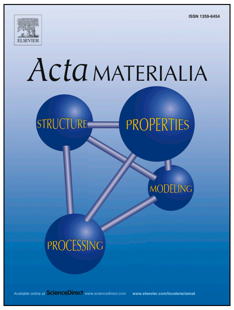
Accepted Manuscript



Understanding the oxidation behavior of a ZrB_2–$MoSi_2$ composite at ultra-high temperatures

Laura Silvestroni, Kerstin Stricker, Diletta Sciti, Hans-Joachim Kleebe

PII: S1359-6454(18)30240-4

DOI: 10.1016/j.actamat.2018.03.042

Reference: AM 14462

To appear in: *Acta Materialia*

Received Date: 13 February 2018

Revised Date: 21 March 2018

Accepted Date: 21 March 2018

Understanding the oxidation behavior of a ZrB_2–$MoSi_2$ composite at ultra-high temperatures

Laura Silvestroni[1*], Kerstin Stricker[2], Diletta Sciti[1], Hans-Joachim Kleebe[2]

[1]CNR-ISTEC, National Research Council of Italy - Institute of Science and Technology for Ceramics, Via Granarolo 64, I-48018 Faenza (RA), Italy

[2]TU-IAG, Technical University Darmstadt – Institute of Applied Geoscience, Schnittspahnstraße 9, 64287 Darmstadt, Germany

ABSTRACT

This basic research investigates the microstructure evolution of a composite based on ZrB_2-$MoSi_2$ from the as-sintered features to the changes occurring upon oxidation at ultra-high temperatures, 1650 and 1800°C, in a bottom-up loading furnace for 15 minutes. Scanning and transmission electron microscopy evidenced the formation of a matrix typified by ZrB_2-cores surrounded by $(Zr,Mo)B_2$-rims with dispersed $MoSi_2$ particles and SiO_2 glass trapped at the triple junctions. The oxidation at 1650°C induced the migration of silica to the surface, which formed a continuous and protective scale. Below this scale, the matrix evolved into ZrO_2 grains encasing MoB nano-inclusions, as a result of the oxygen and boron oxide partial pressures established in the subscales. Underneath, a $MoSi_2$-depleted boride region, but substituted by SiO_2 and MoB was found. The same phases were observed upon oxidation at 1800°C, but a thicker and more turbulent oxidized layer formed as a consequence of the rapid evolution of MoO_3, SiO and B_2O_3 gases from the scales beneath the outermost silica-layer.

According to the observed phases and the calculated phase stability diagrams, the partial pressures gradient within the oxide layer were defined and the effect of Mo-doping in boride matrices on the oxidation behavior was compared to that of other transition metals to establish a criterion design for the realization of ceramics with improved oxidation resistance.

Keywords: UHTC; Oxidation; TEM; Microstructure; Inclusion.

1. Introduction

The great interest in borides and carbides of transition metals, a class of ceramics known as Ultra-High Temperature Ceramics (UHTCs), is motivated by the search for materials that can withstand extreme environments in terms of temperature, chemical reactivity, mechanical stress, radiation and ablation, especially in hypersonic and space aviation [1]. ZrB_2 can be considered a leading material in this field of research, due to its unique combination of properties in terms of high melting point above 3000°C, relatively low density, high thermal conductivity and good strength and refractoriness at elevated temperatures [1-5]. However, pure ZrB_2 is extremely difficult to sinter, due to its strong covalent bonds and low self-diffusion rates [6] and therefore it requires pressure-assisted sintering techniques at very high

* Corresponding author: Laura Silvestroni
Tel. +39 546 699723
Fax. +39 546 46381
e-mail. laura.silvestroni@istec.cnr.it