INVESTIGATION OF CMAS RESISTANCE OF SPS- AND SHVOF-ALUMINA TOPCOATS ON EB-PVD 7YSZ LAYERS

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Thermal barrier coatings (TBCs) undergo severe degradation by interaction with molten calcium-magnesium-aluminum-silicate (CMAS) minerals that are found mainly in volcanic ashes (VA) or desert sands. After the infiltration of the CMAS, chemical reactions, diffusion and phase transformation can lead to residual stress, cracks and spallation and thus significantly shorten the life-time of the components. As the state-of-the-art material 7 wt.-% Y_2O_3 stabilized ZrO_2 (7YSZ) offers limited resistance to the CMAS attack, development of CMAS-resistant TBCs has undergone intense research during the last decades. One of the proposed approaches is the application of a sacrificial layer on top of the TBC which reacts with the molten CMAS/VA to crystalline phases and in this way inhibits further infiltration by sealing the gaps and pores. Al_2O_3 is one candidate for such a sacrificial layer which exhibits good CMAS resistance by formation of arresting phases. However, EB-PVD Al_2O_3-topcoats suffer locally from cracks that arise from crystallization and sintering shrinkage, thereby providing only a discontinuous protection against CMAS infiltration due to their characteristic morphology. Even though the alumina is a candidate material, the coating density and the arrangement of porosity has been found to be a critical factor for restricting CMAS infiltration.

In this work alumina coatings were sprayed on top of EB-PVD 7YSZ TBCs using suspension plasma spraying (SPS) and suspension high velocity oxygen fuel spraying (SHVOF) starting from an aqueous suspension containing fine dispersed Al_2O_3 (d50 about 2.3 µm). The spray parameters were optimized in order to produce Al_2O_3 topcoats with homogeneous distributed porosity from very porous (porosity about 30 %) to denser (porosity about 10-15 %). These coatings were tested under CMAS attack by performing infiltration experiments at 1250 °C for different time intervals from 5 min to 10 hours. One Island volcanic ash from the Eyjafjallajökull volcano (IVA) and two types of synthetic CMAS compositions were tested in this study. The infiltration kinetics and reaction products were studied by SEM, energy-dispersive spectroscopy (EDS) and x-ray diffraction (XRD).

It was observed that the microstructure and especially the presence of the porosity in the Al_2O_3 coatings strongly influenced the CMAS infiltration kinetics. Due to its high and non-uniform porosity, CMAS/VA melt infiltrated the 100 µm thick, very porous alumina SPS-coating inhomogeneously and reached the subjacent 7YSZ layer already after one hour of annealing at 1250°C. Additionally, it was found that the infiltration kinetics varies also with the chemical composition of the CMAS/VA. Different crystalline phases such as anorthite, spinel or others were formed as reaction products of the SPS-Alumina-TBC with the CMAS/VA-melt. The exact phases and its location depend on the used CMAS/VA composition. Furthermore, the annealing time has a major influence on the presence of the various phases. The infiltration kinetics of the SHVOF-coatings was different due to a change in morphology. The current experiments clearly demonstrate that CMAS/VA mitigation depends on the interplay between morphology of the coating which dictates the driving force for infiltration, the reaction speed between alumina and the deposit, and the deposit chemistry.