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Surface shape memory in polymers

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Many crosslinked polymers exhibit a shape memory effect wherein a permanent shape can be prescribed during crosslinking and arbitrary temporary shapes may be set through network chain immobilization. Researchers have extensively investigated such shape memory polymers in bulk form (bars, films, foams), revealing a multitude of approaches. Applications abound for such materials and a significant fraction of the studies in this area concern application-specific characterization. Recently, we have turned our attention to surface shape memory in polymers as a means to miniaturization of the effect, largely motivated to study the interaction of biological cells with shape memory polymers. In this presentation, attention will be given to several approaches we have taken to prepare and study surface shape memory phenomenon. First, a reversible embossing study involving a glassy, crosslinked shape memory material will be presented. Here, the permanent shape was flat while the temporary state consisted of embossed parallel groves. Further the fixing mechanism was vitrification, with Tg adjusted to accommodate experiments with cells. We observed that the orientation and spreading of adherent cells could be triggered to change by the topographical switch from grooved to flat. Second, a functionally graded shape memory polymer will be presented, the grading being a variation in glass transition temperature in one direction along the length of films. Characterization of the shape fixing and recovery of such films utilized an indentation technique that, along with polarizing microscopy, allowed visualization of stress distribution in proximity to the indentations. Finally, very recent research concerning shape memory induced wrinkle formation on polymer surfaces will be presented. A transformation from smooth to wrinkled surfaces at physiological temperatures has been observed to have a dramatic effect on the behavior of adherent cells. A look to the future in research and applications for surface shape memory in polymers will round out the talk.