Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Microscale elastic properties of interphases in polymer matrix composites: correlating spatial mapping with cure history

Kieffer, John, kieffer@umich.edu; Aldridge, Michael; Sebeck, Katherine, University of Michigan, United States

ABSTRACT

Polymer matrix composites with textile reinforcement are used in a wide range of aerospace and industrial applications. Continuum mechanical predictions of the composite behaviors have been inaccurate and resorted to empirical corrections, because of the lack of polymer materials property information. The length scales involved make experimental measurement of the elastic properties of the matrix within fiber tows and proximity to individual fibers difficult. However, micro-Brillouin and Raman light scattering provide sufficiently high spatial resolution to probe the mechanical properties and chemical composition of the matrix, without interfering with the thermo-mechanical equilibrium of the material. The elastic properties of epoxy resin have been measured between and within the fiber tows of a composite with this technique, and compared to a bulk epoxy resin. Using this approach, the elastic properties have also been monitored in situ, during epoxy cure under different thermal and chemical conditions. To interpret and enhance these results, experiments are complemented with molecular dynamics simulations of the interface extrapolating findings to nanometer length scales. We observe that matrix materials in close proximity to fibers have a diminished elastic modulus compared with both bulk epoxy and material between tows. To explain the underlying reason for this finding we identify the extent to which residual stresses, chemical inhomogeneities, or purely structural rearrangements near the interface contribute to this effect. Finally, we correlate the spatial distribution of mechanical properties with the cure history.