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Design and development of (nano) structured electroactive polymers for improved performance in mechatronics

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As conventional energy sources dwindle and associated energy costs correspondingly rise, numerous efforts seek to develop lightweight materials that derive active functionality, especially stimuli responsiveness, from biologically inspired models for contemporary technologies involving (micro)robotic, microfluidic and haptic devices. Electroactive polymers (EaPs) constitute a growing class of synthetic macromolecules that likewise undergo a change in size and/or shape upon electrical stimulation. They are commonly classified as either electronic or ionic, depending on the mechanism of electroactuation, with the former further divided as either dielectric elastomers or ferroelectric (co)polymers. Of these, dielectric elastomers (D-EaPs) exhibit electromechanical attributes, e.g., high actuation strain, blocking stress and energy density that closely resemble those of mammalian skeletal muscle. The use of nanostructured polymers is shown to yield both electronic and ionic EaPs with vastly improved properties over unstructured polymers. One of the most challenging issues regarding the practical application of D-EaPs is their unsatisfactorily low actuation response at acceptably low electric fields. Here, we show that a simple, yet versatile, fiber-elastomer composite design, referred to as Anisotropic D-EaPs with Tunability (ADEPT), yields D-EaPs with vastly improved and directional actuation response. As fibrous systems resembling soft tissue, ADEPT composites are capable of achieving remarkably high actuation stresses and directional strains, as well as correspondingly high electromechanical coupling efficiencies and energy densities, at relatively low electric fields. Their electromechanical metrics are among the highest reported for this class of electroactive materials, thereby establishing that fiber-induced anisotropic electroactuation provides a more energy-efficient alternative to conventional isotropic D-EaP approaches.

Biography

Richard J Spontak is an Alumni Distinguished Professor of Chemical & Biomolecular Engineering and Materials Science & Engineering at NC State and the 2012 Lars Onsager Professor at NTNU in Norway. He earned his PhD from UC Berkeley and pursued post-doctoral studies at Cambridge University. For his research regarding soft materials, he received the American Chemical Society Cooperative Research and Thermoplastic Elastomers Awards, the German Society for Electron Microscopy Ernst Ruska Prize and the Institute of Materials, Minerals and Mining Colwyn Medal. He is an American Physical Society fellow he serves in 19 editorial boards and is an editor for 4 international journals.

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