PRODUCTION AND CHARACTERIZATION OF SELF-HEALING PROPERTIES OF B4C+SIC ADDED TBC

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Abstract

Thermal barrier coatings have significant interest for protecting of the effect of high temperature the materials used under high temperature. To coat the materials used under high temperature such as gas turbine liners, is considerably important. Yttria stabilized zirconia (YSZ) is the most common material used for that purposes in commercial applications. Thermal barrier coatings damage due to the thermal expansion and internal stress, formed by the temperature variation. The micro and macro cracks, which are formed under service life of the coating, causes the coating failures such as spallation by developing crack network. In this research SiC and B4C powders added into commercial YSZ powder to improve thermal shock resistance. Two different powder ratio were prepared as %25(%12,5 SiC +B4C) %75 YSZ and %50(%25 SiC +B4C) %50 YSZ. After preparing powders coatings were manufactured using F4 plasma gun. Coated samples were subjected to thermal shock test in burner rig testing equipment and as well oxidation tests were carried out as well for 10h, 20h and 50h at 1000°C. TG and XRD analysis were used to investigate self-healing products. Scanning Electron Microscope and Optical Microscope were used to examine microstructural properties of SiC and B4C added YSZ.

Introduction

Gas turbine's hot section liner materials and space and aircraft hot section materials, rockets and satellites are protected with a Thermal Barrier Coating (TBC) system from high temperature effects. (1,2,3,4). In order to protect materials from high temperature oxidation TBCs are manufactured consisting two different layers. In present high-temperature systems, a thermal barrier coating (TBC) is applied as a top coating on diffusion or connection coating to lower metal surface temperatures. In combination with internal cooling of the component, a temperature gradient of 100–150◦C can be acquired through the thickness of the TBC (Peters et al. 2001). Today's TBC's are prepared of yttria stabilized zirconia (ZrO2 with 6–8 wt%Y2O3) and deposited by plasma spraying or EB-PVD (5). In the high-temperature TBC coating system, the diffusion or overlay coating, often referred to as bond coating (BC), provides the protection against high-temperature oxidation. In this case, the oxide layer that forms between the BC and the TBC is referred to as the thermally grown oxide (TGO) layer.

Failure of the high-temperature TBC coating systems is limited mainly to the surrounding of the TGO layer, although cracks initiated at the TGO layer can run vertically through the TBC and reach its free surface (6). The fragile TBC experiences cracks that run predominantly parallel to the TGO layer.

Self-healing concept is to fill the cracks by using reaction products of the additives in the top coat during service condition. Wim G. Sloof (7) reported self-healing properties of high temperature properties of coatings at high temperature. Guo, et al.(8) has reported the B4C has self-healing properties as coating on SiC/C composite. In this work, The self-healing properties of B4C and SiC added YSZ top coat was studied.

Experimental

In this work, B4C and SiC powders were mixed with commercial Ytria Stabilized Zirconia (204NS-Sulzer Metco, Switzerland) Figure 1 shows the powder's size distributions and SEM images. %12,5 B_4C and %12,5 SiC %75 YSZ and %25 B4C %25 SiC %50 YSZ powders were ball milled for 1 hour with zirconia balls with 3mm diameters for powder / ball ratio 1/10. Figure 2 shows the SEM images of the %12,5 and %12,5 SiC added powders. It can be seen in Figure 3 SEM image of %25 B4C and %25 SiC added YSZ powder

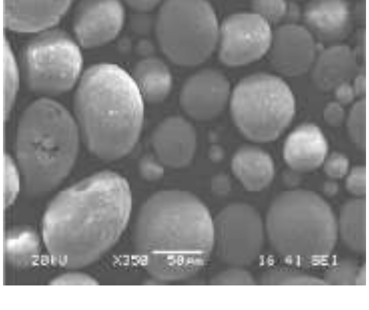
NiCrAlY and B4C and SiC added YSZ powders were sprayed onto 316 stainless steel specimen with a Sulzer Metco F4 MB gun to manufacture the coatings by using the parameters given in Table 1 for both top coat and bond coat. Coated specimens were heated to 1000°C for 10h, 20h, 50h and 100h. Moreover thermal shock tests were implemented with burner rig equipment as well. Burner rig tests were carried out as 5 min. heating and 2 min. cooling.

