WRINKLES IN SOFT DIELECTRIC PLATES

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We investigate the instability of a dielectric plate subject to the combined action of electrical voltage and prestress, based on the nonlinear theory of electroelasticity and the associated linear incremental field theory. We show that a smooth giant voltage actuation of soft dielectric plates is not easily obtained in practice. In principle one can exploit, through pre-deformation, the snap-through behavior of their loading curve to deliver a large stretch prior to electric breakdown. However, we demonstrate here that even in this favorable scenario, the soft dielectric is likely to first encounter the plate wrinkling phenomenon, as modeled by the onset of small-amplitude sinusoidal perturbations on its faces. We derive the three-dimensional equations governing the linearized incremental motion superposed upon a finite deformation. We provide an explicit treatment of this incremental boundary value problem. We derive closed-form expressions for the two limit cases of very thin membranes (with vanishing thickness) and of thick plates (with thickness comparable to or greater than the wavelength of the perturbation). We perform numerical calculations for strain-stiffening Gent materials to illustrate the effect of the applied voltage on the instability of the plate.

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