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Meeting-report

Characterization of Anisotropic Electric Field Effects on Grain Boundary Structures in Oxide Ceramics

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The application of electric fields during sintering can enhance densification in non-conducting ceramics [1] and may alter grain growth behavior [2,3]. Using in-situ TEM Majidi and van Benthem [4] have directly imaged enhanced densification of ZrO2 nanoparticle agglomerates in the presence of electric fields with no observable current flow. While densification and grain growth are governed by grain boundaries, the mechanisms how externally applied electric fields alter grain boundary structures and local bonding configurations remain mostly unexplored.

Using dedicated bicrystal experiments we have recently demonstrated that electric fields directed across grain boundary planes can alter the interfacial width, i.e., the atomic and electronic structures of (100) twist grain boundaries in $SrTiO_3$ [5]. EELS experiments have revealed modifications of the oxygen vacancy configurations within the grain boundary cores. Increasing field strengths have caused anion disordering in the vicinity of the grain boundary core structures (see Fig. 1).

During separate thermal annealing experiments electric fields were applied along the planes of the same grain boundary. STEM characterization has demonstrated grain boundary expansions around 0.8nm near the positive electrode while the interface width decreased to around 0.4nm close to the negative electrode. For a sufficiently high field strength interface decomposition was observed. EELS and XPS experiments revealed oxygen sublattice distortions close to the negative electrode and enhanced concentrations of Ti^{3+} and Ti^{2+} compared to the bulk. The results are interpreted by oxygen migration along the grain boundary plane due to the applied electric field [6].

Recent experiments have focused on the application of electric fields during thermal annealing of (100) tilt grain boundaries in $SrTiO_3$. Preliminary experimental results indicate anisotropic electric field effects on grain boundary core structures, depending on the direction of the electric field within the grain boundary plane. Results from HAADF STEM imaging and EELS experiments will be discussed during the presentation [7].

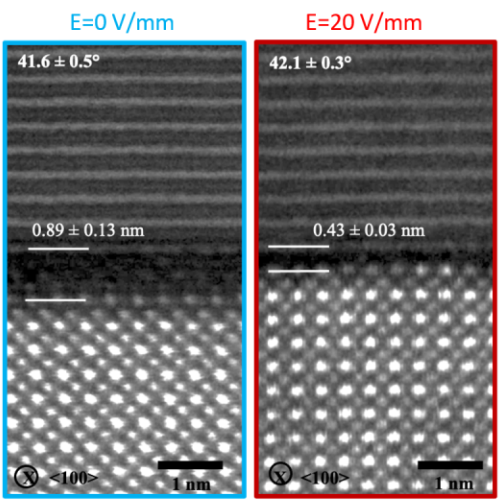

Fig. 1. HAADF-STEM imaging of (100) twist grain boundaries in $SrTiO_3$ that were formed by diffusion bonding during the application of the indicated nominal electric field strength (adapted with permission from [5].

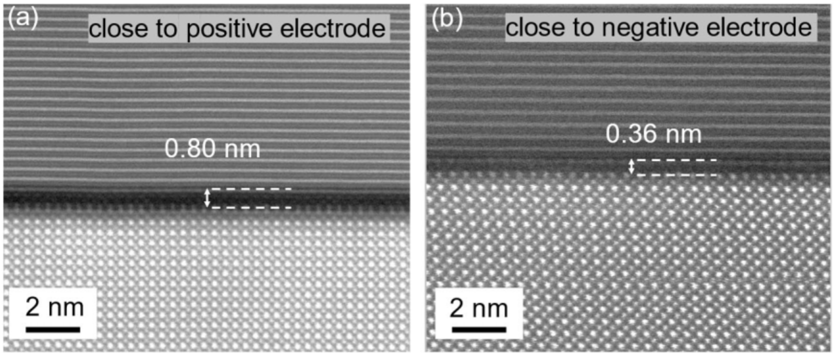

Fig. 2. HAADF-STEM images recorded from the same (100) twist grain boundary in $SrTiO_3$ after annealing with the field directed along the grain boundary plane. (adapted with permission from [6]).

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