3D PRINTED CERAMICS STRUCTURES - CHALLENGES AND APPLICATIONS

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In contrast to the conventional material used in additive manufacturing, ceramics provide beneficial features at high temperature such as hardness and rigidity, as well as electrical and magnetic properties that made them attractive systems for a wide range of applications. However, ceramics also present a number of limitations including ductility, shock resistance, and dimensional tolerance when compared to polymers and metals. The 3D printing process of ceramic materials remains a challenging procedure given their difficulty of manufacturing dense parts while avoiding cracking and delamination, especially during the post-thermal sintering process. Several 3D printing technologies have been used to manufacture ceramics, however, vat photopolymerization and binder jetting remain the two main processes to manufacture ceramic structures. The present work addresses the structure-property relationship of 3D printed ceramics materials using binder jetting. The influence of particle size, spread speed, binder saturation, layer thickness and sintering temperature have been investigated and related to the mechanical performance of the manufactured ceramics (see figure 1). This research program also addresses the work performed on a NanoJetting and a Digital Light Processing (DLP) technology to produce a wide range of ceramic materials ranging from zirconia systems used on electromagnetic platforms to electrode-based materials for batteries such as $LiFePO_4$ (see figure 1). Here, the challenges associated with their printing and sintering stages will be discussed. Indeed, it seems that whilst long sintering cycles and slow heating ramp represent an effective procedure to ensure mechanically robust structures; in several cases, especially on ceramic materials for battery applications, a balance between the mechanical and electrochemical performance needs to be assessed in terms of the post-thermal treatment to guarantee successful electrical features.

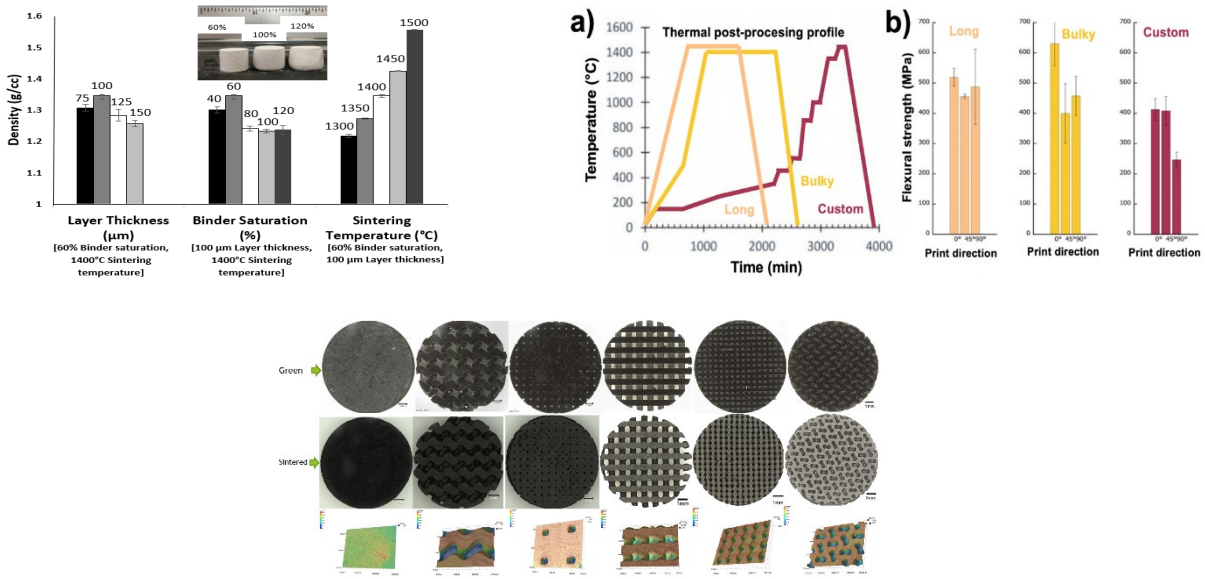

Figure 1 –Top Left: Effect of printing parameters and sintered temperature on the density of sintered ceramics using a BJ Process. Top Right: Sintering study of a NanoJetted 3D printed zirconia ceramic - (a) thermal post-processing profiles; and (b) effect of the sintering profile on the sintered flexural strength. Bottom: 3D printed ceramic electrodes in their green and sintered state for battery applications.