

Microstructure and reaction mechanisms at γ -TiAl brazed interfaces

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Titanium aluminide alloys based on the γ -TiAl intermetallic compound are emerging as potential materials for high performance applications on aircraft engines components, aerospace vehicles and automotive engines, owing to their low density, high specific stiffness, excellent strength retention at high temperature and good creep and oxidation resistance [1]. The development of adequate techniques to join γ -TiAl alloys, either to themselves or to other materials, is a key issue regarding the effective use of these alloys [2,3]. Understanding of the reaction mechanisms that promote bonding is mandatory when optimization of the joining procedure is envisaged.

A detail study focussing the microstructural evolution of the interfacial zone in the course of the processing of Ti-47Al-2Cr-2Nb joints using a Ti/(Cu,Ni)/Ti clad-laminated filler as brazing alloy was performed in this investigation. Joining was carried out in vacuum (better than 10^{-4} mbar) in the temperature range of 980 to 1200°C with a 10 min. dwelling stage at the brazing temperature. Experiments were also performed below the solidus temperature of the filler, at 700, 800 and 900°C, aiming the understanding of the mechanisms that promote the melting of the braze alloy. The resulting interfaces were analysed by scanning electron microscopy (SEM) and by energy dispersive X-ray spectroscopy (EDS).

In the course of the heating stage, several reaction layers composed of Ti-Cu-Ni phases were formed within the filler alloy due to the atomic interdiffusion between the (Cu,Ni) and Ti foils (see Fig. 1). After heating to 900°C, the microstructure of the brazing alloy evolved from the initial Ti(α)/(Cu,Ni)/Ti(α) layers to a symmetrical multilayered microstructure consisting of Ti(α)/Ti(α)+Ti₂Cu/Ti₂Ni/TiNi/TiCuNi/(Cu,Ni) layers.

The results obtained from the experiments suggest that the filler begins to melt near 930°C due to the Ti₂Ni+Ti₂Cu \rightarrow L reaction [4], occurring between two adjacent layers that are composed, at room temperature, of Ti₂Ni and Ti(α)+Ti₂Cu (see Fig. 1c)). The liquid will then dissolve the neighbouring layers as it spreads simultaneously towards the centre and the periphery of the filler.

When the liquid reaches the γ -TiAl alloy surface, dissolution of the intermetallic alloy and diffusion of Al atoms across the interfacial zone became the determinant factors regarding the microstructural evolution of the interface. The resulting interfaces present a multilayered microstructure, which consists of three different reaction layers, composed of α_2 -Ti₃Al+Ti(Cu,Ni)Al/ α_2 -Ti₃Al/ α_2 -Ti₃Al+Ti₂(Cu,Ni)+Ti(Cu,Ni)₂Al, sequentially from the periphery towards the centre of the interface. These layers are indicated by letters A, B and C in Fig. 2; the chemical compositions of the different reaction products detected at the interface are plotted in the isothermal sections presented in Fig. 3. Increasing the brazing temperature induces the formation of wider and Al-richer interfaces: (i) the extension of the interface increases from 111 to 257 μ m after joining at 980 and 1200°C, respectively and (ii) when joining is performed at 1150 and 1200°C Ti(Cu,Ni)Al is detected at the centre of the interface (layer C) instead of Ti₂(Cu,Ni) and Ti(Cu,Ni)₂Al.

References

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 [3] S.L. Draper, D. Krause, B. Lerch et al, *Mater Sci Eng A* 464 (2007) 330.
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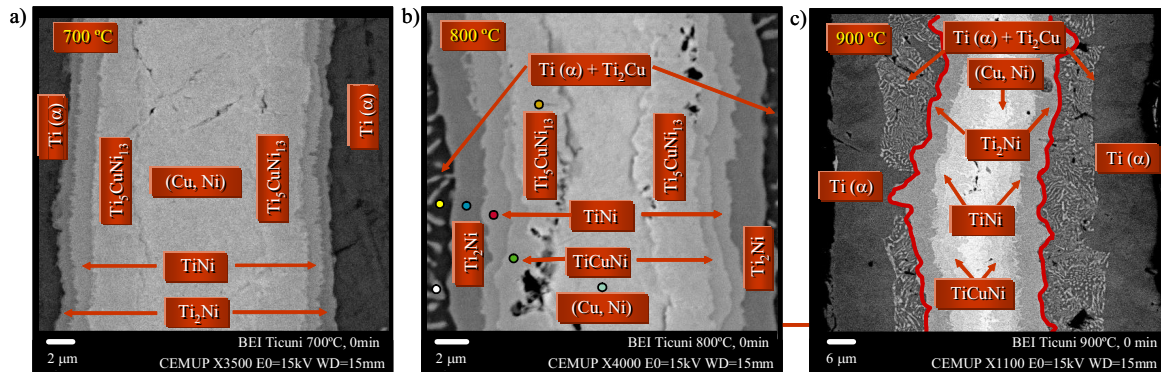


