

Thermo-Mechanical Behavior of Shape Memory Polymer Micro- and Nano-Particles

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Thermally-responsive polymer particles are capable of changing their shapes given external stimuli, which hold significant promises for a range of applications. Hydrogel particles are the most common type of stimuli-responsive particles that display volume-phase transition (VPT) in water. In response to temperature change, these crosslinked polymer particles can swell or expel water, inducing large volume change. The limitations of hydrogel particles are such that VPT can only occur in the presence of a solvent, and incapable of shape change under constant volume. In this study, we report a new approach to fabricate stimuli-responsive polymer micro- and nanoparticles, capable of demonstrating large shape changes while maintaining constant volume under solvent-less conditions and assess the ability of particles to recover their permanent shape during annealing. Our approach is to use nanoimprint lithography (NIL) to program large deformations into crosslinked polymer micro- and nanoparticles, which can then recover their original shapes upon heating. This talk covers our recent work characterizing the shape memory behavior of these particles throughout the shape memory cycle. In particular, we examine the effects of particle properties (size and crosslinking density), particle-substrate contact, and confinement effects of thin metal layers on the kinetics and morphological evolution of particles during the shape memory cycles. Furthermore, we show that under the thin-metal film confinements, the recovery of the programmed polymer particles can lead to a range of hierarchical wrinkling/folding structures atop the particles. The morphology of the wrinkled/folded metal/particle systems can be controlled via the programming of the polymer particles, thickness of the metal films and the particle sizes.