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Influence of the intermixed interfacial layers on the thermal cycling behaviour of atmospheric plasma sprayed lanthanum zirconate based coatings

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Abstract

In application as a thermal barrier coating (TBC), yttria stabilised zirconia (YSZ) approaches some limits of performance. To further enhance the efficiency of gas turbines, higher temperature capability and a longer lifetime of the coating are needed for the next generation of TBCs. Pyrochlore oxides of general composition, $A_2B_2O_7$, where A is a 3^+ cation (La to Lu) and B is a 4^+ cation (Zr, Hf, Ti, etc.) have high melting point, fair coefficient of thermal expansion, and low thermal conductivity which make them suitable for applications as high temperature thermal barrier coatings. Among those oxide materials lanthanum zirconate ($LZ/La_2Zr_2O_7$) offers very attractive properties. This work describes the fabrication, microstructure and high temperature (1280 °C) thermal cycling behaviour of lanthanum zirconate coatings with five different coating architectures, deposited using atmospheric plasma spray process. The coating architecture which had five layers with two intermixed interlayers had much longer life time than other considered architectures. The coatings were characterised using X-ray diffraction, energy dispersive spectrometry, optical and scanning electron microscopy, before and after thermal cycling tests, to study the coating failure mechanisms.

Keywords: B. Interfaces; C. Thermal shock resistance; D. ZrO_2; E. Engine components

1. Introduction

Thermal barrier coatings (TBCs) have been widely used in advanced aircraft and industrial gas-turbine engines in order to enhance the reliability and durability of hot-section metal components as well as the efficiency of engines [1]. The selection of TBC materials is restricted by some basic requirements such as: (1) high melting point, (2) no phase transformation between room temperature and operation temperature, (3) low thermal conductivity, (4) chemical inertness, (5) thermal expansion match with the metallic substrate, (6) good adherence to the metallic substrate, and (7) low sintering rate of the porous microstructure [2]. Therefore, the number of materials that can be used as TBCs is very limited. The state of the art TBC material is 8YSZ, which can hardly be used for long term application above 1200 °C due to the sintering and phase transformation [3]. There are several ceramic materials that have been evaluated as high temperature TBC materials, and lanthanum zirconate is one of the most promising among them. The properties of high-melting point, phase stability up to its melting point, low thermal conductivity, low sintering ability and oxygen-non-transparent are the major reasons for the belief that lanthanum zirconate has potential as TBC material for high-temperature applications [4].

Vassen et al., studied the thermo-physical properties of LZ material and successfully produced a coating through APS technique [5]. Observation from their results clearly underlines that LZ has good potential as a new material for advanced TBCs, even though it has lower Young's modulus and thermal expansion than that of YSZ. Furthermore, their results proved that the thermal conductivity of LZ which is approximately

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