Metallic Muscles: nanoporous materials at work

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We will concentrate on the effect of diffusion 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. In the presentation extrinsic and intrinsic size effects of metallic muscles will be discussed in conjunction of thermal stability due to diffusional processes. Observations of coalescence due to diffusional processes are carried through in-situ transmission electron microscopy.

The key obstacles to the integration of nanoporous metals into current fundamental concepts and technological applications (MEMS, NEMS) are determined by diffusional processes, e.g. (i) the thermal stability of the nano-porous structures, (ii) the rate of actuation due to the relatively low ionic diffusivity when aqueous electrolytes are used to inject charge at the metal/electrolyte interface 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. In addition, a new microstructural design based on a layered structure with enhanced actuation strokes has been developed.