Table 1 Plasma Spray Parameters

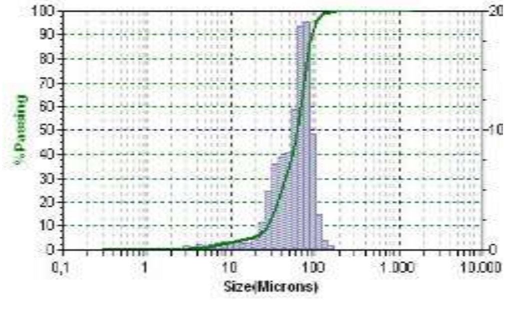
Coating	Argon Flow (NLPM)	Hydrogen Flow (NLPM)	Current	Voltage	Spray Distance	Powder Flow
Bond Coat	40	10	575A	70V	150mm	35 gr/min
Top Coat	38	12	540A	65	120mm	40gr/dk

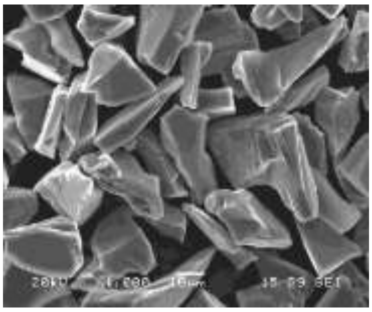
Fig. 4 shows that the as coated situation of the sample produced %75 YSZ powder. It can be seen some B4C and SiC particles were impregnated into top coat. Fig 5 shows the SEM images of coating produced from %50 YSZ powder. It is clear from both images SiC and B4C impregnated into top coat. Furthermore it can be seen from Fig. 6.

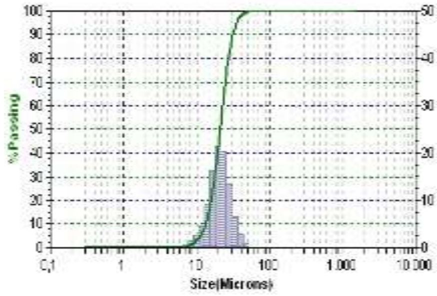
In Fig. 7 A SEM image of the coating manufactured using %75 YSZ (%12,5 B4C and %12,5 SiC) powder. It can be seen vertical crack interior of the top coat body. In Fig. 8 %50 YSZ (%25 B4C and %25 SiC) It can be seen that there is not any spallation after 20h oxidation at 1000°C.



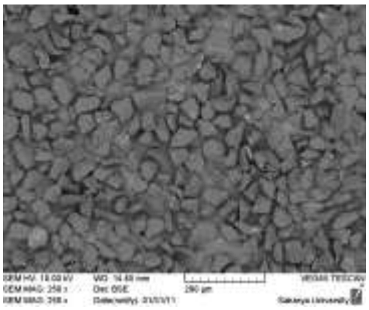
(A)

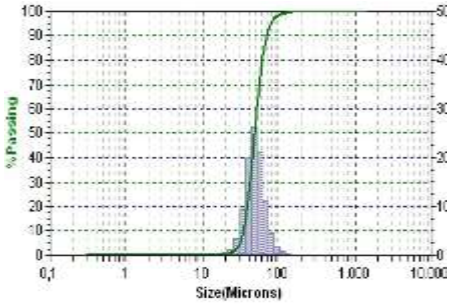






(B)





(C)

