“By modeling the co-evolution of a sample’s microstructure and its strain field, we can predict its overall mechanical response and the sample’s shape change,” said Selinger, a professor of chemical physics. “My students and I wrote a finite element elastodynamics code from scratch and adapted it to model a variety of liquid crystal elastomers with different types of internal structure.” The team collaborates with experimenters in Japan and the Netherlands.

A liquid crystal elastomer with uniform molecular alignment simply contracts and stretches when heated or cooled, but more complex types of actuation are also possible. Graduate student Vianney Gimenez-Pinto studied the way a liquid crystal elastomer with more complex internal microstructure behaves. She showed that a narrow liquid crystal elastomer ribbon can spontaneously twist and contract into a shape reminiscent of a rotini noodle when heated, while wider ribbons curl into the shape of a hollow cylinder. In both cases, she demonstrated that the twist direction reverses with change of temperature, in close agreement with experimental data.

Even more complex structures produce contraction like a pleated window shade on heating. “In fact, by imposing a particular microstructure in a sample,” Selinger suggested, “we can design a material that will spontaneously fold itself into any desired shape, a process known as auto-origami. The challenge here is to determine what internal microstructure will produce a particular desired shape or actuation behavior.” Just for fun, Selinger also modeled how a liquid crystal elastomer “worm” could be actuated to crawl over hilly terrain.

Former graduate student Badel Mbanga, now a post-doctoral student at Tufts University, modeled how a liquid crystal elastomer’s internal structure evolves when a sample is stretched. The resulting soft elastic response suggests that these materials may also find application as directional acoustic dampers.