Chapter 3
Oxidation and Tribology of Al2O3-Induced LaTi2Al9O19/YSZ Double Ceramic Layer Coatings:
Tribo-Oxidation

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ABSTRACT

In the present work, the alumina-induced thermal barrier coatings with LaTi2Al9O19 (LTA) and yttria-stabilized zirconia (YSZ), LTA/YSZ double ceramic layer (DCL) are studied for oxidation and wear tests. Different coatings combinations with varying thickness of LaTi2Al9O19 (LTA) top coat layer are developed using plasma spray method and are tested for isothermal oxidation and wear test. An Alumina layer is induced after the bond coat layer to provide a readily available oxide layer. The activation energy is calculated using the Arrhenius equation. Arrhenius plots are developed using oxidation kinetics. Coatings are tested for wear performance also. The coating combination with a higher thickness of LTA proved best for both oxidation and wear performances. Surface characterization is done using EDS and XRD analysis.

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INTRODUCTION

At higher temperature the oxidation, wear and friction behavior of metals and different alloys is crucial in components of metal working processes, gas engines, internal combustion engines, aero engines and propulsion systems and also cutting tools. At elevated temperatures tremendous changes occur in surface reactivity, overall mechanical properties and thermo-physical properties (Blau P, 2010). The various components of a gas turbine and aero engines operate under a harsh high temperature environment. In these systems the operating temperature of usually varies from an ambient temperature nearly the melting point of metals and alloys. It affects the life span of components due to its degradation and failure. Many components need repair, refurbishment and even replacement due to change in their dimensional tolerance while operating in this aggressive environment. In needs very high cost (Rajendran R, 2012). In the development of high efficiency power generators the gas turbines are of prime importance. Many attempts are made by researchers to develop the most durable thermal barrier coating (TBC) with lower thermal conductivity and higher phase stability. The TBC are modified based on few criteria like use of different coating techniques, modifying the superalloys, by changing the chemical combination of coating architecture or by incorporating some protective elements. Self-healing is the most important desirable phenomenon to enhance the TBC life (Pakseresht A. H. et al., 2018).

Many gas turbine components fail due to erosion, friction, wear and oxidation. Sand particles and fly ash erosion against compressor blades damage it and causes premature engine failure. Components having surface contacts due to rotating and reciprocating motion, subject to high amount of wear and therefore needs some protection. Hot gases produced through burning of fuel causes oxidation and high temperature corrosion in the passages of combustion chamber.

Nuclear reactors are in high demand for the generation of electricity and hydrogen. Higher thermal efficiency is desirable and it increases with the increase in operating temperature (Rahman M. S. et al., 2018). Therefore all the hot sections, other surfaces of rotating as well as stationary components needs thermal and wear protection. In all these applications Nickel based super alloys with thermal barrier coatings (TBCs) are the ultimate solution. The TBC life is mainly affected by the factors like coating microstructure, top coat porosity and the residual stress developed in it. Residual stress contributes to different phenomenon like wear resistance, hardness, creep and fatigue behavior, development of micro-cracks and adhesion strength of coating. Thus the residual stress affects the overall performance of the TBC. The formation of residual stress is due to the mismatch stress caused by the varying coefficient of thermal expansion in the different coating layers and the superalloy substrates (Pakseresht A. H. et al., 2016).

As, lanthanum titanium aluminum oxide ($LaTi_2Al_9O_{19}$, LTA) is having best phase stability from room temperature to 1600°C. It is having low fracture toughness which results in poor thermal cycling behavior. LTA and yttria stabilized zirconia (LTA/YSZ) double ceramic layer (DCL) proved better. Its failure is observed due to decomposition of LTA coating exposed to high temperature (Xie et al., 2011). The decomposition of LTA coating is current challenge. It can be overcome by introducing an alumina layer as a protective oxide layer. It provides a protective oxide layer and contributes towards slower oxidation of bond coat. The intact alumina protects the bond coat and underlying substrate from accelerated oxidation. Also LTA also possesses good thermo-physical properties. Thus, combination of LTA/YSZ and alumina layer makes the thermal barrier coating wear and oxidation resistant coating. In present work the $LaTi_2Al_9O_{19}$ (LTA) powder is used to develop the top coat of varying thickness along with Zirconia stabilized Yttria (YSZ) using thermal plasma spray method. Also Al_2O_3 layer is incorporated on the bond