ACOUSTIC EMISSION CHARACTERISTICS OF TGO GROWTH IN THERMAL OXIDATION TEST

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Introduction

The investigations on thermal barrier coating(TBC) by plasma spraying have been continuously conducted by many researchers to meet the need for developing heat-intercepting films for space shuttles and improving the efficiency of gas turbine engines. By lowering the surface temperatures of the heat-resistant metals in the gas turbines, TBC protects the parts damage from oxidation, corrosion, and abrasion that occur in a high-temperature atmosphere. In addition, TBC improves the efficiency of the gas turbine engines and the life of functional parts.[1]

TBC consists of double–layer structure of ceramic coating on top of ZrO_2-(6~8wt%)Y_2O_3 and metal bond coating of MCrAlY(M=Ni and/or Co). It is reported that TBC is the most durable in applications.[2] However, in high temperature environment, oxygen flows through the porous ceramic coating layer, and this forms a thermal grown oxide(TGO) layer. This TGO layer prevents oxidation in the substrate and coating layer. Also, peeling is generated in the coating layer due to reduced adhesion. Many researchers are trying to reduce this defect to enhance the durability of the coating layer.[3] In investigating defect of coating layer, the acoustic emission(AE) technology has recently drawn attention. This technology can be used to continuously detect deformation or damage caused from the interior of the materials.[4]

Accordingly, this study examines the grown behavior of TGO layer and the applicability of AE signal as the technology for TBC damage diagnosis in thermal oxidation test.

Experimental Process

Sample Preparation

Inconel-738 steel was used as substrate with dimensions of 40×4×5mm3. Spray powder was commercial CoNiCrAlY powder (AMDRY 9954, GTV, <45㎛) and ZrO2-8%Y2O3(8YSZ 204NS, Sulzer Metco, <70㎛), and was deposited by vacuum and atmospheric plasma spraying. Plasma spray parameters are given in Table 1. The coated samples were heating inside tube furnace with 1050℃ for 50, 100, 200hours by thermal oxidation tester.

Table 1 Conditions of plasma spraying process

Parameters	Bond coating	Top coating
Plasma spray process	VPS	APS
Working Pressure[mbar]	200	1013
Plasma Arc current[A]	800	600
Primary Gas[SLPM]	55	45
Secondary Gas[SLPM]	6	11
Stand-off distance[mm]	300	65
Powder feeding rate[g/min]	48	45
Carrier Gas[SLPM]	3	6

AE Test

AE monitoring system is shown in Fig. 1. It composed of PICO type sensor, a wide band pre-amplifier (40dB), computer with AE DSP(16/32 PAC)board. The Elastic wave was generated by Nd:YAG(wavelength 1.06㎛) laser. The laser beam with diameter of 3mm was focused on the TBC surface. The laser power was 5mJ and pulse width 0.1sec. The AE hits, energy and AE RMS of coating specimens are analyzed.

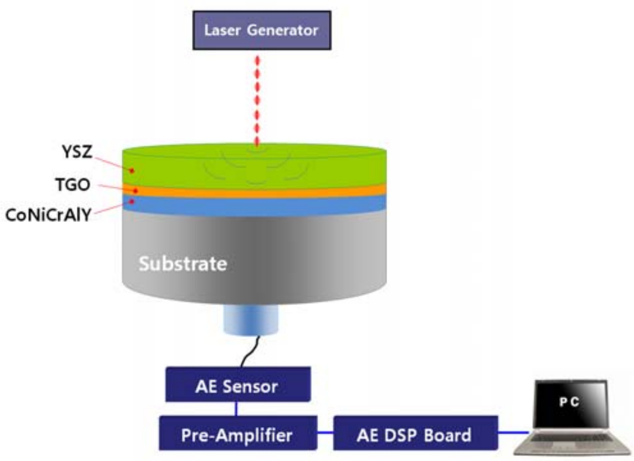

Fig. 1 Schematic diagram of laser and AE system

Results and Discussion

Microstructures

Fig. 2 shows the images of TGO between bond(CoNiCrAlY) and top coating(ZrO_2-8%Y_2O_3) layers in condition of 50, 100, 200 hours. The TGO thickness increase as the thermal oxidation time increases. It has been reported that, in the early stage of the thermal oxidation tests, the reaction of Al with a high oxygen affinity resulted in the formation of TGO which can could lead to the failure of TBC.[5]