Figure 1 Powders SEM images and size distrubitions a) YSZ b) SiC c) B4C

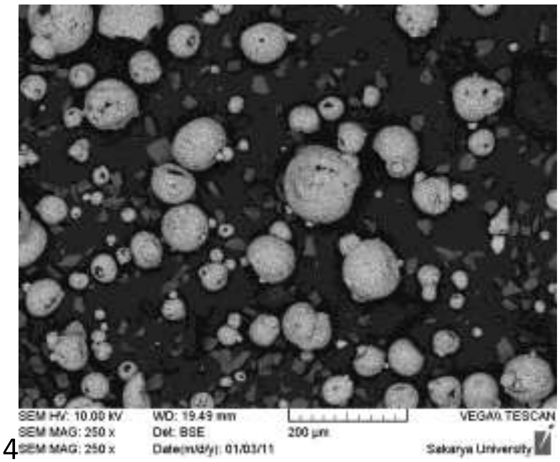


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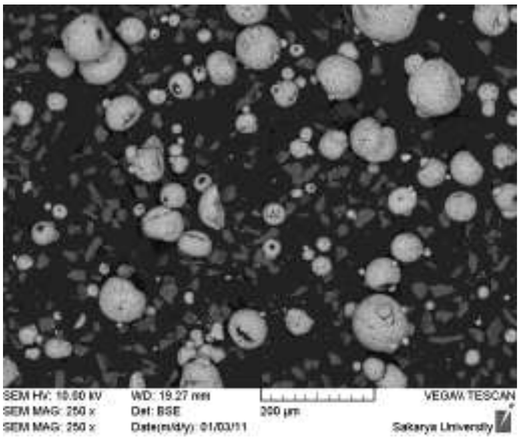
Figure 2 SEM image of %12,5 B4C and%12,5 SiC added YSZ



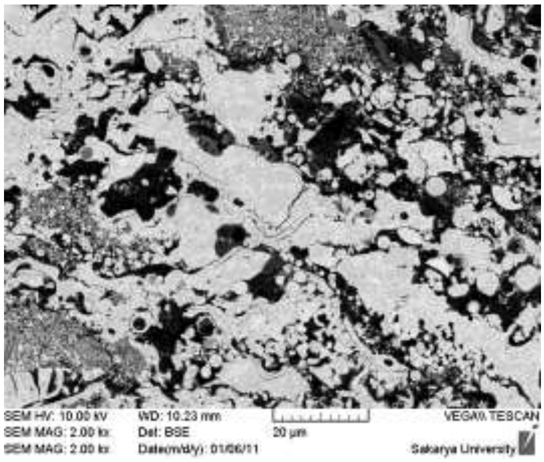
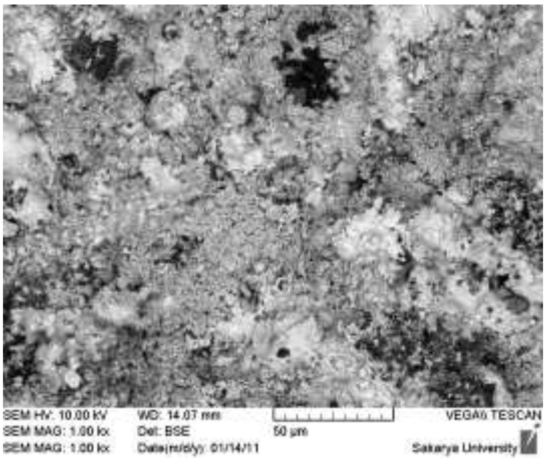


