Spring 3-6-2016

Flash sintering of covalent non–oxide ceramics at low temperatures with low DC electric fields: An in situ EDXRD study by synchrotron probe

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The fundamental purpose in Functional Ceramics Technology is to obtain 100% dense polycrystalline covalent nonoxide ceramics with grain size <100 nm at lowest temperature and shortest time. We report a new method of utilizing a low applied electric field on nano/ micro B_4C powder at low temperature <1000 ^oC so as to obtain a properly sintered ceramics. Also as to obtain a fully with small grain size. The applied electric field helps to reduce the sintering temperature by at least a factor 0.33. The time frames involved are measured in minutes/seconds and not in tens of hours/days. We will focus on the B4C system. However, other nonoxide ceramics nanocomposites such as ZrB_2, TiB_2, Si_3N_4, SiC, BN and their combinations will be reviewed. We will also present results of an in situ time- resolved EDXRD study, using synchrotron radiation of 200 keV photons, as a function of electric field and temperature whereby the flash sintered nano-B_4C particulate system shows an anomalous lattice expansion accompanied by a maximum current draw with an increase in density up to 99%. The effectiveness of the sintering method which relies on the understanding of the conductivity mechanism of non-oxide ceramics will be also discussed. Applications of the B_4C ceramics in this flash sintering processing exhibiting small grain size including but not limited to ballistic armor will be shown.

We will present an in-situ synchrotron diffraction, impedance analysis, and thermally stimulated currents so as to probe the phenomenological landscape pertaining to anomalous mass transport under simultaneous electric and thermal fields which is the core phenomena associated with burst mode densification (BMD) which is also known as flash sintering. This presentation will include results on which builds upon the prior success in the in situ energy dispersive x-ray diffraction work using a synchrotron probe on materials such as yttria doped zirconia (Y_2O_3-ZrO_2), barium titanate ($BaTiO_3$), zirconium diboride (ZrB_2) and boron carbide (B_4C) in which the authors of this proposal discovered anomalous lattice expansion associated with high diffusion rates under superimposed thermal and electric fields –the fundamental boundary conditions in burst mode densification of ceramics.