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TAUT DOMAIN ANALYSIS OF TRANSVERSELY ISOTROPIC DIELECTRIC ELASTOMER MEMBRANES

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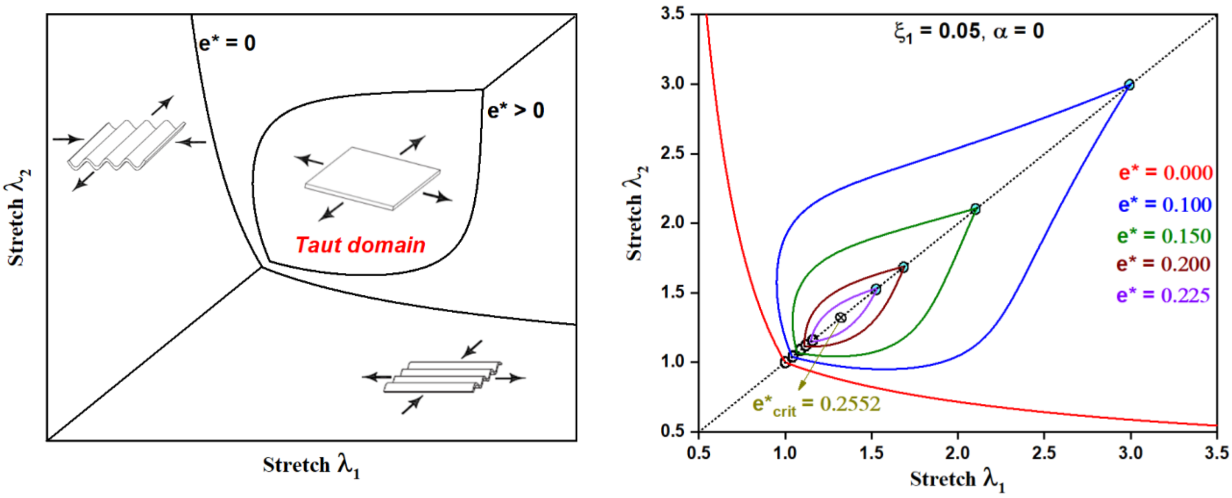
ABSTRACT

Actuation devices made of dielectric elastomers are prone to compression induced wrinkling instabilities, which can adversely affect their performance and may lead to device failure. On the other hand, wrinkles can be used constructively in certain applications demanding a controlled alternation of the surface morphology. The idea of taut states and the natural width under simple tension plays an important role in the analysis of compression generated instability (wrinkling). In case of electrically driven DE membranes, the domain of taut states in the plane of principal stretches is influenced substantially by the applied voltage and the film's constitutive properties. In the recent past, there has been an increasing interest in exploiting anisotropy in the material behavior of dielectric elastomers for improving their actuation performance. Spurred with these ongoing efforts, this paper presents a continuum mechanics-based electromechanical model for predicting the thresholds on the domain of taut states of transversely isotropic planar dielectric elastomers. The developed analytical framework uses an amended energy function that accounts for the electromechanical coupling for a class of incompressible transversely isotropic dielectric membranes. The required expressions for the total Cauchy stress tensor and the associated principal stress components are evaluated utilizing the amended energy function. Finally, the concept of natural width under simple tension is implemented to obtained the nonlinear coupled electromechanical equation that evaluates the associated taut states domain of the transversely isotropic planar dielectric elastomers.

Our results indicate that the extent of taut domain can be controlled by modifying the level and the principal direction of the transverse isotropy. The taut states domain for a particular level of applied electric field increases with increase in the anisotropy parameter, while the taut domains depleted with the increase in fiber orientations from 0^0 to 90^0 for an applied level of electrical loading.

The fiber-reinforced wrinkle-tunable surfaces can be effectively designed and developed using the underlying analytical framework and the trends obtained in this study.



(a) **(b)**

Fig: (a) Schematic representation of the taut state domain of an electrically activated dielectric elastomer membrane, (b) Evolution of the taut state domain of transversely isotropic DE membrane.

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