Figure 3 SEM image of %25 B4C and %25 SiC added YSZ powder



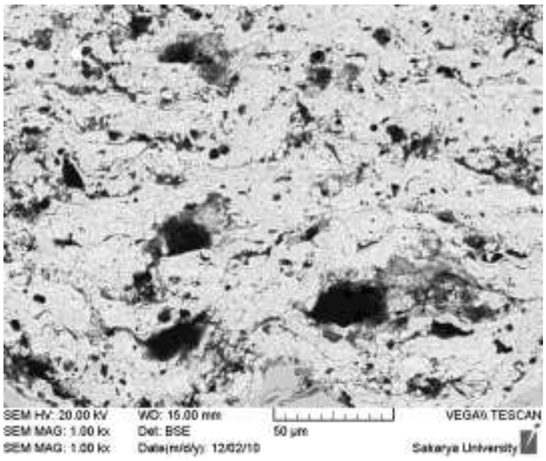


Figure 4 As coated sample produced %75 YSZ powder

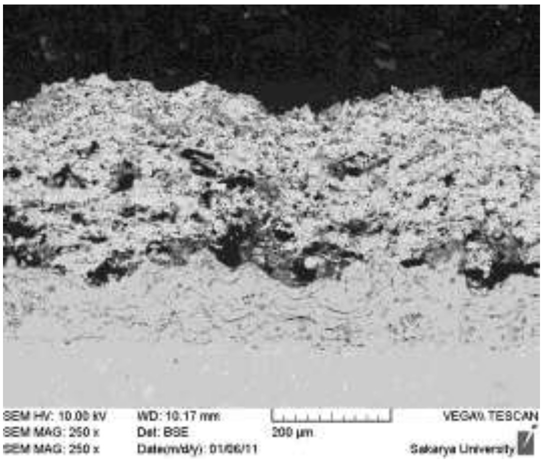
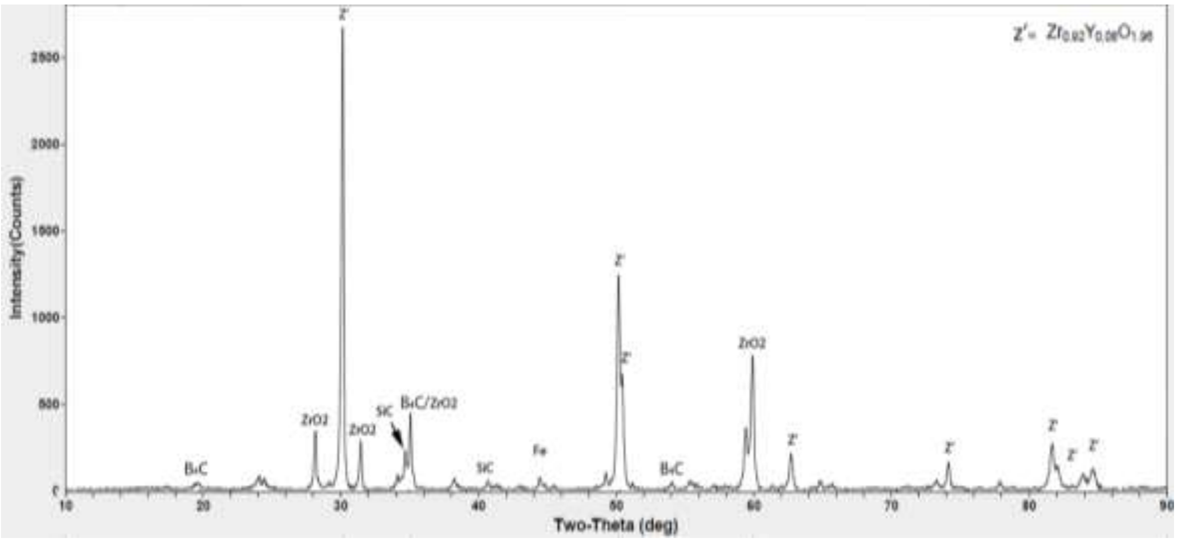
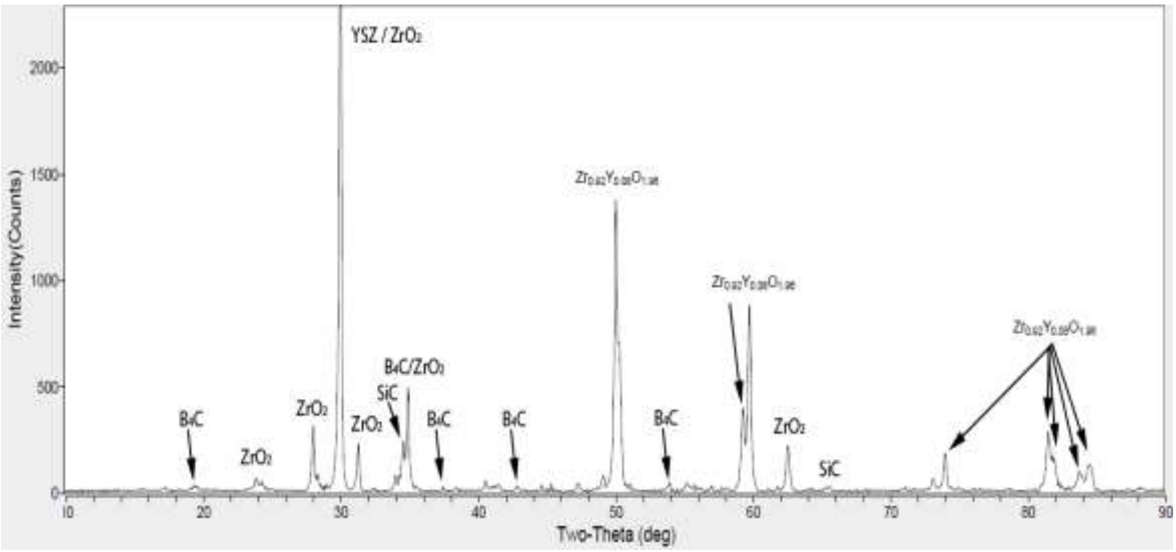


