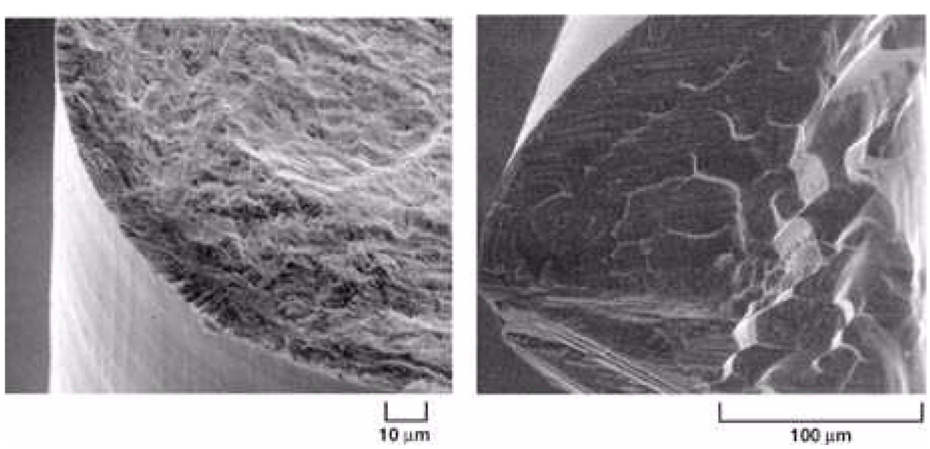
Directionally Solidified Ceramics Produced

Multiphase, interpenetrating structures are an alternative route to obtaining structural ceramic materials with adequate strength, toughness, and stability for high-temperature aerospace applications. The eutectic architecture, a continuous-reinforcing phase within a higher volume phase or matrix, can be described as a naturally occurring, in situ composite. The phases of a eutectic are thermodynamically compatible at high homologous temperatures. Strong and stable materials have been produced. Toughness, however, remains a technical obstacle. The potential for producing materials with enhanced toughness along with adequate strength and stability was demonstrated using the laser-heated float zone (LHFZ) growth method at the NASA Glenn Research Center at Lewis Field.

LHFZ growth at Glenn provides a means to efficiently produce and record the underlying growth phenomena associated with two-phase structures. To initiate directional solidification, a seed of single-crystal sapphire (<0001> direction) was lowered onto the molten liquid until wetting occurred and then withdrawn at a constant rate. Neither the crystal nor the source rod was rotated. The materials produced were tested mechanically in tension, and the resulting microstructure was examined with a scanning electron microscope.

Both the inherent properties of the constituent phases and the properties of the interface between them affect the mechanical behavior and the fracture surfaces. The following scanning electron micrographs show the microstructures of two different materials that were tested to failure in tension. In the left micrograph, the flat fracture surface is typical of a material that is strong but has low toughness. In the right micrograph, the crack is effectively deflected at the interface between the two phases, achieving higher toughness at moderately lower strength levels. Conducting mechanical tests to determine the high-temperature properties of these materials is the next step in determining their eventual suitability.



Top: Fracture surface showing moderate surface roughness. Bottom: Enhanced toughness material showing a stepped fracture surface caused by a strong tendency to deflect cracks at two-phase boundaries.

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