High temperature plastic deformation in oxide ceramics accelerated under electric field and current: the origin and related phenomena

Hidehiro Yoshida
Department of Materials Science and Engineering, The University of Tokyo, Japan
Next Generation Zirconia Social Cooperation Program, The University of Tokyo, Japan

In the field of ceramic processing, R. Raj's group has recently developed significant technology of electric field-assisted sintering, particularly flash sintering. Flash sintering is the technique that allows almost immediate densification under a threshold condition of external electric field strength and ambient temperature [1]. The accelerated sintering densification in ceramics indicates that atomic diffusion is highly enhanced under the onset of flash event under the threshold condition. It is therefore expected that the acceleration in the atomic mass transport under an electric field may facilitate high temperature plastic deformation in ceramics. In fact, H. Conrad's group demonstrated in their pioneering experiments that external strong electric field can improve high-temperature ductility of structural ceramics [2]. Our group has recently found that high temperature tensile deformation with the nominal strain of beyond 100% can be achieved in Y_2O_3-stabilized tetragonal ZrO_2 polycrystals (TZP) at ambient temperatures below 1000°C and strain rates above 10^{-3} s^{-1} under the occurrence of flash event [3]. High temperature three-point flexural test with carefully controlled DC current has revealed that the electric field and current under flash event athermally accelerates grain boundary sliding in TZP [4]. In the seminar, our recent results on the acceleration in the high temperature plastic flow and mass transport phenomena in TZP and other ceramic materials under electric field and current will be summarized.

References

[1] M. Cologna, B. Rashkova, R. Raj, *J. Am. Ceram. Soc.*, **93** (2010) 3556.
[2] D. Yang, H. Conrad, *Scripta Mater.*, **36** (1997) 1431.
[3] H. Yoshida, Y. Sasaki, *Scripta Mater.*, **146** (2018) 173.
[4] H. Motomura, D. Tamao, K. Nambu, H. Masuda, H. Yoshida, *J. Eur. Ceram. Soc.*, **42** (2022) 5045.