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Extreme Mechanics in Soft Pneumatic Robots and Soft Microfluidic Electronics and Sensors

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In the near future, machines and robots will be completely soft, stretchable, impact resistance, and capable of adapting their shape and functionality to changes in mission and environment. Similar to biological tissue and soft-body organisms, these next-generation technologies will contain no rigid parts and instead be composed entirely of soft elastomers, gels, fluids, and other non-rigid matter. Using a combination of rapid prototyping tools, microfabrication methods, and emerging techniques in so-called "soft lithography," scientists and engineers are currently introducing exciting new families of soft pneumatic robots, soft microfluidic sensors, and hyperelastic electronics that can be stretched to as much as 10x their natural length. Progress has been guided by an interdisciplinary collection of insights from chemistry, life sciences, robotics, microelectronics, and solid mechanics. In virtually every technology and application domain, mechanics and elasticity have a central role in governing functionality and design. Moreover, in contrast to conventional machines and electronics, soft pneumatic systems and microfluidics typically operate in the finite deformation regime, with materials stretching to several times their natural length. In this talk, I will review emerging paradigms in soft pneumatic robotics and soft microfluidic electronics and highlight modeling and design challenges that arise from the extreme mechanics of inflation, locomotion, sensor operation, and human interaction. I will also discuss perceived challenges and opportunities in a broad range of potential application, from medicine to wearable computing.