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Abstract

A series of ferroelectric ceramic models with grain and grain-boundary structures of different sizes are established via Voronoi tessellations. The relation between the electric displacement and electric field and the hysteresis loop are calculated using a finite element method based on a classical and modified hyperbolic tangent model via COMSOL Multiphysics. The results indicate that as the grain size decreases, the dielectric strength is enhanced, but the dielectric permittivity is reduced. The discharge energy density and energy storage efficiency of these ferroelectric ceramics extracted from the as-calculated hysteresis both increase along with a decrease in their grain size at their breakdown points. However, under the same applied electric field, the ferroelectric ceramic with a smaller grain size possesses a lower discharge energy density but a higher energy storage efficiency. The results suggest that ferroelectric ceramics with smaller grain sizes possess advantages for applications in energy storage devices.

Figures used in the abstract

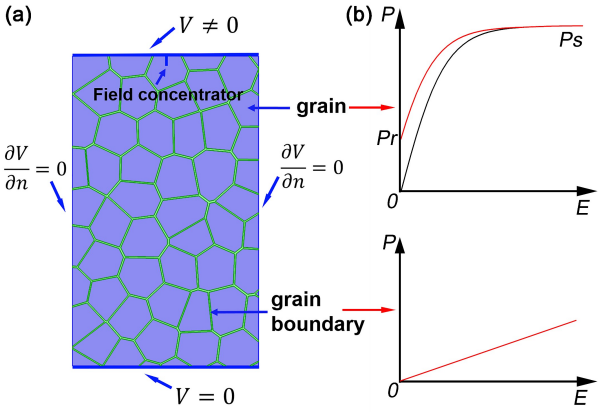

Figure 1: Schematic of (a) the loading setup for the computational domain in the finite element model and (b) the polarization response of the ferroelectric ceramic grain and grain boundary. In polarization response illustration of the ferroelectric ceramic grain. The up-branch (red curve) represents the discharging process and the down-branch (black curve) represents the charge process.