SIMULATION OF A FOLDED DIELECTRIC ELASTOMER ACTUATOR

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ABSTRACT

A powerful and lightweight, yet inexpensive electrostatic actuator can be fabricated by coating the surfaces of a thin dielectric elastomer and then folding it into many layers to produce a multi-layer stack of capacitors. This has been proposed and demonstrated by Federico Carpi *et al*. [1]. The elastomer ability to contract when subject to the electric field has many biomedical, automotive and aerospace applications. An interesting feature of an elastomer actuator is that its capacitance increases when voltage is applied. Due to the softness of the elastomer the electrostatic force compresses its thickness and increases its area due to lateral expansion produced by the Poisson effect . It also has a very long "stroke" compared to solid state actuators of less flexible materials. A strongly coupled structural-electrostatic simulation is required due to the large geometry changes during actuation and the increase in the electric field. Elastic strains up to 15% are typical in the elastomer. An accurate physical representation of the elastomer needs to account for the nonlinear hyperelastic constitutive equations, the effect of the constraints at the borders of the structure and fringe electric field. A singe coupled-field element can be used to represent all the nonlinear geometric and material properties, as well as coupled effects between the physics needed for the simulation of the elastomer. This provides ease of use, improved accuracy and performance of a tightly coupled solution. HPC is shown to provide a significant solution speed up. The presentation shows that a finite element model of a folded dielectric actuator using coupled-field elements can closely match the deformation and stress obtained by physical experiment. Once the simulation model has been calibrated to the experimental results, it becomes possible to confidently modify the design to improve the performance.

REFERENCE

[1] F. Carpi, C. Salaris and D. De Rossi, “Folded dielectric elastomer actuators,” Smart Materials & Structures, vol. 16, pp. 300-305 (2007)