Presented at 12th International Conference of the European Ceramic Society (ECERS),

Stockholm, 19-22 June 2011.

Production and characterization of toughened ultra-high temperature ceramics

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Abstract

Ultra-high temperature ceramics are material candidate for application in aggressive environment, especially in sharp components of future generation of space vehicles, driven by the ultimate goal of major speed with new propulsion and hypersonic models. This class of materials is arising always more interest for wing leading edges and nose tips, as well as propulsion system elements.

The most investigated system concerns the ZrB_2-SiC ones, owing to a high strength, up to 1 GPa, high hardness, around 20 GPa, and oxidation resistance. The major weak point remains the low fracture toughness, 3 to 5 $MPam^{1/2}$. It has recently been demonstrated that the introduction of elongated secondary phases and the choice of the proper sintering additive, can lead to almost twofold increase of the fracture toughness.

This work presents the last development of toughened ZrB_2 ceramics with addition of SiC whiskers or chopped fibers, or through the *in-situ* elongation of SiC particles. The effect of various sintering additives, $MoSi_2$, Si_3N_4, $ZrSi_2$ and WSi_2, is investigated in relationship to the microstructure evolution upon sintering, to the interface between matrix and reinforcing element and to the high temperature behaviour.

Flexural strength, with the 4-point method, and toughness, measured by the CNB technique, are compared to those of reference unreinforced materials. The addition of whiskers to ZrB_2 -based materials allows both strengthening and toughening compared to the reference material, whilst the addition of fibers only leads to a toughness increase, but it is accompanied by a decrease of strength, due to a change of the defects population. The oxidation tests conducted in a bottom-up loading furnace at 1200, 1500 and 1700°C show that the reinforced composites behave similarly to the baseline ZrB_2-SiC well known material.