# Domain switching model embedded on scaled boundary finite element method for nonlinear hysteretic behavior of ferroelectrics

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## Abstract

The piezoelectric behavior of ferroelectric ceramics is widely applied in electromechanical stack actuator devices. The complex behavioral study of piezoelectric polycrystal-based devices is as critical as when this applies to an electromechanically coupled scenario. This complex behavior of polycrystalline ferroelectrics for higher electromechanical loads stems from the underlying microscopic domain switching. The advanced finite element method contributes to understanding the domain switching phenomenon happening micromechanically. Voronoi polygons adopted for obtaining intergrain effects of the piezo-polycrystal are introduced by assigning different material properties to each grain. Each ferroelectric grain is represented by a naturally evolving random Voronoi polygon with all possible domain variants during the numerical implementation.

A micromechanical model embedded in an advanced numerical framework, the scaled boundary finite element method, as applied to Voronoi-based discretization of the two-dimensional ferroelectric plane, is presented in this work. This existing study exhibits the application of the scaled boundary finite element method in conjunction with a two-dimensional micromechanical model to analyze the non-linear ferroelectric behavior of the polycrystalline material. The advantage of this method is to evaluate the solution of the classic hysteresis and butterfly response of a piezoelectric material semi-analytically when situated in a high electric field and stress application. The butterfly strain responses and the hysteresis polarization responses of ferroelectrics under various electromechanical loading conditions are simulated and compared with the experimental observations. Additionally, the polarization rotation test performed by the proposed finite element method matches empirically, which profoundly exposes the effect of switching domains by which rotating the spontaneous polarisation at various angles.