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NEW ACTUATION MODES OF DIELECTRIC ELASTOMER COMPOSITE DEVICES

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A Dielectric Elastomer (DE) actuator is usually shaped as a thin membrane with compliant electrodes painted on the two main opposite faces. Maxwell forces attract electrodes each other, resulting in a reduction of the thickness with an expansion of the in-plane area. However, the overall response also depends on the local effects induced by the polarization. Macroscopically, this is accounted for through a dependence of the dielectric constant on the current strain experienced by the material. In this case, the polymer is called electrostrictive [1,2]. A theoretical remarkable property of an electrostrictive actuator is that it can contract under a voltage stimulation. In our work, we show that such a property can be achieved with a tailored hierarchical dielectric composite whose phases obey an extended neo-Hookean strain energy with an ideal dielectric behaviour (i.e. dielectric constant independent of strain). The examples cover rank-1 and rank-2 laminated composites for which a semi-analytical solution is available [3]. In the presentation, we highlight the main design parameters that are necessary to manufacture an actuator displaying this property: shear modulus and dielectric constant ratios and angles of lamination. The effect of the layout in limiting, suppressing or promoting electromechanical instability is also presented. In some cases, where the instability is suppressed, the maximum in-plane stretch orthogonal to the laminae can increase considerably with respect to a homogeneous actuator, a property that can be anyway exploited for soft robotics applications. Our results demonstrate how to conceive hierarchical DE composite materials exhibiting counter-intuitive properties that can be exploited for the design of innovative actuators, sensors and energy harvesters.

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