Evidence for joule heating during flash sintering of 8YSZ

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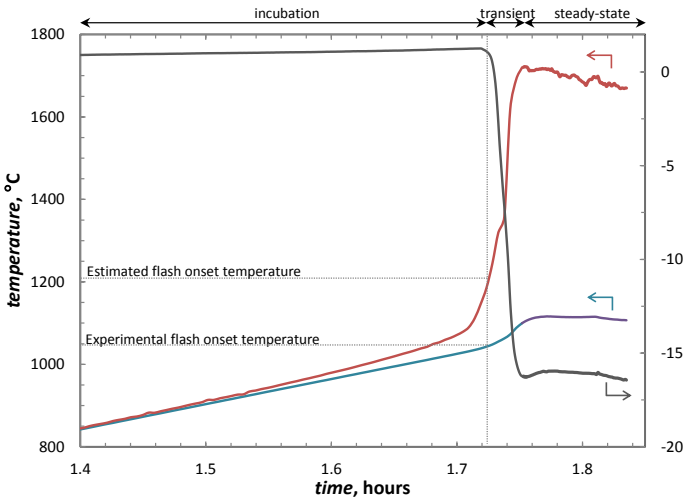
This work describes a systematic study of samples obtained by flash and conventional sintering, and provides evidence for temperature-driven flash sintering process, accounting for otherwise interpreted as abnormal behavior. The study was made using 8%-Yttria-doped Zirconia as reference materialand under low flash conditions (50 V/cm) to avoid external current-limiting control.

Firstly, we compared the microstructural evolutions of during interrupted flash and conventional sintering cycles. SEM characterization shows similar trends for average grain size, porosity levels and distribution in both processes. Impedance spectroscopy shows that bulk and grain boundary conduction follow are identical, regardless of the processing route.



Furnace (blue) and estimated sample temperature (red) during shrinkage of a flash sintered 8YS sample.

Secondly, samples were prepared flash sintering samples with different initial relative density. The conductivity was measured as a function of relative density between 150 and 600 °C. Results were used to derive a scaling-law for flash sintering, which expresses sample conductivity versus temperature, corrected for instantaneous densification during sintering. This model replicates the signature current runaway during flash sintering which has been associated with unconventional sintering mechanisms.

Finally, we estimate sample temperature from the black body radiation equation. Using the estimated temperature instead of the furnace temperature in the shrinkage, powder dissipation and conductivity plots, eliminates any abnormal sample behavior typically regarded as evidence for unconventional sintering mechanisms [1,2].

We describe all the characteristic features of flash sintering (non-linear conductivity, lower sintering temperature and temperature kinetics) based on the interdependence of conductivity, densification and sample self-heating through joule effect [3]. Results apply equally well to previously published data, both in isothermal or constant heating conditions.

[1]Naik, K. S.et al.*J. Eur. Ceram. Soc.***34,** 4063–4067 (2014)
[2] Narayan, J. *Scr. Mater.***69,** 107–111 (2013)
[3] Todd, R. I. *J. Eur. Ceram. Soc.***35,** 1865–1877 (2015)