INVESTIGATING THE MICROSTRUCTURE OF AS-SPRAYED HIGH-CRYSTALLINE $Yb_2Si_2O_7$ ENVIRONMENTAL BARRIER COATING (EBC) DEPOSITED BY ATMOSPHERIC PLASMA SPRAY (APS)

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The atmospheric plasma spray (APS) has been recognized as a robust coating process to deposit environmental barrier coatings (EBCs) to protect silicon-based ceramic matrix composites (CMCs) against hot water vapour attacks in combustion environments of gas turbines. Nevertheless, high crystallinity, dense and crack-free microstructures with a desirable phase composition and distribution in the coatings are vital to meet the required protective properties of such layers. Today's best approaches to address these challenges are placing the samples in a furnace to increase the substrate temperature during spraying or using a vacuum chamber as the very low-pressure plasma spray (VLPPS) technique. However, both these solutions encounter severe limitations such as the complexity of required setups or cost and energy inefficiency. Accordingly, deposition of as-sprayed high crystalline Yb2Si2O7 environmental barrier coatings (EBCs) with controlled secondary phase formation on SiC ceramics is great interest. In this study, by manipulating the plasma spray parameters, including but not limited to stand-off distance, gas regime, arc current, plasma torch power, as well as applying a controlled preheat and cooling cycle, high levels of crystallinity (up to 92%) was achieved in as-sprayed condition without the need of any assistive heating (furnace), vacuum chamber, or subsequent heat treatment. The only secondary phase detected in the microstructure of the coatings was Yb2SiO5 which was uniformly distributed throughout the coating microstructure, and a minimal fraction of <20 wt.% was reported in the as-sprayed condition according to the XRD analysis. The lack of Yb2O3 formation demonstrated that the silicon mass evaporation during spraying was controlled. Furthermore, a desirable microstructure comprising a dense structure with uniform distribution of tiny porosities was obtained, and undesirable vertical cracks or any interconnected discontinuities were prevented. Reducing the enthalpy of plasma, while conducive for mitigating the silicon mass loss, was detrimental for microstructure by increasing the fraction of porosities and partially melted or non-melted fragments. The unnecessary post-deposition torch heating and gradual decreasing of the torch power after deposition alleviates microcracking but insignificantly affects the crystallinity level. The evaluation of coatings at 1300 °C for 24 hours demonstrated healing of the caracks and closed the tiny microcracks through the thickness. Improved composition of secondary phases was also observed after annealing the substrates close to their operating temperatures (1300 °C). The transformation of Yb2SiO5 to Yb2Si2O7 in all the coatings after annealing was desirable, and the reaction of oxygen with the SiC substrate provided the excess silicon source required for this transformation.