EVALUATION OF CREEP BEHAVIOR OF Ti-6Al-4V ALLOY WITH TBC AFTER LASER REMELTED PLASMA SPRAYED

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Abstract

Titanium alloys have been applied in aeronautical components mainly due to their high strength weight ratio. Yttria-stabilized zirconia (YSZ) of thermal barrier coating systems (TBC) applied by air plasma spraying (APS) increases the lifetime of turbine blades by providing higher operating temperatures. Laser modification of YSZ layer is a technique that has been investigated to enhance the properties of components with TBC. This work evaluated the creep behavior of Ti-6Al-4V alloy with CO_2 laser remelted plasma sprayed thermal barrier coating. Creep tests were performed at constant temperature and load in the range of 500 to 700 °C at 125 MPa. The microstructure and fractography of the specimens were also investigated. The stationary creep rate at 600 °C reduced by 50 % and the creep rupture life increased by 20 %, which can be associated with greater oxidation resistance and thermal protection. Typically ductile fractures formed by equiaxial dimples were observed. In a region close to the fracture, it was observed a dual phase (α+β) equiaxed microstructure homogeneously distributed.

Introduction

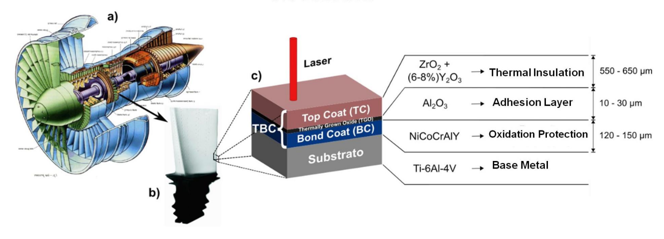

Figure 1: (a) Turbine. (b) Turbine blade with TBC. (c) Schematic representation of TBC system.

Materials and Methods

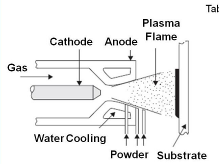

Figure 2: Air plasma spray (APS) deposition.

Table: Testing parameters used in the creep test.

Samples	σ (MPa)	T (°C)
TBC L-TBC	125	500 600 700

Figure 3: Creep test sample with TBC.

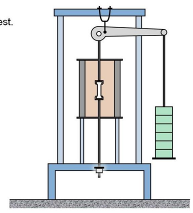

Figure 4: Schematic diagram of creep testing machine.

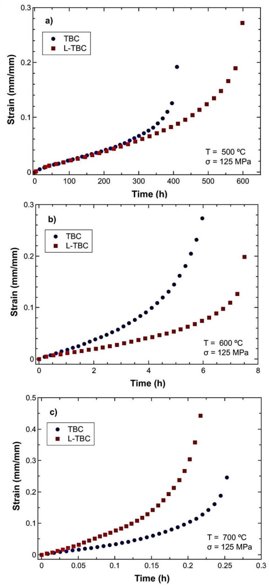

Figure 5: Creep curves of TBC and L-TBC at 125 MPa at a) 500 °C; b) 600 °C; c) 700 °C.

Table 1: Creep data of TBC e L-TBC at 125 MPa.

Sample	T (°C)	t_p (h)	$\dot{\varepsilon}_s$ (1/h)	t_r (h)	ε_f (mm/mm)
TBC	500	27.30	0.0002	409.00	0.1922
	600	0.21	0.0187	6.16	0.4092
	700	0.01	0.3050	0.25	0.2458
L-TBC	500	30.00	0.0002	598.10	0.2723
	600	0.52	0.0094	7.50	0.1990
	700	0.01	0.7893	0.21	0.4429

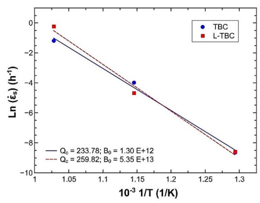

Figure 6: Dependence of steady-state rate on temperature at 125 MPa for TBC and L-TBC.

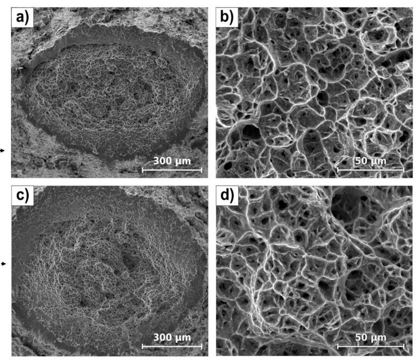

Figure 7: SEM images showing the fracture morphology after creep test at 600 °C and 125 MPa: (a) and (b) TBC; (c) and (d) L-TBC.

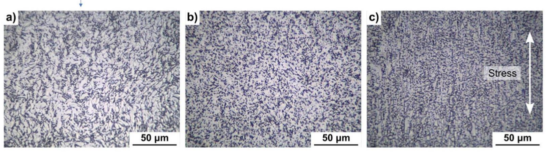

Figure 8: Microstructure images of L-TBC sample tested at 500 °C and 125 MPa: (a) (b) cross section and (c) longitudinal section.

Conclusions

In most of tested samples, the laser remelting treatment improved creep behavior, reducing the secondary stage rate by 50% and increasing the creep lifetime by 20% in condition at 600 °C. The better creep life of the L-TBC samples can be associated with greater oxidation resistance and thermal protection. The creep behavior can be described by the power law and the creep activation energy found for TBC and L-TBC was, respectively, 233.78 kJ/mol and 259.82 kJ/mol.

The fractures show a cup-and-cone morphology and a surface formed by dimples, characteristic of ductile type failure.

A thin equiaxed microstructure was observed, in which it is composed of α and β phases that are homogeneously distributed. After creep test, there was a grain size reduction and a grain elongation in the direction of applied stress.

Acknowledgments

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