MECHANICAL PROPERTIES OF ZIRCONIUM DIBORIDE CERAMICS

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This presentation will focus on the mechanical properties of zirconium diboride ceramics. Diboride ceramics offer a combination of properties that include high elastic modulus, hardness, strength, and moderate fracture toughness to elevated temperatures. However, like all structural ceramics, their mechanical properties are controlled by microstructure wherein grain size, dispersion and size of second phases, and impurities limit their potential use at elevated temperatures, particularly for proposed extreme environment applications at temperatures exceeding 2000°C. As an example, the flexure strength of nearly phase pure ZrB_2 ranges from 300 to >600 MPa at room temperature but retains a strength of >300 MPa at temperatures >1500°C. Further, the fracture toughness of ZrB_2 ceramics is generally low, typically in the range of 3 to 4 MPa-$m^{1/2}$, at both room and elevated temperatures.

Our group is researching methods for improving the flexure strength and fracture toughness of ZrB_2-based ceramics for use at elevated temperatures. Current studies with respect to strength are focusing on methods to reduce impurities that result in strength degradation at elevated temperatures. Hot pressing of borothermally synthesized, high purity ZrB_2 was used to produce a series of ZrB_2 ceramics with < 75 ppm Hf and <0.5 wt% of other metal impurities, compared to 1 to 4 wt% Hf plus >1 wt.% O, N, and other metallic impurities for ZrB_2 ceramics processed with commercial grade powders. Mechanical properties for ZrB2 ceramics with reduced impurities will be discussed and compared to previous studies in the literature.

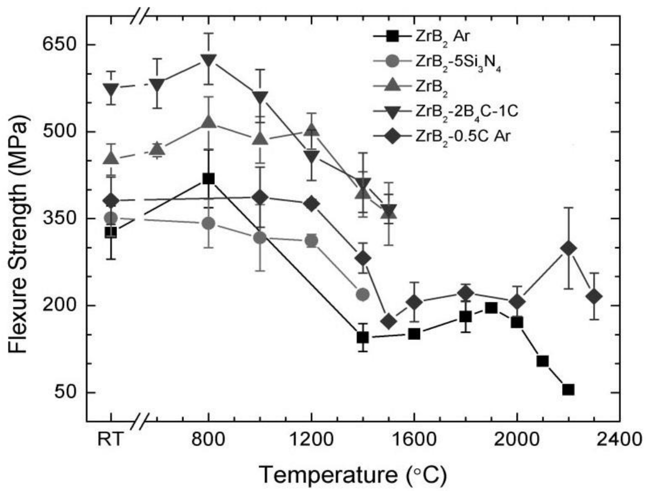

Figure 1 – Elevated temperature flexure strength of hot pressed ZrB_2 ceramics with and without additives in air and argon.

Studies with respect to fracture toughness have focused on processing methods to produce engineered architectures designed to control crack propagation and fracture behavior. Recent studies have included the development of ZrB_2/graphite laminate composites and dual composite architectures. Results from these studies will be presented and compared to the fracture behavior of largely monolithic ZrB_2 or ZrB_2-based ceramics having a dispersed second phase.

The presentation will conclude with a discussion of the remaining research challenges related to improving the mechanical properties of diboride ceramics for applications in extreme environments.