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Cyclic Oxidation of Gamma Met PX

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Titanium aluminide alloys are candidate materials for a number of high-temperature applications. The development of alloys with adequate oxidation resistance is one of the challenges in the application of titanium aluminide alloys. Cooling from a high temperature oxidation exposure generates thermal stresses in the oxide scale, which can lead to scale spallation and degradation of the oxidation resistance. Thus, the resistance to cyclic oxidation can be inferior to the resistance to isothermal oxidation.

The oxidation resistance of titanium aluminide alloys is affected by even small additions of alloying elements. Niobium has been shown to be one of the most effective elements and is a major alloying addition in a commercial alloy, Gamma Met PX, which has been developed by Plansee, AG (Tirol, Austria) for improved strength, creep resistance and oxidation resistance. In this paper, the cyclic oxidation of Gamma Met PX at 900ºC and 1000ºC in air is reported and discussed.

The weight changes of the alloy during cyclic oxidation at 900ºC and 1000ºC are shown in Figure 1. The lines in Figure 1 represent fits using a parabolic rate law. At 900ºC, a parabolic rate law (k_p = 2.2 x 10^{-2} mg^2/cm^4h) was followed through 50 hours. At 1000ºC, a parabolic rate law (k_p = 1.7 x 10^{-1} mg^2/cm^4h) was followed for the first 16 hours, after which the weight decreased indicating that the oxide scale had spalled. Although attempts were made to collect the spalled oxide in the crucible holding the sample, after adding the weight of the spalled oxide to the sample weight, a weight loss was still observed indicating that some of the spalled oxide fell outside the crucible.

The scale formed on the alloy is shown in Figure 2. The numbers represent the locations at which EDS spectra were collected, the concentrations from which are summarized Table I. The scale of some of the microstructural features is on the order of the EDS spot size, so the compositions may represent averages of multiple features. As is typical of titanium aluminide alloys, the scale contains multiple layers. Below an outer titania-rich layer there is a layer that is rich in alumina. Niobium is present in the scale, but only in the mixed alumina-titania layer below the alumina-rich layer. The EDS results indicate that nitrogen is present in the interlayer between the alloy and the oxide scale, although the specific amount is not certain, since quantitative analysis of nitrogen using EDS is not reliable.

The parabolic rate constants and the conditions (time and temperature) for the onset of spallation are in agreement with those reported for other niobium-containing titanium aluminide alloys.

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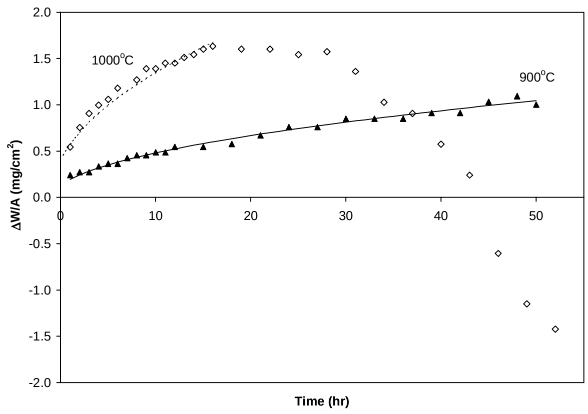

Figure 1. Weight change during cyclic oxidation (1-hour cycles) of Gamma Met PX in air at 900ºC and 1000ºC.

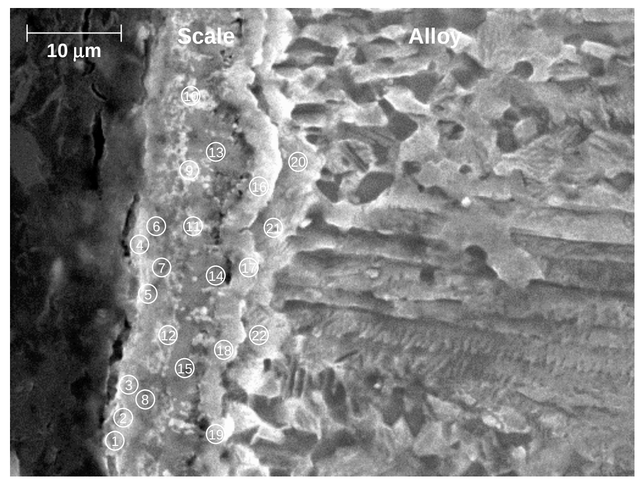

Figure 2: Secondary electron SEM micrograph of scale formed on Gamma Met PX in air after 50 1-hour cycles in air at 900ºC.

Table I: Compositions Determined from Energy Dispersive X-Ray Spectroscopy

Region	Points	Concentration (At%)					Al/Ti Ratio
		Ti	Al	Nb	O	N	
Outer layer	1-5	25	15	0	61	0	0.6
Alumina-rich layer	6-8	9	28	0	63	0	3.2
Middle of oxide	9-12	17	16	1	67	0	0.9
Inner oxide	13-15	25	9	2	65	0	0.4
Nitrogen-containing interlayer	16-19	38	21	2	14	25	0.5
Alloy beneath scale	20-22	Proprietary					1.0