Microstructure and Mechanical Behaviour Relationship of Plasma Sprayed Mullit+YSZ Coatings

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Abstract

The YSZ/mullite composite coatings have been given an impression for improved high temperature resistance over YSZ coatings under severe service conditions and should be investigated further for its possible use in thermal barrier coating (TBC) systems. In this study, a composite thermal barrier coating made from a combination of YSZ and mullite (wt%25 to 50) was investigated. Powders of each powders were mechanically mixed together and then sprayed on superalloy substrates. Microstructure and mechanical behaviour relationship of these composite coatings were investigated. Crystallinity and phase ratios were determined by XRD analysis. Results showed that mullite addition improved the mechanical behaviour of YSZ coating under high temperature conditions.

Keywords: YSZ-Mullite Coating, Plasma Spray, Durability, Thermal barrier

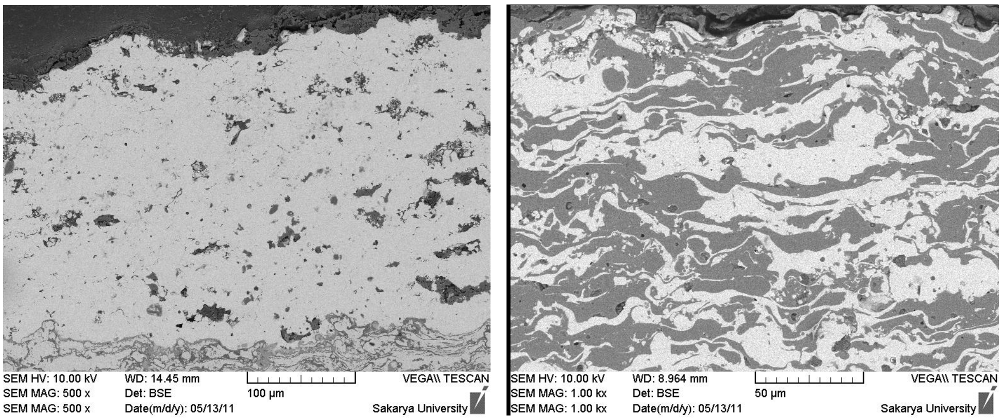
Introduction

TBCs have been extensively developed for aero gas turbines operating in clean environments. Because of their promise to improve engine efficiency and component life, TBCs are expected to be widely used in the future in industrial gas turbines or diesel engines. In industrial gas turbines or diesel engines, hot corrosion resistance over extended exposures (20000 h) in 'dirty' fuel is another key durability issue. Dirty fuels may contain higher levels of sulfur plus additional contaminants such as sodium, vanadium and phosphorous, accelerating the degradation of YSZ TBCs.

Experimental Details

YSZ/mullite composite coatings were fabricated by air-plasma spraying (APS). Spray-dried 7-8 wt.%Y_2O_3-ZrO_2, fused and crushed mullite, and a mechanically mixed combination of the two powders onto stainless steel plate. Coatings were sprayed using with a Metco F4MB plasma torch.

A Na_2SO_4 was selected as corrosive salt. Corrosive salt was spread over the surface of the coatings in a concentration of 25 mg/cm^2. The specimens were set in an electric furnace with air atmosphere at 950 ◦C for 40 h and then cooled down inside the furnace. The coatings were inspected periodically after each of 10 h. The microstructure, morphology and chemical compositionof the surface and the cross-section of the coatings were examined by scanning electron microscopy (SEM) equipped with energy dispersive spectrometer (EDS). X-ray diffraction (XRD) was used to determine the crystalline structure of the coatings and hot corrosion products.



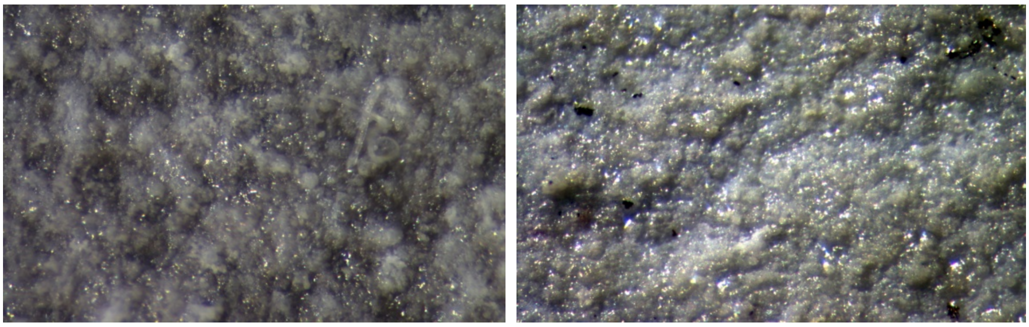
a.Standard YSZ Coating b.YSZ+Mullite Composite Coating

Fig.1. As Sprayed coatings

Results and Disscusions

In this study influences of the mullite addition to YSZ was investigated. Mullite addition improved the hot corrosion resistant. Mullite ($3Al_2O_3$-$2SiO_2$) addition to YSZ provided excellent resistance to molten salt attack in hot corrosion furnace tests. TBCs with mullite showed higher life than standard YSZ. There was no evidence of salt causing any damage to the YSZ, YSZ/ TGO or TGO/bond coat interfaces. No chemical reaction was reported between sodium sulfate and mullite. Stabil Al_2O_3 layer between TGO and top coat had effective role in prevention for top coat deterioration. In Fig.1, After corrosion testing, micrograph cross-section of samples 3.

