Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Crystallizable triple shape memory polymers: constitutive modeling and numerical simulations

Moon, Swapnil, sqm2@njit.edu Rao; I. Joga; Chester, Shawn A., New Jersey Institute of Technology, United States

ABSTRACT

Shape memory polymers have the ability to change their shape on demand in response to external stimuli. Recently triple shape memory polymers (TSMPs) have been reported in the literature. These materials can be deformed from the permanent shape, fixed in a second temporary shape, which may then be further deformed and fixed in a third temporary shape. The third temporary shape is retained until the polymer is exposed to an external stimulus, which induces recovery to the second temporary shape, which on further exposure recovers to the permanent shape. Crystallizable TSMPs are a subclass of TSMPs where the change in shape is thermally actuated – this research focuses on modeling the behavior of crystallizable TSMPs with a goal for predicting complex thermo-mechanical deformation cycles. The framework used in developing the model is based on the theory of multiple natural configurations. In order to model the mechanics associated with TSMPs, the different stages of crystallization and melting during a thermo-mechanical cycle need to be characterized. This includes developing a model for the permanent (amorphous) phase, and the semicrystalline phases that are formed after their respective crystallizations, and later melting of the crystalline phases to capture recovery of the polymer to its original permanent shape. The model has been used to simulate results for analytically tractable boundary value problems, and calibrated to uniaxial experiments. Further, we have numerically implemented the theory by writing a user-material subroutine for the widely used finite element program Abaqus. We show that our theory is capable of simulating TSMPs undergoing complex thermo-mechanical deformation cycles.