Microstructural Analysis of the nano TGO layer in TBC on Ti-6Al-4V after cyclic oxidation test for aerospace application

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Thermal Barrier Coatings (TBC) applied to Ti-6Al-4V alloys are used in aerospace turbine blades to provide thermal protection to the metallic alloy while maintaining its mechanical strength at elevated temperatures, low specific gravity, and corrosion resistance. TBC systems typically consist of a metallic substrate, a metallic coat, a thermally grown oxide (TGO), and a ceramic topcoat. Corrosion and high-temperature oxidation lead to highly destructive damage in thermal barrier coatings under service conditions; thus, protection against high-temperature oxidation is closely linked to the evolution of TBC, particularly the TGO layer, which forms a stable nanometric oxide scale that acts as a barrier to slow down the diffusion of cations and oxygen and plays an important role in the adhesion of the TBC.

This study investigates the microstructural changes and cyclic oxidation behavior of Ti-6Al-4V alloy both with and without a TBC. The TBC comprised a BC of NiCrAlY and a TC of yttria-stabilized zirconia containing 8 wt% yttria (8YSZ). Both layers were deposited using a commercial air plasma spray (APS) process. Oxidation tests were conducted cyclically in air at temperatures of 500, 600, and 800 °C in an automated furnace, where each cycle consisted of 60 minutes at the specified temperature followed by 10 minutes in air. After 100 cycles, the oxide scale and the coating were characterized using optical microscopy, scanning electron microscopy, energy dispersive spectroscopy and X-ray diffraction analysis.

Following the oxidation tests, the TBC system did not exhibit macroscopic failure at any of the tested temperatures. As the test temperature increased, the uncoated Ti-6Al-4V

alloy formed a thicker titanium oxide layer on the surface, accompanied by a more pronounced increase in grain size compared to the TBC samples. The grain size of the TBC samples increased gradually. The growth of the TGO layer was minimal, indicating the effectiveness of the TBC in mitigating the effects of thermal cycling and temperature fluctuations.