FIELD ASSISTED MATERIAL ENGINEERING (FAME)

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In order to further improve the energy saving of Spark Plasma Sintering we have developed a very rapid sintering technique called Flash SPS (FSPS) with heating rates in the order of 10^4-10^5 °C/minute[1]. Unlike the Flash Sintering based on high voltage (≈100V), FSPS is based on low voltage (≈10V) and it can be up-scaled to samples volumes of several tens of cubic centimetres. Flash SPS allows densification of metallic conductors like ZrB_2 and HfB_2, under a discharge time as short as 20-30 seconds. FSPS of semiconductors like silicon carbide and boron carbide was also demonstrated. Highly customized and versatile equipment with ultrafast responsive controls and programmable bipolar power supplies (up to 20 kHz, 1 MA, 500V) has been built. The developed methodology has been applied to produce FSPSed samples even larger than 6 cm in diameter of ultra refractory materials. Understanding the intrinsic electrical field role in the triangle properties-microstructure-processing remains one our primary scientific goal and the main open question. We tried to give some answers by approaching the problem at different length scales (see figure 1) by developing dedicated equipment/controls, simulations (FEM and ab-initio), thermo-kinetic analysis, in situ observations and accurate temperature measurements/calibrations.

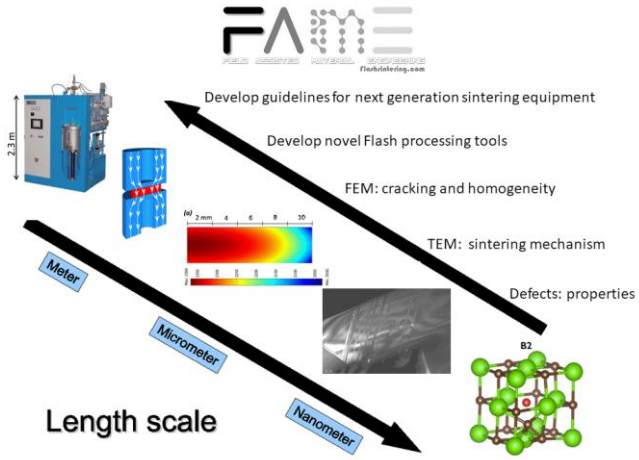

Figure 1 – Proposed Multiscale approach

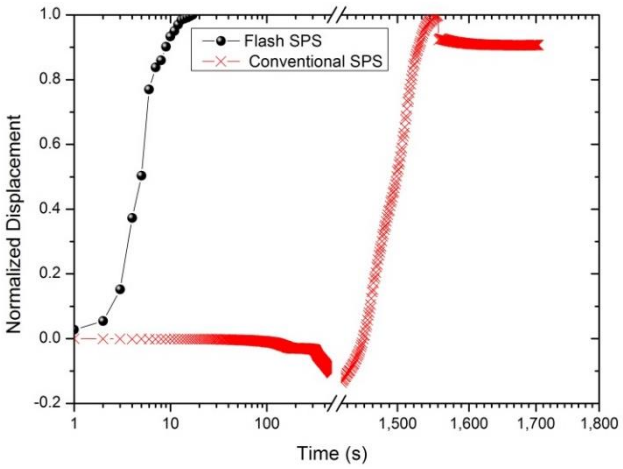

Figure 2 –Comparison of normalized displacement (SiC, Φ 20mm) as function of time for Flash and Conventional SPS

References

[1] S. Grasso, T. Saunders, H. Porwal, O. Cedillos-Barraza, D.D. Jayaseelan, W.E. Lee, M.J. Reece, Flash spark plasma sintering (FSPS) of pure ZrB2, J. Am. Ceram. Soc. 97 (2014) 2405–2408. doi:10.1111/jace.13109.

[2] M. Yu, S. Grasso, R. Mckinnon, T. Saunders, M.J. Reece, Review of flash sintering: materials, mechanisms and modelling, Adv. Appl. Ceram. 116 (2017) 24–60. doi:10.1080/17436753.2016.1251051.