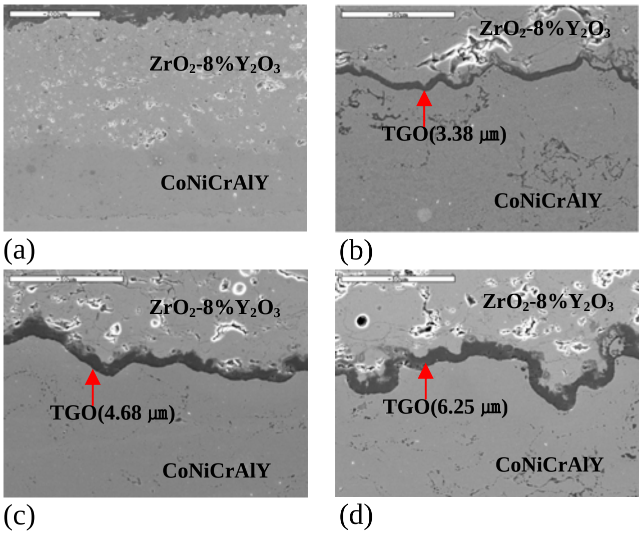

Fig. 2 SEM images of cross section after thermal oxidation test
(a)as-spray (b)50hr (c)100hr (d)200hr

AE Signal Characteristics

The laser beam was focused on the TBC surface for generation of elastic wave. Fig. 3 shows the AE hits and AE energy obtained from the specimen which is composed of the CoNiCrAlY bond coating layer and the ZrO_2-8%Y_2O_3 top coating layer. TGO thickness tended to increase as the thermal oxidation time was in creased. This TGO could reduce AE signal inclined from laser beam. As shown Fig. 3, AE hits and AE energy tended to decrease as the thermal oxidation time was increased.

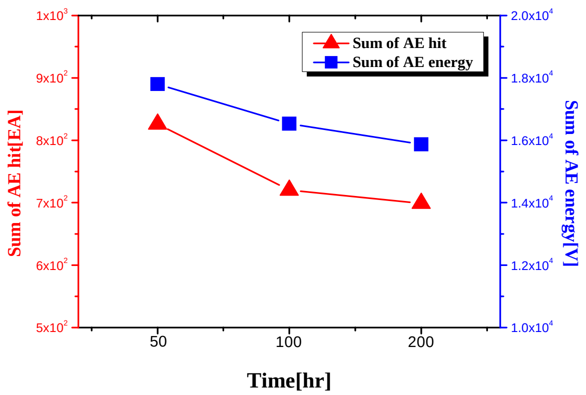

Fig. 3 AE hit and energy depending on thermal oxidation time

Fig. 4 shows the AE RMS signal depending on thermal oxidation time. The AE RMS tended to decrease as the thermal oxidation time was increased. This can be ascribed to the TGO layer that can be generated between bond coating layer and ceramic top coating layers.

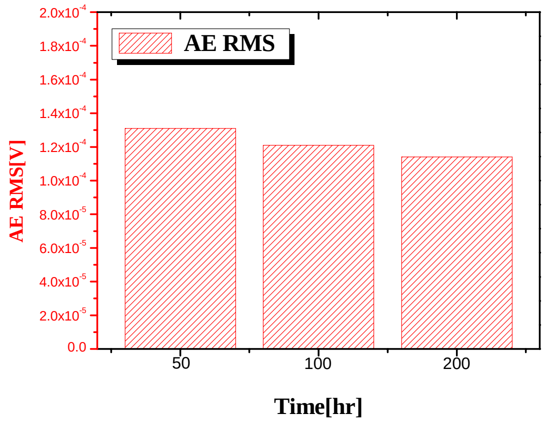

Fig. 4 AE RMS depending on thermal oxidation time

Conclusions

The characteristics of AE signal were investigated in thermal oxidation test with laser beam focusing. AE hits, AE energy and AE RMS signal derived from TGO were decreased as the thermal oxidation time was increased. The analysis method of AE signal can be used to monitor the behavior of TGO growth.

Acknowledgements

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