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Study on the Voltage Induced Wrinkling of Elastomer with Different Electrode Areas

Authors : Zhende Hou, Fan Yang, Guoli Zhang

Abstract : Dielectric elastomer is a promising class of Electroactive polymers which can deform in response to an applied electric field. Comparing general smart material, the Dielectric elastomer is more compliance and can achieve higher energy density, which can be for diverse applications such as actuators, artificial muscles, soft robotics, and energy harvesters. The coupling of the Electroactive polymers and the electric field is that the elastomer is sandwiched between two compliant electrodes and when the electrodes are subjected to a voltage, the positive and negative charges on the two electrodes compress the polymer, so that the polymer reduces in thickness and expands in area. However, the pre-stretched dielectric elastomer film not only can achieve large electric-field induced deformation but also is prone to wrinkling, under the interaction of its own strain energy and the applied electric field energy. For a uniaxially pre-stretched dielectric elastomer film, the electrode area is an important parameter to the electric-field induced deformation and may also be a key factor affecting the film wrinkling. To determine and quantify the effect experimentally, VHB 9473 tapes were employed and compliant electrodes with different areas were pant on each of them. The tape was first tensed to a uniaxial stretch of 8. Then a DC voltage was applied to the electrodes and increased gradually until wrinkling occurred in the film. Then, the critical wrinkling voltages of the film with different electrode areas were obtained, and the wrinkle wavelengths were obtained simultaneously for analyzing the wrinkling characteristics. Experimental results indicate when the electrode area is smaller the wrinkling voltage is higher, and with the increases of electrode area, the wrinkling voltage decreases rapidly until a specific area. Beyond that, the wrinkling voltage becomes larger gradually with the increases of the area. While the wrinkle wavelength decreases gradually with the increase of voltage monotonically. That is, the relation between the critical wrinkling voltage and the electrode areas is U-shaped. Analysis believes that the film wrinkling is a kind of local effect, the interaction and the energy transfer between electrode region and non-electrode region have great influence on wrinkling. In the experiment, very thin copper wires are used as the electrode leads that just contact with the electrodes, which can avoid the stiffness of the leads affecting the wrinkling.

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