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A Finite Element Framework for the Electromechanical Analysis of Dielectric Elastomers

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ABSTRACT

Dielectric elastomers (DEs) have been considered as the promising material for the transduction technology due to its capabilities in sustaining large deformation and electromechanical coupling properties. Recent advances in the constitutive modeling of DEs from the microstructure aspects is also accompanied by the increasing demands in the development of feasible numerical analysis approaches for the complex structures undergoing nonlinear deformation. In this proposed research, a finite-element (FE) framework is established to investigate the electromechanical responses of DEs by combining the nonlinear field theory with the micro-macro constitutive model. In addition, the underlying deformation mechanisms are also incorporated into the FE framework by introducing the deformation-dependent material viscosity. With the proposed FE framework, the electromechanical behaviors of DEs with various configurations are simulated by developing the user defined subroutines in Abaqus, and furthermore, the common instabilities including electromechanical instability (EMI), buckling, wrinkling, and crumpling are also investigated. The accuracy and robustness of the FE framework are validated by comparison with existing experimental data and analytical studies. This study is expected to function as a general platform for the simulation of electromechanical responses and prediction of instabilities of DE structures, and further can be utilized to provide guidance for the novel design and applications of DE based devices.