Electric Field Assisted Sintering of Oxide Ceramics: Fields Matter!

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Sintering as a consolidation, densification and coarsening process depends on numerous different intrinsic and extrinsic factors: materials composition, particle size distribution and morphology, temperature programme (heating rate, maximum temperature, dwell time), atmosphere, pressure, microstructure of the green body, etc.

The use of external electric fields offers additional degree of freedom to accelerate densification and taylor microstructure. In order to use their full potential, systematic investigations under well-controlled experimental conditions are required.

Taking the example of doped ceria, sintering parameters required for continuum mechanical modeling are significantly affected by very moderate fields without the generation of macroscopic Joule heating in the sample. For example, the decrease in viscous Poisson's ratio observed with fields is correlated to a clear decrease in shear viscosity, which can be attributed to an easier grain boundary sliding.

In addition, by increasing the amplitude of the electric field, transition to flash sintering is correlated with the generation of n-type electronic conductivity in air under direct-current bias. Its origin is attributed to partial reduction of the material which propagates from the cathodic-to-anodic region. When using AC fields, frequency needs to be taken into account, leading to different kinetics compared to DC fields. Current-rate flash sintering with controlled power leads to a uniform density and grain size. Such strategies are required in order to get homogeneous microstructure and high-quality parts of large dimensions on the way to industrial production.