density and significant shrinkage. Statistical analyses revealed no statistically significant differences among scaffold regions, indicating a high level of grain size homogeneity. Furthermore, the scaffold structure exhibited notable porosity, featuring interconnected pores. These findings underscore the potential of FS for producing porous networks, which hold promise in various biomaterial applications.