Abstract

Thermal barrier coating (TBC) consists of a low thermal conductivity ceramic top coat and a metallic bond coat deposited on superalloy substrate to protect the gas turbine engine components from high temperature degradation. The predominant mechanisms behind the premature failure of TBC systems are residual stress development due to (a) thermal expansion mismatch between the ceramic top coat and metallic bond coat and (b) growth of thermally grown oxide (TGO) layer formed on the surface of bond coat during service. The use of compositionally graded TBCs is to reduce the thermal residual stress which increases the component life. Apart from reducing thermal residual stress, growth kinetics of TGO is also important in compositionally graded TBC. In the present study, an extensive study on the characteristics of compositionally graded TBC developed by air plasma spray (APS) deposition and pulsed laser deposition (PLD) has been undertaken. Following coating development, a detailed study of microstructure (morphology and phase) by scanning electron microscopy (SEM), transmission electron microscope (TEM), X-ray diffraction (XRD), and energy dispersive X-ray spectroscopy (EDS) has been undertaken. Furthermore, the study was extended to evaluate the mechanical properties (hardness, indentation toughness, and wear resistance), thermal properties (thermal expansion coefficient and thermal conductivity) and high temperature oxidation properties (both the kinetics and mechanism) of the coated systems. From the present study, it is concluded that the compositionally graded TBC shows improvement in interface fracture toughness. The high temperature oxidation study (both isothermal and non-isothermal) of the graded TBCs shows a superior oxidation resistance in the compositionally graded TBC as compared to the duplex one. A critical analysis to thermal conductivity shows that apart from intrinsic thermal conductivity, the shape and concentration of microstructural defects also play an important role in reducing the thermal conductivity effectively. The geometry of porosities varies with different coating composition. The gradual variation in mechanical properties and thermal properties is observed which is thought to be beneficial for decreasing the residual thermal stress. YSZ, Al_2O_3 and YSZ/Al_2O_3 multilayer were successfully developed by pulsed laser deposition with superior adhesion strength. The Al_2O_3 coating deposited on conventional TBC by PLD showed a maximum improvement in oxidation resistance as compared to other coating.