MECHANICAL PROPERTIES OF HOT CORROSION TESTED APS AND EB-PVD MULTILAYER THERMAL BARRIER COATINGS USING NANO INDENTATION

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Introduction:

Thermal Barrier Coatings (TBCs) are the thin film protective layer coatings used to improve the life of the turbine blade material and increase the efficiency of turbines. TBCs consist of three different layers namely Bond Coat (MCrAlY, M = Ni or Co or Both), Thermally Grown Oxide (TGO, Al_2O_3) and Top Coat (YSZ) [1]. Air Plasma Spray (APS) and Electron Beam Physical Vapor Deposition (EB-PVD) processed samples have been used for thermo-mechanical evaluations of TBCs under high temperature conditions. Mechanical behaviors of the TBC samples are analyzed by Portinha et.al and Limarga et.al using Vicker's indenter as a function of porosity and axial distance [2, 3]. In recent studies, hardness and elastic modulus were measured on the TBC coatings using nano-indentation techniques [4, 5].

In our study, different percentages of alumina are added to the top coat layer of the TBCs in multi-layered TBC samples. The performance of TBCs is of critical interest for severe corrosion conditions at elevated temperatures. The hot corrosion Type II effects (705ºC) have been analyzed for up to 100hrs with 20hrs intervals after testing in sulfur bearing environments using Dean Rig test equipment. Young's modulus and hardness values of post corrosion tested TBC specimens are evaluated using nano-indentation technique.

Experimental:

The TBC samples used for the study of mechanical properties are prepared using APS and EB-PVD processes with different compositions of alumina as top coat layer. The changes in the mechanical properties are studied using Hysitron Triboindenter. It is specialized equipment with capability of measurement of mechanical properties to nano resolution. Bercovich tip is used for the indentation on to the samples tested. Hardness and the reduced Young's modulus are calculated by the equipment. The compositions of the samples tested are shown in Table 1.

Table 1 Composition of Nano Indentation Tested Samples

Material Process	Top Coat Composition	Hot Corrosion (hrs)
APS	YSZ (150 µm) + 70%YSZ-30% Al_2O_3(150 µm)	20, 100
	YSZ (150 µm) + 85%YSZ-15% Al_2O_3(150 µm)	20, 100
EB-PVD	70%YSZ-30% Al_2O_3 (300 µm)	20, 80
	85%YSZ-15% Al_2O_3 (300 µm)	20, 100

Results and Discussion:

SEM micrographs of the hot corrosion tested samples after 100 hrs under type II test conditions of APS and EB-PVD multi-layered specimens are shown in Figure 1. Figure 2 and 3 show the nano indentation hardness values and Young's modulus (GPa) results plotted for the four different test conditions after type II hot corrosion testing. In the specimens evaluated; longer durations were 100 hrs except for EB-PVD 70%YSZ-30%Al_2O_3 which had difficulty in specimen preparation after 100 hr duration hot corrosion test. For this condition, 80 hrs test duration was used.

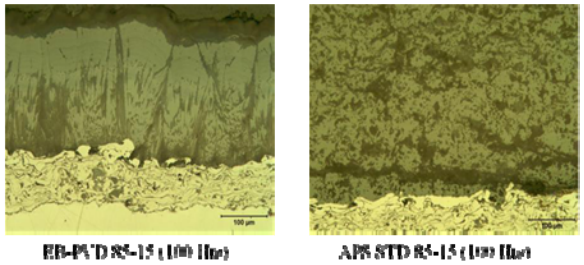

Figure 1Type II Hot Corrosion of APS STD and EB-PVD Multilayer TBCs

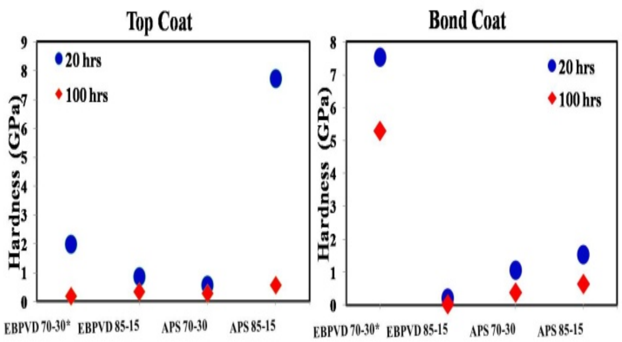

Figure 2 Hardness (GPa) for Different Test Specimen Conditions

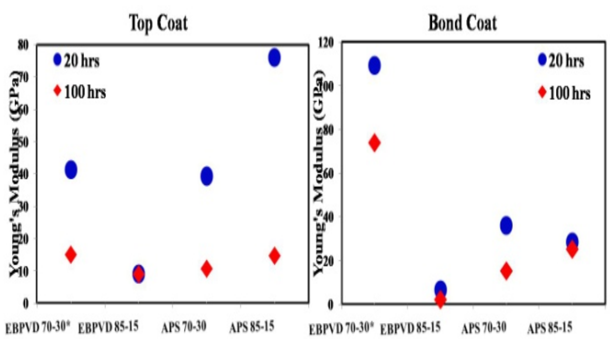

Figure 3 Young's Modulus (GPa) for Different Test Specimen Conditions

Conclusion:

Nano indentation tests are performed to study the mechanical properties of the hot corrosion tested multilayer thermal barrier coatings. Decrease in the hardness and the Young's modulus are observed with extension in hot corrosion testing time. Study of Nano indentation results has demonstrated that Young's modulus and hardness values decreased which indicates the effect of hot corrosion. As the hot corrosion effects intensify, a trend is seen that could be correlated to lowering of peel stress and eventual spalling of the TBCs. It is also noted that corrosion damage is reduced with addition of alumina in the multi-layered TBCs.

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