

Inspiring Design of Soft Active Systems by Theory

Historically, design of physical systems is often inspired by theory, analysis and simulations. We present the design of a particular class of soft active system – dielectric elastomer, inspired by theoretical analyses. Dielectric elastomer consists of a thin membrane of polymer, sandwiched by compliant electrodes. Subject to an electric field, the membrane changes shape. When a mechanical force deforms a charged membrane, the electrical state is altered. The dielectric elastomer is hence an electromechanical system, transducing between mechanical and electrical states by electrostatics. A dielectric elastomer may be used as a soft actuator, a stretchable sensor and a stretchable generator. We describe the design of these systems starting from thermodynamic equations-of-state. Elegant methods to seek the maximum energy of conversion and maximum actuation will be presented. We further present analyses that enable the conversion efficiency of these systems to be appraised, thereby allowing performance parameters to be determined. Finally, prototypes inspired from our analyses will be presented. These prototypes display the strength of analyses, and its capability of inspire the design of record-breaking performances.