A SHORT REVIEW OF FS MECHANISMS

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The current views on flash sintering (FS) will be reviewed with focus on mechanism research [1]. The mechanism of FS has been under debate since its discovery and three main mechanisms were suggested: defect nucleation, Joule heating runaway and electrochemical reactions. We believe that thermal runaway is essential for FS initiation; by calculating the thermal runaway of the green body, the onset temperature can be predicted. Since sintering under AC stimulus was achieved, electrochemical reactions can account for FS only if breaking the symmetry is dealt with. Symmetry breaking is indeed possible due to imperfect contacts and uneven kinetics of, e.g., redox reactions at different facets in oxides. The effect of electrode material on threshold conditions and of electrochemical reactions on the final microstructure were also discovered.
The work done in our group showing that the FS onset conditions of highly Fe doped strontium titanate change under different pO2, unties the link between flash onset and ionic defect concentrations [2]. However, the influence of charged defects and of electrode materials on the flash process and threshold conditions cannot be ignored. Clear evidence for the nucleation of a new phase using in-situ XRD analysis was also shown.
Further research to unveil all the effects affecting all stages of FS and their relations is needed. The evidence for a formation of a new phase during the flash found by Raj group might be connected to formation of a softened / liquid phase. Moreover, since phase transition limits temperature rise, it might account for the low temperatures measured using in-situ XRD. Lastly, since both liquid formation and electrochemical reactions are a trigger for thermal runaway, we believe that all the suggested mechanisms are linked. Further research for discovering proof of liquid formation and electrode effects will shed light on the triggers of thermal runaway thus solving the problem of FS mechanism. Stages II and III of the flash are yet to be understood, with currently clear hints toward the importance of point defects and of huge temperature gradients.

[1] M.Z. Becker, N. Shomrat, and Y. Tsur, Recent Advances in Mechanism Research and Methods for Electric-Field-Assisted Sintering of Ceramics, Advanced Materials, 1706369 (2018)
[2] N. Shomrat, E. Dor, S. Baltianski, and Y. Tsur, The influence of doping on flash sintering conditions in $SrTi_{1-x}Fe_xO_{3-\delta}$, Journal of the European Ceramic Society, 37, 179-188, (2017).