Regular Paper

High Temperature Corrosion of ZrO_2-4mol%Y_2O_3 Thermal Barrier Coatings with Volcanic Ash

Byung-Koog JANG[1,*], Seongwon KIM[2], Yoon-Suk OH[2] and Hyung-Tae KIM[2]

[1]*Research Center for Structural Materials, National Institute of Materials Science (NIMS), 1-2-1 Sengen, Tsukuba, 305-0047, Japan*

[2]*Korea Institute of Ceramic Engineering and Technology(KICET), 3321 Gyeongchung Rd, Sindun-Myeon, Icheon 17303, Korea*

Received Jun. 15,2017; accepted for publication Jul. 6, 2017

Abstract

High temperature corrosion behavior was evaluated by chemical reaction between ZrO_2-4mol%Y_2O_3 (YSZ) coatings and volcanic ash at high temperature. YSZ coated specimens were obtained by electron-beam physical vapor deposition (EB-PVD) process. The volcanic ash sprinkled YSZ coatings specimens were exposed at 1200°C for 10 min~50 hr by isothermal heat treatment. At the interface between YSZ coatings and volcanic ash, YSZ coatings were partially dissolved in the molten volcanic glass, resulting in the degradation of YSZ coatings by the formation of the reacted region. The chemically reacted area between YSZ coatings and volcanic ash showed increasing tendency with an increase in isothermal heat treatment time.

Keywords: ZrO_2-4mol%Y_2O_3, Thermal barrier coatings, EB-PVD, Volcanic ash

1. Introduction

Thermal barrier coatings (TBCs) are applied to metallic components of engines to prevent the temperature of the metal becoming too high, as well as to provide environmental protection and extend the life of the components in the gas turbine engine. Among the various coating processes for producing TBCs, electron beam-physical vapor deposition (EB-PVD) is widely used because it has several advantages over other techniques, including a high deposition rate, the ability to use high melting point oxides, and excellent thermal shock resistance behavior due to the columnar microstructure of the coatings produced [1–3]. The state-of-the art material for TBCs of turbine engine airfoils is tetragonal Y_2O_3 partially stabilized ZrO_2. Several studies on thermal properties and the microstructure of TBCs fabricated by controlled deposition processes have been reported [4-6]. However, TBCs have received the degradation or damage by chemical reaction with CMAS (calcium–magnesium–aluminum–silicates) or volcanic ash particles attached to the TBCs surface at a high temperature, above 1400°C, resulting in a critical accident for aircraft. In spring 2010, the severe disruption in air travel and the economic loss approaching two billion dollars were caused by the flight stop of all air plane due to explosive eruption of Eyjafjallajökull volcano in Iceland because the volcanic ash clouds can give dangerous damage to aircraft jet engines during aircraft flying [7]. For the reason, the investigation of thermally chemical corrosion of TBCs is an important for long life time of TBCs at high temperature.

Therefore, in this work, we investigate the influence of volcanic ash on high temperature corrosion of EB-PVD YSZ coatings by isothermal heat treatment at a high temperature.

2. Experimental Procedure

The YSZ coatings onto coin-shaped dense ZrO_2 substrates 10.0 mm in diameter and 2 mm in thickness were performed by the EB-PVD process under a vacuum level of 10^{-4} Pa using a 45 kW electron beam gun and the use of YSZ ingot. The average coated thickness was about 300 μm. The volcanic ash (Kagoshima, Japan) was used to evaluate the high temperature corrosion of YSZ coatings. The volcanic ash of 1wt% against

*Corresponding author: JANG.Byungkoog@nims.go.jp