Fig.2. After corrosion testing, micrograph of sample 3



a) b)

Fig.3 Surface of “sample 3” a)before corrosion test, b)after corrosion test

The amount of coating cracks at increasing the amount of mullite increased after the experiment, so it reduces the resistance of the coating were observed with high-temperature corrosion. In addition to being much thicker than the coating cracks and pores generated within a larger structure (Fig.3).

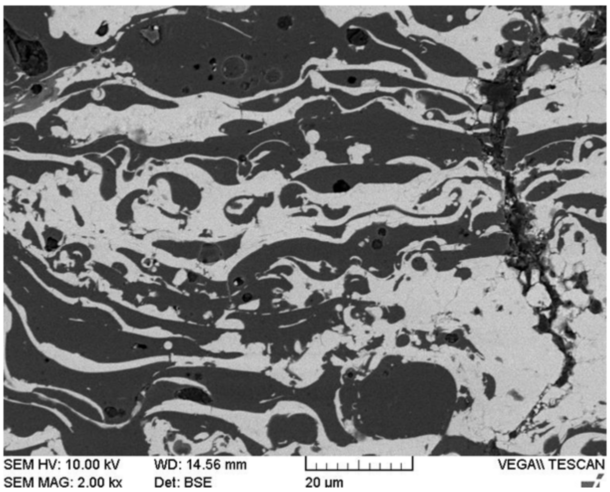


Fig.4.SEM analyses of sample 3 after corrosion test

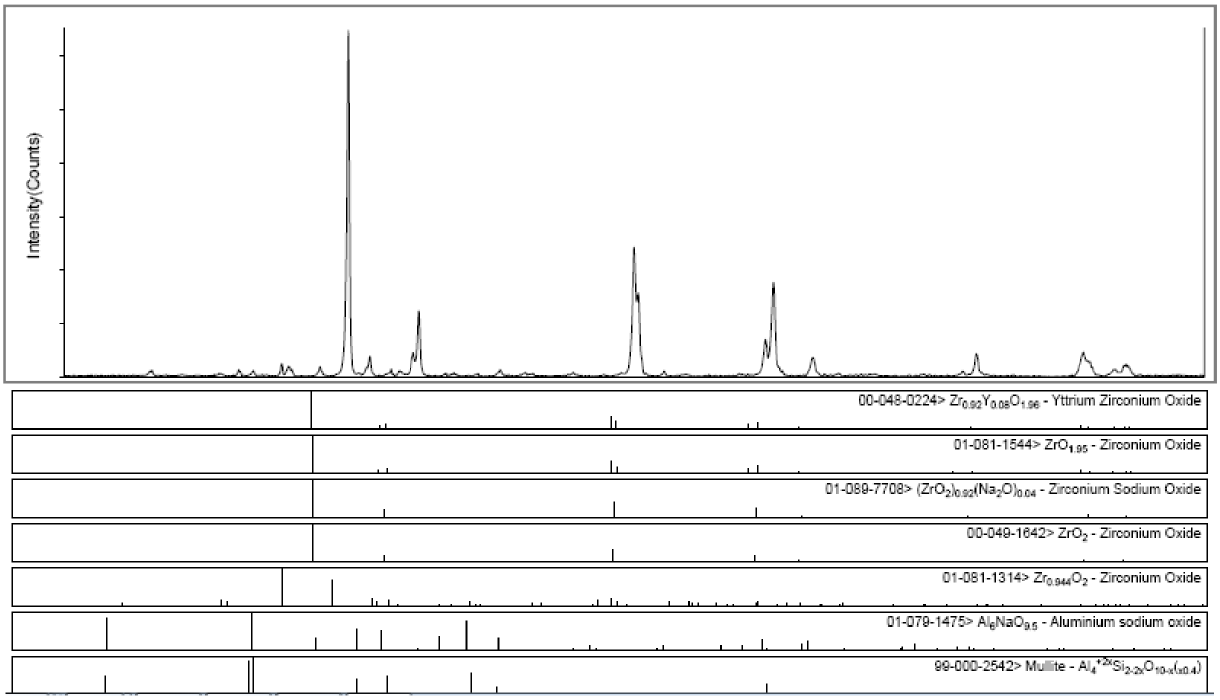


Fig. 2. XRD pattern after hot corrosion test at 950 ◦C for 10 h