Improvement of the γ-TiAl Oxidation Resistance by Aluminizing

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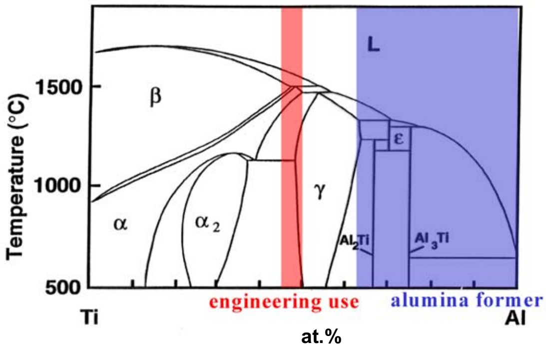
Introduction

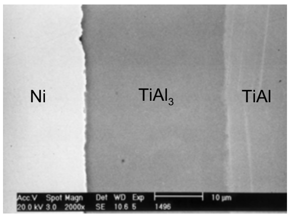
In combination with good stiffness and strength, titanium aluminides offer the potential for component weight savings on the order of 50% over superalloys and steels. The target application temperature range for Ti-Al intermetallics is 600-1000°C. However, the use of TiAl based components above 800°C is limited especially by their poor environmental resistance. The present study deals with aluminizing as a possible method for improving γ-TiAl high-temperature oxidation resistance.



Experimental procedure

The pack-cementation coating process was used to aluminize the surface region of a γ-TiAl alloy to a potential alumina-forming phase. Coating was formed by burying γ-TiAl coupons for 5 h at 800°C in a powder mixture consisting of 5 wt.% Al, 0.5 wt.% NH_4Cl, and balance Al_2O_3. The aluminized samples were tested at 800, 900 and 1000°C in laboratory air for up to 100 h.

After aluminizing

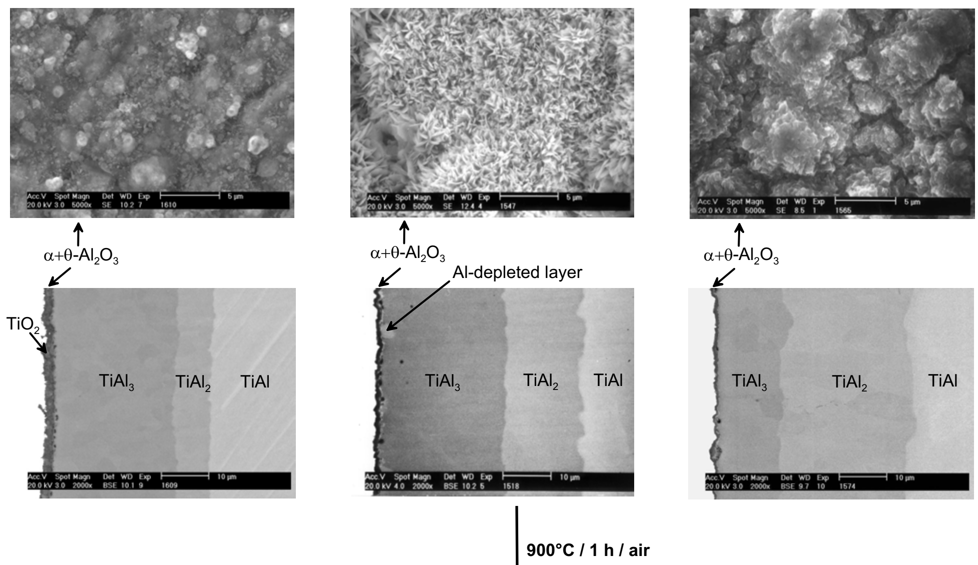


The aluminizing treatment resulted in the formation of a 30 µm thick adherent and free of cracks $TiAl_3$ layer. This layer interdiffused rapidly with the γ-TiAl substrate during oxidation, leading to the formation of a $TiAl_2$ layer at the oxide/$TiAl_3$ interface.

The $TiAl_3$ coating on γ-TiAl showed excellent oxidation resistance in air at 900 and 1000°C for 10 h, forming a protective and adherent Al_2O_3 scale. At 800°C, the oxidation process induced the formation of a thicker Al_2O_3 scale containing TiO_2 grains. At 800, 900, and 1000°C, the oxide was α+θ-Al_2O_3 as confirmed by Fluorescence spectroscopy analysis.

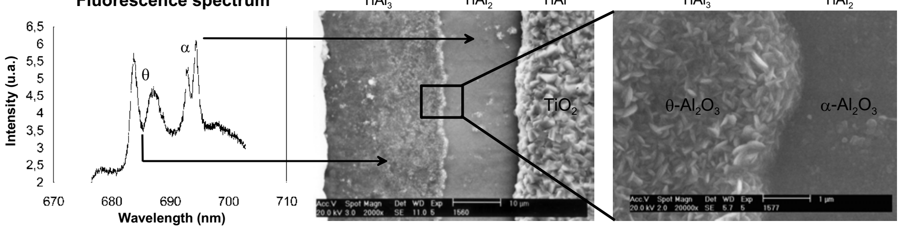
After oxidation

800°C / 10 h / air **900°C / 10 h / air** **1000°C / 10 h / air**



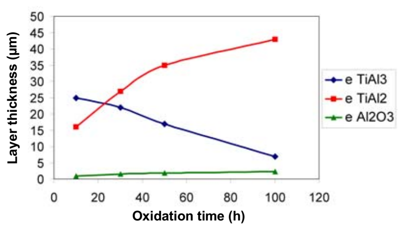
Oxidation behavior of $TiAl_3$ and $TiAl_2$ phases

To study the oxidation behavior of the different TiAl phases, a short term oxidation test was performed at 900°C on the cross section of the γ-TiAl substrate coated and oxidized at 900°C for 10 h in air. Surprisingly, the α-Al_2O_3 scale formed on the $TiAl_2$ phase was significantly thinner and free of whiskers compared to the metastable θ-Al_2O_3 formed on the most promising oxidation resistant $TiAl_3$ phase.

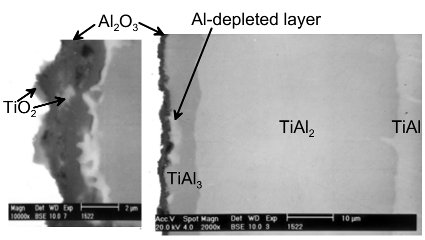


100 h oxidation at 900°C in air

When the oxidation time was prolonged to 100 h, both the oxidation and interdiffusion processes induced a decrease of the $TiAl_3$ layer thickness and an increase of the $TiAl_2$ layer thickness. From 10 to 50 h exposure time, the oxide scale was only composed of Al_2O_3. After 100 h oxidation, the alumina-forming $TiAl_3$ layer was only 7 µm thick, and some TiO_2 grains were formed in the Al_2O_3 layer.



900°C / 100 h / air



Conclusion

- An adherent oxidation resistant Al-diffusion coating was successfully formed on the surface of a γ-TiAl alloy using the pack-cementation technique. The protection was provided by aluminizing of the γ-TiAl substrate to its highest aluminide, the alumina-forming $TiAl_3$ phase.
- After 10 h oxidation at 900 and 1000°C in air, a protective and adherent Al_2O_3 layer identified as α+θ phase was formed on the $TiAl_3$ coating. The effectiveness of the $TiAl_3$ coating was seriously affected by the $TiAl_2$ phase which develops during oxidation, and after 100 h oxidation at 900°C in air, the formation of a protective Al_2O_3 layer was no longer maintained.

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