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Electro-mechanical modeling of dielectric viscoelastomers

Shuolun Wang[1] **and Shawn A. Chester**[2*]

[1] Mechanical Engineering, New Jersey Institute of Technology, 200 Central Ave, Newark, NJ 07102 USA, sw263@njit.edu

[2] Mechanical Engineering, New Jersey Institute of Technology, 200 Central Ave, Newark, NJ 07102 USA, shawn.a.chester@njit.edu

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Soft dielectrics are electrically-insulating elastomeric materials, which are capable of large deformation and electrical polarization, and are used as smart transducers for converting between mechanical and electrical energy. While much theoretical and computational modeling effort has gone into describing the ideal, time-independent behavior of these materials, viscoelasticity is a crucial component of the observed mechanical response and hence has a significant effect on electromechanical actuation. A constitutive theory and numerical modeling capability for dielectric viscoelastomers, able to describe electromechanical coupling, large-deformations, large-stretch chain-locking, and a time-dependent mechanical response is summarized [1, 2]. The model is calibrated to the widely-used soft dielectric VHB 4910, and the finite-element implementation of the model is used to study the role of viscoelasticity in instabilities in soft dielectrics, namely (1) the pull-in instability, (2) electrocreasing, (3) electrocavitation, and (4) wrinkling of a pretensioned three-dimensional diaphragm actuator. Our results show that viscoelastic effects delay the onset of instability under monotonic electrical loading and can even suppress instabilities under cyclic loading. Furthermore, quantitative agreement is obtained between experimentally measured and numerically simulated instability thresholds.

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