Non-Linear Finite Element Modeling of Partially Electroded Actuators

By

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Abstract

Ceramic piezoelectric materials are widely used in multilayer stacked actuators. These actuators utilize multiple stacked piezoelectric layers that are relatively thin, compared to the overall actuator size. This configuration considerably reduces the voltage needed for actuation and often employs electrodes which terminate inside the piezoelectric material in order to enable connections to alternate layers and to reduce manufacturing costs. A strain incompatibility between the active and inactive regions and a large corresponding stress gradient in the immediate vicinity of the electrode edge often leads to component failure. Cracking can occur in these brittle materials when an electric field is applied, depending on the magnitude of the tensile stresses present and the mechanical properties of the material. Accurately predicting material response in these regions is vital to the design of reliable components.

A custom finite element program that utilizes a micromechanics-based ferroelectric constitutive law which displays the properties of ferroelectric and ferroelastic behavior is used to analyze partially electroded piezoelectric ceramic plates subjected to voltage and mechanical boundary conditions. Non-linear FEM results are compared to linear ABAQUS simulations and previous experimental observations from various researchers.