Flash sintering of carbides and borides

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Flash sintering was officially discovered about fifteen years ago as a ground-breaking method to consolidate ceramics in very short time at temperature much lower than that used for conventional sintering. Since then, it has been applied to several ceramics and composites with the common feature to be characterized by a negative temperature coefficient (NTC) for resistivity while few attempts have been made on materials with metal-like electronic conduction like hard ceramics, i.e. borides and carbides.
WC, ZrB_2 and ZrC commercial powders were used in the present work. Flash sintering experiments were carried out using a custom-made apparatus operating in lab air, which allowed to control the applied pressure and voltage, temperature and displacement. The obtained materials were characterized from a physical, structural and mechanical point of view.
Tungsten carbide, zirconium diboride (and their composites) and zirconium carbide can be successfully flash sintered by using optimized processing conditions in very short time (less than a minute). Final microstructure, density and mechanical properties (like hardness and fracture toughness) depend on three fundamental processing parameters like surface chemistry of the starting powder, applied pressure and voltage.
Sintering behaviour is correlated with a thermal runaway phenomenon generated by the extrinsic NTC behaviour of the powder compact at the beginning of the process although the considered materials are intrinsically PTC (positive temperature coefficient for resistivity) like metals. Surface chemistry of the starting powder and pressure have a fundamental role in the densification behaviour since they determine the initial electrical resistance of the powder compact and, therefore, influence the power which is initially dissipated in the material to activate the diffusional phenomena necessary for sintering.
The results of the present work greatly expand the potentiality of flash sintering as an efficient, low-energy intensity process for electrically conductive materials and, especially, hard ceramics.