A simple methodology for observing mechanical properties of nanocomposites
Part 2: Investigation of interfacial properties in E-glass fiber model composites

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Abstract

The fiber/matrix interfacial shear strength (IFSS) and the fiber/matrix interphase fracture toughness are critical parameters that control failure initiation and crack propagation in composites. In spite of this importance, most IFSS test methods ignore these parameters. As a result, output results from IFSS tests cannot be used as input parameters for modeling the failure behavior of real or model composites. These results are not used to quantify the failure behavior of real fiber interaction, and this ignorance causes the difference between the measured values determined by single fiber-model composites (i.e. fragmentation test) and multi fiber-real composites (i.e. direct shear and short beam test).

For these reasons, we have sought to obtain *in situ* IFSS parameters through the testing of micro-composites that consist of 2-D and 3-D multi-fibers arrays, whose inter-fiber spacing is comparable to the spacing observed in typical composites. This testing methodology admits the direct observation how IFSS, inter-fiber spacing, deformation rate, and matrix cracks influence fiber break clustering, critical flaw nucleation, and the *in situ* IFSS. The *in situ* IFSS obtained from this testing approach provides an experimental link to the ineffective length parameter that is used in statistics-based micromechanics models. These models seek to quantify the strength and failure behavior of unidirectional laminae, the basic building blocks of composite structures, using micromechanics input parameters. The key goal of this research is to develop a predictive composite failure model by linking micromechanics parameters that quantify the local properties controlling failure initiation and crack propagation in a composite lamina to computationally efficient failure criteria.

Using this measurement technique, the IFSS of single fiber and 2-D multi fiber composites having 15 µm interfiber distance were measured using testing conditions where the interval between successive deformations was 10 min or 1 h. The experimental results showed that the average IFSS of the cluster fibers measured with the 10 min time interval is lower than those tested using the 1 h time interval. Moreover, the IFSS obtained from a single fiber was found to be lower than the *in situ* IFSS that is obtained from the 2-D multi-fiber micro-composite. It was concluded that the reduction in IFSS is due to the interaction between the closely spaced fibers and the clustering of fiber breaks that occurs in the adjacent fibers surrounding the fiber that contains the initial break.