Figure 1 – Backscattered electron images (BEI) of the microstructure of the brazing alloy at room temperature, after heating to: a) 700°C; b) 800°C; c) 900°C.

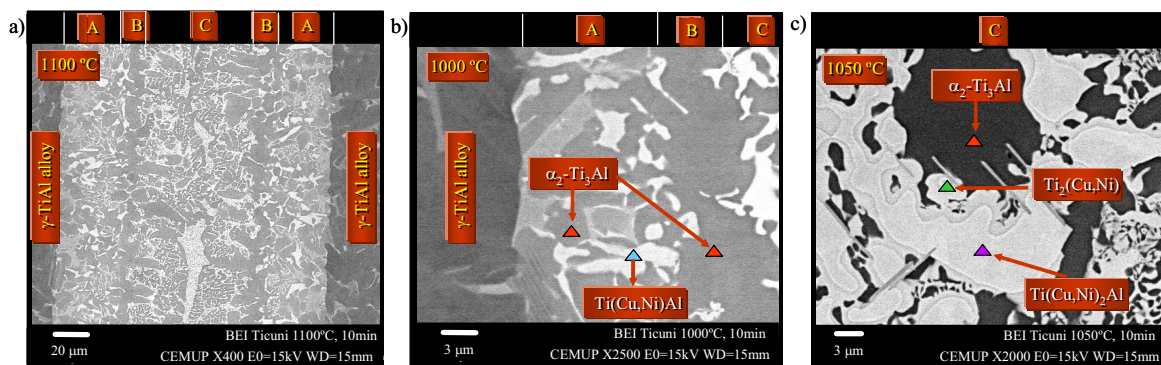


Figure 2 – BEI of the interface: a) global, after brazing at 1100°C; b) magnification showing layers A, B and part of layer C, after brazing at 1000°C; c) layer C, after brazing at 1050°C.

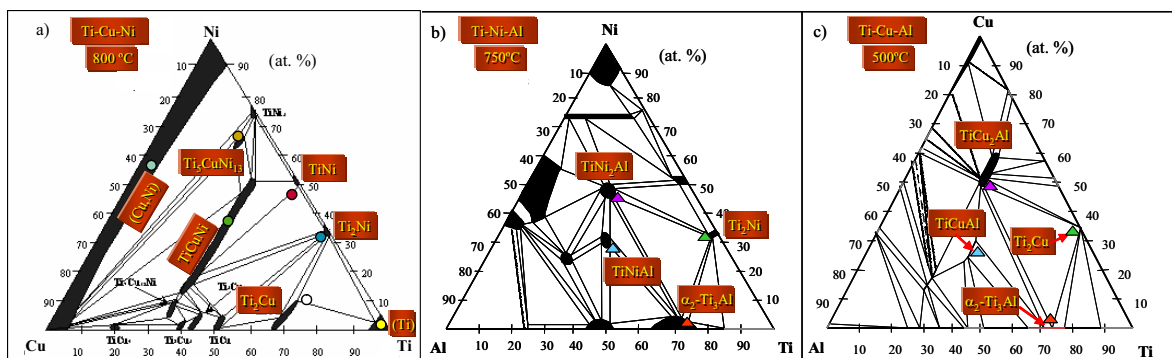


Figure 3 – Ternary isothermal sections, adapted from [4], where the compositions of some the reaction layers/products formed within the braze alloy and at the interface, respectively, are plotted: a) braze alloy (see Fig. 1); b) and c) interface (see Figs. 2b) and 2c)).