Fracture strength of multi-component ultra-high temperature carbides

Abstract

Ultra-high temperature ceramics (UHTCs) have emerged as a promising material for next generation re-entry hypersonic vehicles due to high melting point (>3000 °C), and high mechanical properties and oxidation resistance. Yet none of the unary UHTCs can satisfy the whole gamut of demanding requirements for aerospace applications. Recently, the single-phase solid-solution formation in a multi-component ultra-high temperature ceramic (MC-UHTC) materials have gained interest due to their superior thermo-mechanical properties compared to conventional UHTCs. Herein, a systematic approach was used to fabricate binary (Ta, Nb)C, ternary (Ta, Nb, Hf)C, and quaternary (Ta, Nb, Hf, Ti)C UHTCs by gradual addition of UHTC components via spark plasma sintering (SPS). Fracture strength of the samples were measured using 4-point bend testing to understand the effect of UHTC components on the failure behavior of MC-UHTCs. A high-speed camera was also used to visualize and record the failure in each sample. The results showed that the quaternary UHTC has a fracture strength of ~351 MPa, which is ~227% and 10% higher than binary and ternary samples, respectively. Enhancement in the fracture strength has been attributed to increase in the entropy of a MC-UHTC with gradual addition of UHTC component. The present findings promote MC-UHTCs as a candidate damage tolerant structural material for aerospace applications.

Key words:

Multi-component ultra-high temperature ceramics (MC-UHTCs)

Fracture strength

4-point bend test

High-speed camera

Ultra-high temperature ceramics (UHTCs)

Spark Plasma Sintering (SPS)