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FEM CALCULATIONS OF CRACK GROWTH PATTERNS IN FERROELECTRIC MULTILAYER ACTUATORS BASED ON A CONTINUUM DAMAGE MODEL

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Ferroelectric materials as components of smart structures are widely used in e.g. actuators, acoustic sensors as well as in airfoil control systems. The mechanics of these materials is based on irreversible nonlinear effects such as polarization switching [1]. These switching processes are accompanied by internal stresses due to the strain incompatibility between neighboring grains, which results in damage and thus a significant variation of the material properties [2]. That means that a comprehensive ferroelectric material model should consider fracture and damage mechanical approaches. Besides that, the long term reliability of smart structures requires the application of numerical tools predicting crack initiation and growth under electromechanical loading conditions. In this paper we present a damage model for ferroelectric materials. It is implemented in terms of a user element in a commercial FEM-code Abaqus. The model is based on micromechanical considerations of domain switching and its interaction with microcrack growth and coalescence. We demonstrate the influence of damage evolution on the effective material properties. Further, a finite element analysis of a multilayer actuator is performed, showing damage and crack patterns which are in accordance with experimental observations.

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