

[Abstract Guideline (Leave two lines for presentation number)]

Deformation-resistant UHTC composites with superior hardness, toughness, and flexural strength up to 2000°C

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The request for new multipurpose deformation-resistant ultra-high temperature ceramics (UHTC), able to act as special engine and vehicle protection, ceramic segmented leading edge components for aerospace, plasma-facing, ceramic parts for solar towers used for gas turbine operation in a combine cycle power plants (grids, superheaters, reheaters, evaporators, stream turbines, condensers, and chimneys) cause the worldwide demand in a new class of ceramic composites of incredible high strength, sufficient balance between high toughness & hardness.

Confirmed room to ultrahigh temperature deformation resistivity of reaction-driven SPSed (RD-SPS) boron carbide, TiB_2 with stiff skeleton of B_4C , Zr-Ta boride composite with artificially created hierarchical superstructure, TaB, and high-entropy $\text{TaB}_2\text{-ZrB}_2\text{-TiB}_2\text{-HfB}_2$ to be addressed.

Mechanism of ultra-high temperature flexure & strain driven amorphization in polycrystalline boron carbide been analyzed. With RT to 1800 °C mean strength of 650 MPa, B_4C exhibits ultrahigh flexural strength far exceeding 1000 MPa accompanied by change in the deformation mechanism from brittle fracture to plastic deformation at 2000 °C. STEM observations revealed that the amorphization is of microstructural origin for the observed plasticity in B_4C at 2000 °C. Depending on loading rate B_4C ceramic showed 1000 - 8400 MPa strength with plastic stress-strain curve (Fig. 1). Even rapid deformation in elastic manner at 25 mm/min was resulted in mean strength 675 MPa - same as for RT, confirming its deformation resistivity (*Scripta Materialia* 210 15 Mar (2022) 114487).

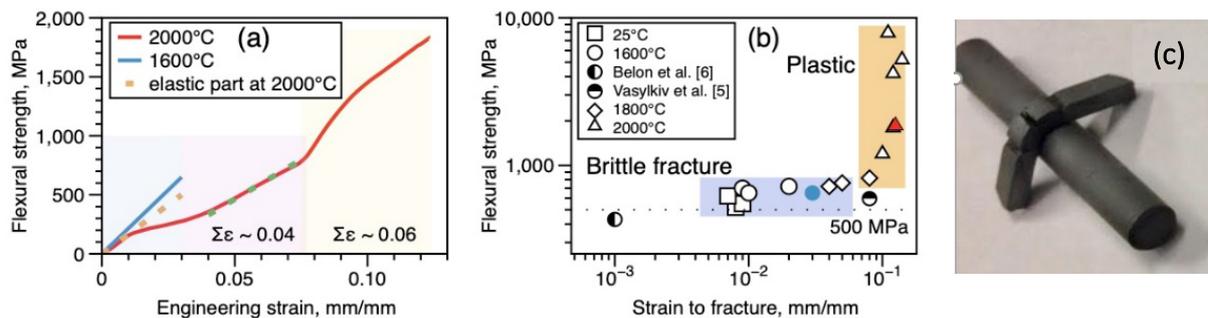


Fig. 1. Effect of temperature on the strain-stress relation in monolithic boron carbide. (a) shows the typical strain-stress curves at 1600 °C & 2000 °C. (b) shows the flexural strength as a function of the temperature and total strain accumulated during the test at a 0.5mm/min rate. (c) bulk ceramic sample deformed at 2000 °C.

RD-SPSed $\text{TiB-B}_4\text{C}$ exhibits mean flexural strength of 1000 MPa for up to 1800 °C (*Scientific Report*, 13 (2023) 6915) with further increasing to 1760 MPa at 2000 °C. Same as above, the ultrahard, tough, deformation resistant Ta monoboride (*Scripta Materialia* 229 May (2023) 115383), Zr-Ta multiboride (*J. Am. Ceram. Soc.*, 105 [11] Nov. (2022) 6989-7002), Zr-Ta-Nb diboride (*Scripta Materialia* 225 1 Mar (2023) 115170), and high-entropy $\text{TaB}_2\text{-ZrB}_2\text{-TiB}_2\text{-HfB}_2$ with an average flexural strength of 400 MPa of up to 2000 °C are the new multipurpose deformation-resistant ceramics with wide range of possible applications.