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PROCEEDINGS

Phase Field Modeling of Coupling Evolution of Polarization, Fracture and Dielectric Breakdown in Ferroelectric Materials

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ABSTRACT

Ferroelectric materials have been widely used in various electromechanical devices such as sensors, actuators, transducers and energy storage devices due to their distinguished electromechanical coupling properties. Ferroelectric materials usually bear large mechanical loads and high electric fields in order to give full play to their potential. The interaction between fracture and dielectric breakdown is able to occur since the filler inside a crack will change the dielectric behaviors around it and dielectric breakdown can change the local mechanical properties of dielectric materials because of its weakening of chemical bonds. Therefore, a comprehensive and in-depth understanding of the fracture and dielectric breakdown behavior of ferroelectric materials and their interaction is very important for the advanced and reliable application of ferroelectric materials. A phase field model was developed to investigate the coupling evolution behavior of polarization, fracture and dielectric breakdown in ferroelectric materials subjected to both mechanical and electrical loadings. Driving forces for fracture and dielectric breakdown were analysed based on the generalized configurational forces. The phase field simulations showed that dielectric breakdown can be induced by the concentrated electric field at impermeable crack tips. At the same time, the dielectric breakdown can influence the stress distribution around the crack tip as well as the driving force for crack propagation. The attraction of fracture to breakdown path and the deflection of breakdown to fracture path were observed during the coupling evolution of fracture and breakdown. The developed model framework can be employed to investigate more complex coupling failure behaviours of ferroelectric and dielectric materials.

KEYWORDS

Ferroelectrics; fracture; dielectric breakdown; domain switching; phase field model

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