Modification of Grain Boundary Core Structures by Applied Electric Fields

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Electric field assisted sintering, which includes spark plasma sintering and flash sintering, has demonstrated that the application of electric fields during materials processing can lead to accelerated densification and modified grain growth behavior. In many applications the application of electric fields at high sintering temperatures leads to additional Joule heating, which directly enhances mass transport. The mechanistic effects of electrostatic fields on densification and grain growth in the absence of any current flow remain unclear.

In this study we report initial in-situ TEM experiments that demonstrate enhanced densification of Yttrium-stabilized ZrO_2 at reduced sintering temperatures as a result of applied electric fields. A custom-built experimental geometry was employed to enable the application of temperatures as high as 900ºC while simultaneously applying non-contacting electrostatic fields across powder compacts.

The second half of the presentation will review a systematic study of electric field effects on grain boundary core structures of (100) twist grain boundaries in $SrTiO_3$. Grain boundaries diffusion bonded in the presence of an applied electrostatic field strength of nominally 20 V/cm show an abrupt and atomically structured interface with an interface expansion of 0.43±0.03 nm. In the absence of an applied electric field, however, the grain boundary core structure revealed a width of 0.89 ± 0.13 nm. An increase of the applied field strength to 170V/cm retained the cationic structure of the grain boundary core, but caused an apparent disordering of oxygen vacancies in the vicinity of the grain boundary plane. Experimental observations will be discussed with respect to the ability of potential “complexion transitions” due to applied electrostatic fields.

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