Figure 5 Fig 5 shows the SEM images of coating produced from %50 YSZ powder.



(a)



(b)

Figure 6 XRD patterns of as coated samples a) %75 YSZ b)%50 YSZ

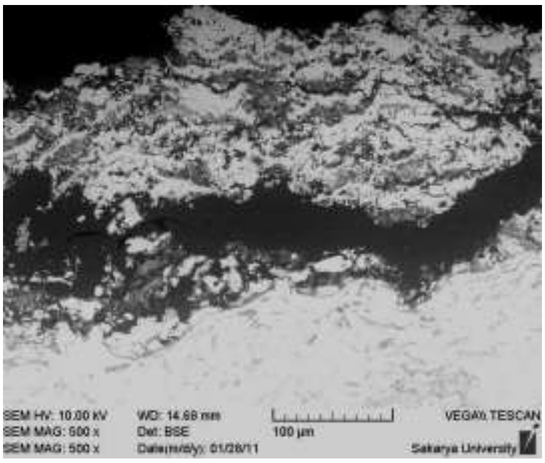


Figure 7 SEM images of %75 YSZ coating after 20h 1000°C

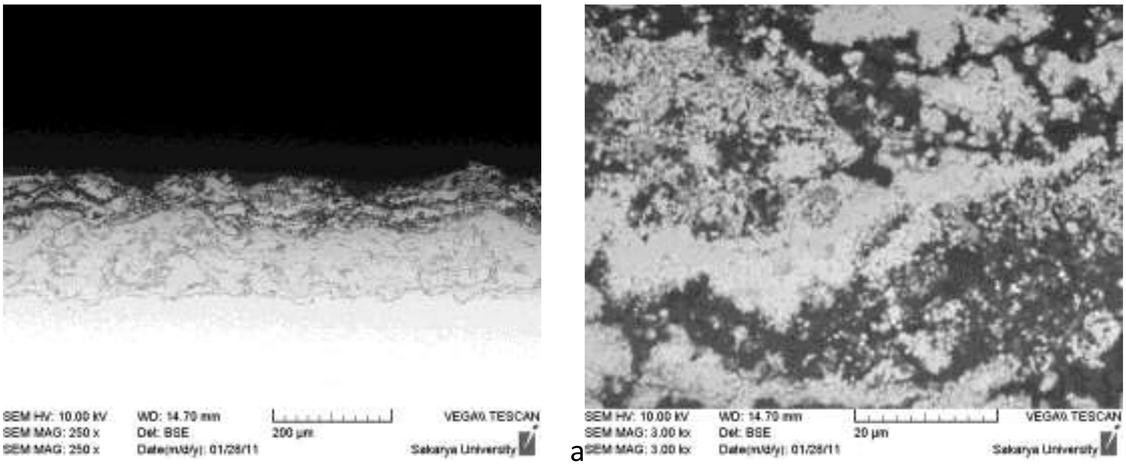


Figure 8 SEM image of %50 YSZ coating after 20 hour oxidation at 1000°C

Figure 9 shows that SEM image of top surface of %75 YSZ coating after 50h oxidation. From EDX analysis some boron oxide can be observed

