In situ TEM study of the electric field-induced phenomena in ferroelectric ceramics

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Ferroelectric oxides are responsive to both electrical and mechanical stimuli and have found wide applications in capacitors, transducers, actuators, and random-access-memories. In most practical applications, these ceramics are subjected to strong electric fields. This presentation will be focusing on several field-induced phenomena in ferroelectric ceramics directly observed at the nanometer scale for the first time using a unique *in situ* TEM technique. These include the polarization switching in nanometer-sized ferroelectric domains and the grain boundary cavitation in a commercial lead zirconate titanate (PZT) polycrystalline ceramic, the domain wall fracture in a $Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$ single crystal, the transformation of incommensurate modulations in $Pb_{0.99}Nb_{0.02}[(Zr_{1-x}Sn_x)_{1-y}Ti_y]_{0.98}O_3$ (PZST100x/100y/2) polycrystalline ceramics, and the interactions between the polar nanoregions and the cation ordering nanodomains in $Pb(Mg_{1/3}Nb_{2/3})O_3$-based relaxor ferroelectrics. In the PZT ceramic, a cavitation process was uncovered for the electric field-induced intergranular fracture. In the ferroelectric single crystal, a preexisting crack was observed to deflect and to follow a 90° domain wall, indicating the presence of severe incompatible piezoelectric strains at the domain wall. In the antiferroelectric PNZST ceramics where incommensurate modulations in the form of Pb-cation transverse displacement wave were commonly observed, the electric field-induced antiferroelectric-to-ferroelectric phase transformation was found to be accompanied with the disappearance of incommensurate modulations.