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TEM analysis on $TaSi_2$–containing ultra-high temperature ceramics

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Abstract

Ultra-high temperature ceramics are suitable structural ceramics for applications under high heat fluxes at temperature that can exceed 1600°C. Future hypersonic vehicles have a potential use temperature above 2000°C and require oxidation resistant materials. The ceramics object of this study, namely ZrB_2, HfB_2, HfC and TaC, possess a unique combination of properties including high melting point temperature (ZrB_2: 3245°C, HfB_2: 3250°C, HfC: 3890°C, TaC:3985°C), high hardness and strength, good oxidation resistance and high thermal conductivity.

Ceramics based on borides and carbides of Zr, Hf and Ta were hot pressed at 1750°C-1900°C to full density thanks to the addition of 15 vol% of $TaSi_2$.

$TaSi_2$ was selected to promote the densification, due to its high melting point (2200°C), its ductility at the sintering temperature and its capability to provide increased oxidation resistance.

The microstructure of the composites was analyzed by X-ray diffraction, scanning and transmission electron microscopy in order to investigate the densification mechanisms occurring during sintering.

In the boride-based composites the formation of $(Ta,Me)B_2$ solid solution growing epitaxially on the matrix with low-angle grain boundary was observed. The chemistry of the triple points suggest that cation transfer is an active process and the passage through a liquid phase is also strongly hypothesized. The secondary phases identified were SiC, Ta_5Si_3 and Ta-oxides.

Concerning the carbide-based materials, a higher solubility between Ta and Hf was observed both in the carbide grains and in the silicide. Also in these systems, Ta-rich solid solutions were observed surrounding the matrix.

The microstructure evolution is discussed with respect to the chemistry of the elements involved, the phase diagrams and the thermodynamics.