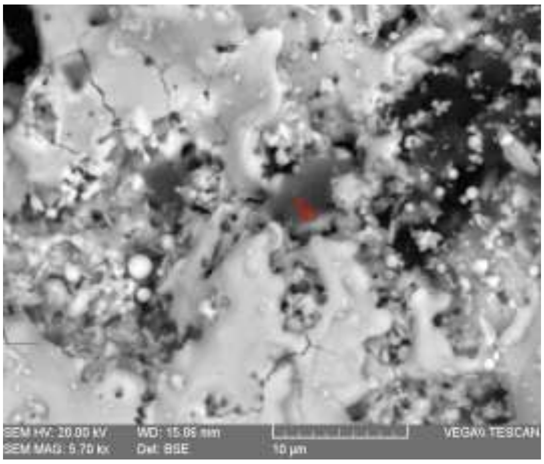


Figure 9 Top Surface SEM image of %75 YSZ after 50h oxidation.

Figure 10 shows the DSC-TGA graph of %75 coating. It can be seen there is a weight change over 700°C . From DSC –TG analysis ıt can be thought that there is clear oxidation after 700°C.

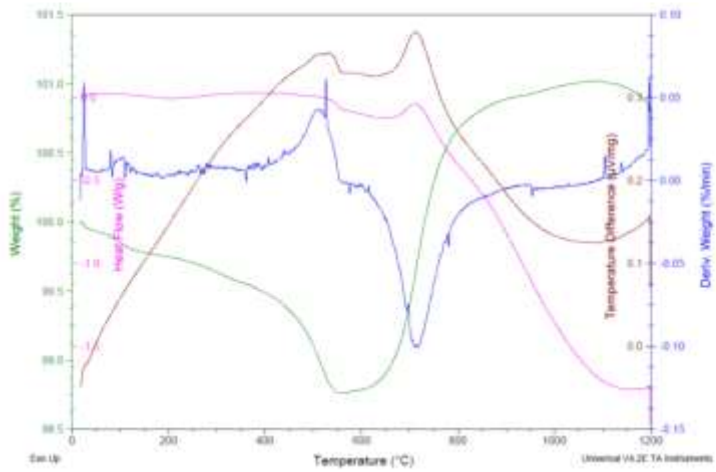


Figure 10 DSC-TG analysis of %75 YSZ coating.

It can be observed some reaction products after 200cycle burner rig tests from top surface SEM image given in Figure 11.

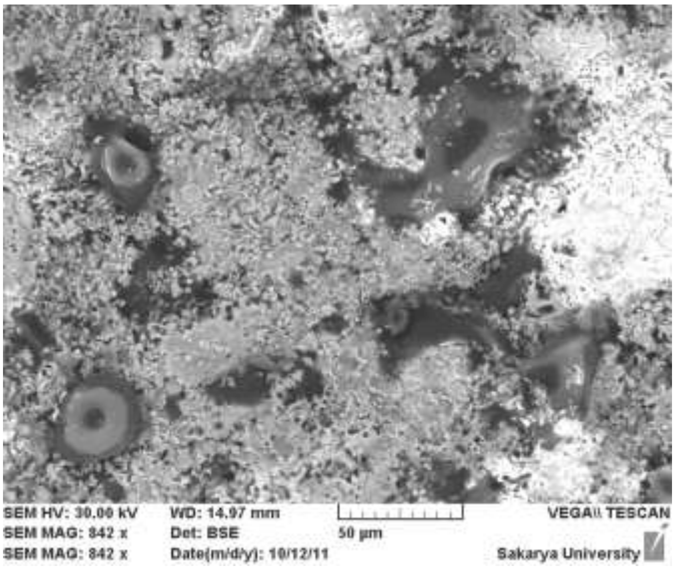


Figure 11 Top Surface SEM image of %50 YSZ coating after 200 cycle in burner rig.

Conclusions

Two different powder mixture were prepared and isothermal oxidation and thermal burner rig test were carried out in order to understand the self – healing behaviour of the coatings. Several silicon oxide and boron oxide phases were observed after both isothermal oxidation and burner rig tests.

References

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