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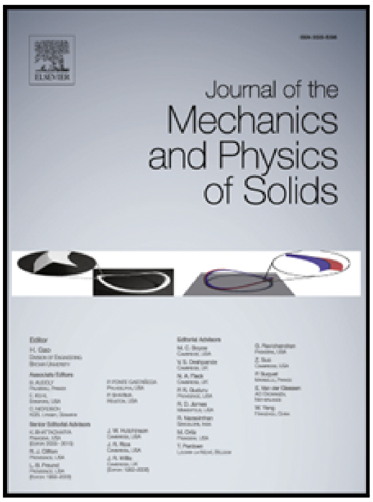

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Simulation of ~~mechanical and electrical~~ fatigue damage in ferroelectric polycrystals under mechanical/electrical loading

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Abstract

The reliability of smart-structures made of ferroelectric ceramics is essentially reduced by the formation of cracks under the action of external electrical and/or mechanical loading. In the current research a numerical model for low-cycle fatigue in ferroelectric mesostructures is proposed. In the finite element simulations a combination of two user element routines is utilized. The first one is used to model a micromechanical ferroelectric domain switching behavior inside the grains. The second one is used to simulate fatigue damage of grain boundaries by a cohesive zone model (EMCCZM) based on an electromechanical cyclic traction-separation law (TSL). For numerical simulations a scanning electron microscope image of the ceramic's grain structure was digitalized and meshed. The response of this mesostructure to cyclic electrical or mechanical loading is systematically analyzed. As a result of the simulations, the distribution of electric potential, field, displacement and polarization as well as mechanical stresses and deformations inside the grains are obtained. At the grain boundaries, the formation and evolution of damage are analyzed until final failure and induced degradation of electric permittivity. It is found that the proposed model correctly mimics polycrystalline behavior during poling processes and progressive damage under cyclic electromechanical loading.

To the authors' knowledge, it is the first model and numerical analysis of ferroelectric polycrystals taking into account both domain reorientation and cohesive modeling of intergranular fracture. It can help to understand failure mechanisms taking place in ferroelectrics during fatigue processes.

Keywords: ferroelectric polycrystal, fracture mechanics, domain switching, electromechanical cohesive zone model, finite element method

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