The durability of thermal barrier coatings (TBCs) affects the life of the hot section engine components on which they are applied. Fatigue is the general failure mechanism for such components and is responsible for most unexpected failures; therefore it is desirable to develop lifetime approximation models to ensure reliability and durability.

In this study, we first examined the microstructural degradation of air plasma sprayed ZrO2-8wt.%Y2O3 TBCs with a low-pressure plasma sprayed CoNiCrAlY bond coat on an IN 738LC superalloy substrate. The durability of TBCs were assessed through furnace thermal cyclic tests carried out in air at 1100°C with a 1-, 10-, and 50-hour dwell period, preceded by a 10-minute heat-up and followed by a 10-minute forced-air-quench. Failure mechanisms of the TBCs were thoroughly investigated through materials characterization techniques including: X-Ray Diffraction, Scanning Electron Microscopy, and Energy Dispersive X-Ray Spectroscopy.

Quantitative microstructural analyses were then carried out to document the growth of the thermally grown oxide (TGO) scale, the depletion of the Al-rich Ω-NiAl phase in the bond coat, and the population and growth of micro-cracks near the YSZ/bond coat interface. Trends in the TGO growth and the Ω-phase depletion in the bond coat followed those of diffusion-controlled processes—parabolic growth of the TGO and exponential depletion of the Ω-phase. Formation and propagation of cracks within the YSZ resulted in complete spallation of the YSZ topcoat from the bond-coated superalloy substrate.

Evolution in these microstructural features was correlated to the lifetime of TBCs, which showed cracking within the YSZ to be the cause of failure; thus a lifetime approximation model was developed, via modification of Paris Law, based on the experimental data. The model predicted the TBC lifetime within 10% of the experimental lifetime.

Major: Materials Science & Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2010, University of Central Florida

Committee in Charge:
Yong-Ho Sohn, Chair, MMAE/AMPAC
Linan An, MMAE/AMPAC
Helge Heinrich, Physics/AMPAC

Approved for distribution by Yong-Ho Sohn, Committee Chair, on October 14, 2011.

The public is welcome to attend.