Multiscale Advances in Electroelastomers for Energy-Efficient and Controllable Shape Transformation

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Abstract:

Dielectric elastomers (DEs) constitute an increasingly important category of electroactive polymers, a class of generally soft materials that, upon exposure to an electric stimulus, respond by changing size and/or shape. Derived from network-forming macromolecules, DEs are lightweight, robust and scalable, and they are furthermore capable of exhibiting giant electroactuation strains, high electromechanical efficiencies and relatively low strain-cycling hysteresis over a broad range of electric fields. Due primarily to their attractive electromechanical attributes, DEs are of growing interest in diverse biomedical, (micro)robotic, and analytical technologies. Since the seminal studies of these electroresponsive materials (initially fabricated mainly from chemically-crosslinked acrylic and silicone elastomers), advances in materials design over multiple length scales have resulted in not only improved electromechanical performance but also better mechanistic understanding. In this work, we first review the fundamental operating principles of DEs developed from conventional elastomers that undergo isotropic electroactuation and then consider more recent advances at different length scales. At the macroscale, incorporation of oriented fibers within elastomeric matrices is found to have a profound impact on electroactuation by promoting an anisotropic response. At the mesoscale, physically-crosslinked thermoplastic elastomer gel networks formed by midblock-swollen triblock copolymers provide a highly tunable alternative to chemically-crosslinked elastomers. At the nanoscale, the chemical synthesis of binetwork and bottlebrush elastomers permits extraordinarily enhanced electromechanical performance through targeted integration of inherently prestrained macromolecular networks.

Keywords: Dielectric elastomers, stimuli-responsive polymers, self-morphing materials

Relevant Image:

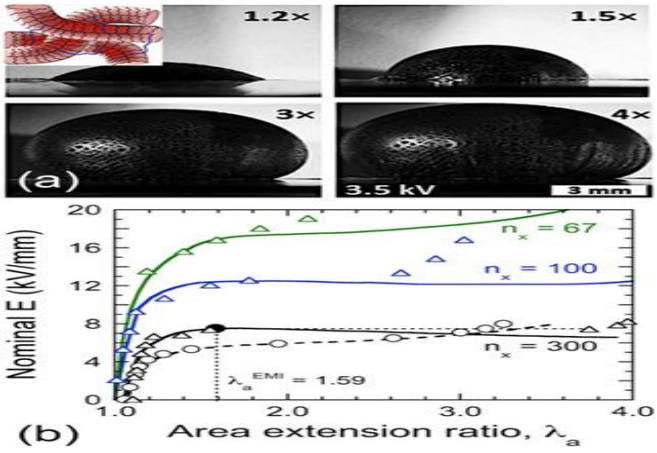

Figure 1. In (a), electroactuation of a siliconebottlebrush elastomers (BBEs) constrained in a diaphragm test configuration at different field strengths. A schematic illustration of BBEs is included in the inset. Extension ratios are provided in (b) for silicone BBEs with nx = 200 at two values of nsc: 14 (, solid line) and 28 (, dashed line). Included in (b) are results measured from BBEs with nsc = 14 at different values of nx (labeled and color-coded). Ref.: Vatankhah-Varnosfaderani, M. et al., Adv. Mater. 2017, 29, 1604209.

Biography:

Richard Spontak, a Distinguished Professor at NC State University, received his B.S. and Ph.D. degrees in Chemical Engineering from Penn State and UC Berkeley, respectively. He has >290 peer-reviewed journal publications and >35 book chapters and invited works, and his research has been featured on 30 journal covers and cited over 13,000 times. He has received numerous honors including the ACS Chemistry of Thermoplastic Elastomers Award, the IOM3 Colwyn Medal and the SPE International Award. He is a fellow of the American Physical Society and the Royal Society of Chemistry, and a member of the Norwegian Academy of Technological Sciences