Influence of Nb coating on the oxidation behavior of ZrB_2

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Abstract

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ZrB_2 has an extreme high melting point over 3000°C and one of the lowest densities in the group of ultra-high temperature ceramics. Unfortunately, the poor oxidation behavior above 1400°C limits its reusability. It is proven, that the addition of transition metals like 4mol% Nb to ZrB_2 has a beneficial influence on the oxidation behavior. In this study, application of Nb as an overlay coating on ZrB_2 has been tried as a potential solution to improve the oxidation behavior. The overlay coatings were applied by means of magnetron sputtering technique. The coated ZrB_2 samples were pre-annealed in high vacuum at 1800°C for 2h and 4h. Afterwards, the oxidation experiments were performed in a tube furnace at 1500°C under flowing synthetic air for 1h, 4h, and 10h exposure times. The samples were analyzed by SEM, EDS, and XRD to understand the different mechanisms and the oxidation kinetics.

Based on the oxide scale thickness measurements, a reduction of the scale thickness by approximately 30% was observed in the pre-vacuum annealed Nb-coated ZrB_2 as compared to the pure ZrB_2 and exhibited the parabolic oxidation kinetics. The effect of pre-annealing and the oxygen flow rate has also shown various differences in the oxidation behavior of the Nb coated ZrB_2 samples. The pre-vacuum-annealing led to an interdiffusion zone at the coating/ZrB_2 interface. The interdiffusion increased with the annealing time and led to a better adhesion between the Nb-coating and ZrB_2. It is evident that a thicker interdiffusion zone is formed with longer annealing times, increasing the formation of dense reaction layer upon oxidation, which has improved the oxidation behavior. Similarly, it was found that the oxidation rates of Nb coated ZrB_2 were decreasing with increasing oxygen flow rates. The corresponding underlying mechanisms were thoroughly discussed.