Strains in a 2-D Fiber Composite

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Introduction

As a first step toward obtaining detailed information concerning the deformation of composites, three Ti-matrix/SiC-fiber composites were investigated. The data support earlier investigations concerning this material and open up this technique as viable for a more in-depth examination of fiber composites.

Methods and Materials

Residual strains were measured using the *d* vs. $\sin^2\psi$ technique.[1] An area of 2 mm x 1 mm was continuously irradiated by the 25-keV beam on all samples. Angular resolution was improved through use of a Si analyzer crystal. Alignment was verified with an 004 Si wafer. Three $\sin^2\psi$ experiments were performed. To eliminate absorption effects, ψ was taken to be in the χ orientation. One of the samples was also analyzed using microdiffraction at NSLS.[2]

Two additional experiments using a tensile stress rig to load the tensile sample up to 1200 MPa were also performed. Loads were applied in steps of 200 to 300 MPa. Applied strains and loads were averaged from the initial and final values recorded using a strain gauge and Entran load cell. CeO_2 powder was used as an internal standard to calibrate the Ti-SiC data. While most of the data were collected using θ-2θ scans from the 10 to 60º 2θ range, image plates were also used to collect information regarding the samples.

Results

The data clearly show a residual strain state for which the matrix is under tension and the fibers are under compression. This result is in agreement with a more fundamental analysis performed using strain-free reference materials.[3] Under load, diffraction was performed giving strain results in the transverse direction. Single-peak fits show a distribution of strains for a given direction with load.

Discussion

The analysis at multiple facilities compares α-Ti (203) reflections and suggests a three-dimensional stress state likely induced from polishing.[2] For 25-keV x-rays, $G_{0.99}$ (the thickness that contributes 99% of the diffracted intensity at q = 44.3o) is approximately equal to the thickness of the sample; therefore, the strain data obtained is a through-thickness exponentially weighted average. Further analysis of unpolished samples at additional reflections suggests a three-dimensional residual strain state with a wide range of orientation-dependent strains.

The results from the loading experiments are typical of transverse strains for a hexagonal system. The grains, on the order of 29 μm, interact individually with each other and with the 150-μm diameter fibers. This data is complemented well by longitudinal strain measurements performed at the same beamline in February 2001.

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References

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