TOPIC
Structural ceramics

Ultrahigh temperature ceramics for aerospace and solar energy applications

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Borides and carbides of early transition metals are considered a class of promising materials for several applications, the most appealing ones being in the aerospace and energy sectors. Beside the well known characteristics that make UHTCs attractive as TPS, there is a strong interest in their applications as sunlight absorbers for solar concentrating systems that can operate in the high temperature regime.
The first part of this work is focused on toughening of UHTCs, which is a crucial issue that needs to be addressed for application in the aerospace sector. Different strategies have been developed to increase the fracture toughness, through either incorporation of elongated reinforcement (SiC chopped fibers, SiC whiskers) or in-situ development of SiC platelet-reinforced materials. The mechanical properties are compared to those of the un-reinforced materials and the effect of different kinds of sintering aids amongst Si3N4, MoSi2 and ZrSi2 is studied. Toughening mechanisms such as crack deflection, bridging, bowing and residual stresses are explored through analysis of crack propagation. Experimental increases of toughness are compared to those predicted by theoretical models. Addition of fibers or whiskers allows toughness to be increased from 3-4 $MPa \cdot m^{1/2}$ (for unreinforced materials) to 5.0-6.3 $MPa \cdot m^{1/2}$. On the other hand, quite often, the improvement of fracture toughness is accompanied by a decrease of strength, due to a change of the defects population.
The second part of this work is dedicated to the characterization of various carbides and borides, in terms of room temperature and high temperature mechanical, thermal and optical properties. The discussion on properties relevant to solar energy applications will help to select the most promising matrices and/or composites for concentrating solar power (CSP) technologies.