Metallic Muscles: nanoporous materials at work

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Abstract: In this contribution we will concentrate on electrical-to-mechanical energy conversion using nanoporous metal-polymer composite materials. Nanoporous metallic actuators constitute a new class of low-voltage actuators that feature a unique combination of relatively large strain amplitudes, low operating voltages, and high specific stiffness and strength. These so-called 'metallic muscles' consist of ligaments and pores in the nanometer regime giving rise to a very high internal surface area.

The key obstacles to the integration of nanoporous metals into current fundamental concepts and technological applications (MEMS, NEMS) are (i) the presence of the aqueous electrolyte itself that is needed to inject electronic charge in the space-charge region at the metal/electrolyte interface. (ii) the rate of actuation due to the relatively low ionic conductivity of the electrolyte, and (iii), the magnitude of the actuating displacements. Here we discuss a novel approach to generate work from metallic muscles that overcome these hurdles. From an experimental viewpoint a new ultrafast, all-solid organometallic actuator has been designed, synthesized and tested. The tunable, semiconducting properties of conjugated polymers are exploited to inject charge into the metal. In addition, a new microstructural design based on a layered structure with enhanced actuation strokes has been developed. In the presentation also size effects of metallic muscles and ion beam induced bending of nanoporous systems will be discussed.