Supporting Technologies: Materials Characterization

Objectives

In order to understand the role of the fiber-matrix interface on bulk composite behavior, it is necessary to completely evaluate both the mechanical and structural aspects of this interface region. It is especially important to relate micro-structural stability of both the fiber and interfacial coating to the time, temperature, and environmental factors which will ultimately determine the lifetime of the composite. Understanding the critical life-limiting mechanisms at the interfaces in any given composite system will certainly aid in the design of improved CFCCs for a given application. Thus, there are several important objectives within the scope of this subtask:

- evaluate the fiber-matrix interfaces in a variety of composite systems, both mechanically and structurally, and relate these observations to the bulk composite properties
- correlate microstructural changes at the interfaces with observed changes in the mechanical behavior of a CFCC system
- understand the degradation mechanisms controlling the stability of the fiber-matrix interfaces in CFCCs as a function of time, temperature, and environment

These efforts are integrated not only with other CFCC Supporting Technologies Subtasks, including the interface design, environmental effects, time-dependent behavior, and mechanical reliability subtasks, but also with the industrial participants.

Challenges

In order to accomplish the main subtask objectives, it is necessary to use characterization techniques that isolate the fiber-matrix interfacial regions for analysis. Techniques such as the Interfacial Test System, used to measure interfacial mechanical properties, were developed at Oak Ridge National Laboratory. Other advanced characterization methods, including analytical electron microscopy have been applied to the study of the interfaces in CFCC with great success.

The Interfacial Test System

The ORNL Interfacial Test System (ITS) is used to characterize the interfacial properties (such as the interfacial shear strength) of embedded fibers by performing single fiber push-in and push-out tests. The ITS uses a 10 mm flat-head diamond indenter to push an individual fiber and has 1.0 mN force and 0.1 mm displacement resolution capabilities. The force vs. displacement data acquired during the push-out tests are fitted using standard models and the interfacial properties are then derived from the data/curves.

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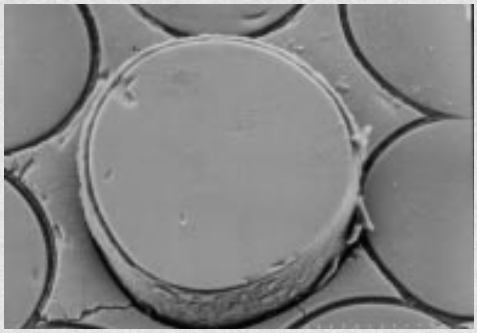
Analytical Electron Microscopy

Various electron microscopy techniques are currently being used for compositional and structural evaluation of fibers, interfaces, and matrices in many CFCC systems. These techniques include high resolution scanning and transmission electron microscopy,



analytical electron microscopy, and Auger electron spectroscopy. In order to elucidate the different composite degradation mechanisms at both intermediate and elevated temperatures in corrosive environments, it is critical to image and chemically characterize the microstructural changes and reactions which occur primarily at the fiber-matrix interfaces. High resolution, state-of-the-art analytical techniques are required to interpret mechanical properties data, since many of the changes that occur during use/service are 'nanometer-scale' changes. Understanding the relationship between microstructure and mechanical properties is important for the future design of improved CFCCs and for incorporation into existing lifetime models.

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CFCC

Continuous Fiber Ceramic Composite Program

A 10-year joint R&D effort initiated in 1992 to develop processing methods to produce reliable and cost-effective CFCC components for industrial applications.

CFCCs are light, strong, and corrosion-resistant materials capable of performing at high temperatures.

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