ULTRA-FAST HIGH TEMPERATURE SINTERING (UHS) OF STRONTIUM TITANATE

Martin Bram, Forschungszentrum Jülich GmbH, Institute of Energy and Climate Research, IEK-1: Materials Synthesis and Processing, Germany
m.bram@fz-juelich.de
Tarini Prasad Mishra, Forschungszentrum Jülich GmbH, Institute IEK-1
Shufan Wang, RWTH Aachen University, Institute for Materials Applications in Mechanical Engineering (IWM), 52062 Aachen, Germany
Christian Lenser, Forschungszentrum Jülich GmbH, Institute IEK-1
Dylan Jennings, Forschungszentrum Jülich GmbH, Institute IEK-1
Moritz Kindelmann, Forschungszentrum Jülich GmbH, Institute IEK-1
Wolfgang Rheinheimer, Forschungszentrum Jülich GmbH, Institute IEK-1
Christoph Broeckmann, RWTH Aachen University, Institute IWM
Olivier Guillon, Forschungszentrum Jülich GmbH, Institute IEK-1

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Recently, ultra-fast high-temperature sintering (UHS) has been introduced as novel fast sintering method. UHS enables rapid densification of ceramic materials within seconds [1]. Therefore, green compacts are placed between thin strips of carbon felt, which are then heated by direct current. Joule heating of the stripes enables extremely high heating rates beyond 10^4 K/min. In the present work, strontium titanate and 2 mol. % iron doped strontium titanate were used as model materials for systematically studying the relationship between UHS parameters and resulting properties [2]. Similar to other fast sintering technologies, exact control and measurement of temperature and the occurrence of larger temperature gradients remain challenging. Therefore, FEM modelling was conducted to estimate the temperature distribution of setup and sample. FEM model was validated by thermocouple, pyrometer and melt phase formation at predicted temperatures. Figure 1 exemplarily shows the temperature distribution of the used setup (carbon stripe 80 x 10 x 4 mm heated by DC current varying between 5 and 24 A). A special focus was to investigate the influence of the applied current on degree of densification and resulting grain size. For both materials, rapid densification of small samples (diameter 8 mm, height 1 mm) within 10 s was demonstrated successfully. In the case of undoped strontium titanate, exaggerated grain growth in combination with the formation of isolated pores was observed. The addition of 2 mol. % iron helped to limit the grain growth and therefore enabled a more uniform densification and grain growth. On the other hand, these samples were more susceptible to cracking, especially at higher currents. Segregation of cations at grain boundaries was analysed by scanning transmission electron microscopy/energy disperse x-ray spectroscopy (STEM/EDS). Electrical performance of both materials was demonstrated by impedance spectroscopy. A comparison of the conductivity of UHS sintered and conventionally sintered samples did not show remarkable differences.

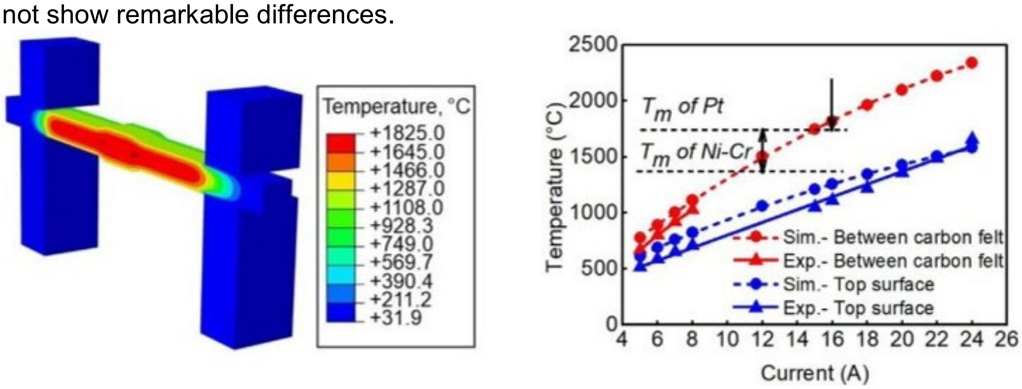

Figure 1: Temperature distribution of UHS setup used in this study [2]. Comparison of FEM modelling with temperature measurement by thermocouple K (up to 1100°C), by melting NiCr and Pt wires (T_m = 1420°C and 1768°C) and by pyrometer (300 – 2500°C).

[1] C. Wang et al., Science 368 (2020) 521 – 526.
[2] T. Prasad Mishra et al., Acta Mat. 231 (2022) 117918.