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Diffusion Brazing of Ti6Al4V and γ-TiAl alloy with Al/Cu multifoils fillers

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Hybrid structures or bi-material components made of lightweight alloys, such as Ti6Al4V and γ-TiAl based alloys, have a great prospect in aerospace, chemical and automotive industry applications, where high strength to weight ratio and good corrosion resistance are key requirements [1,2]. The development of suitable and cost-effective methods to join dissimilar materials is a major prerequisite towards the production of such structures/components. Decreasing the temperature at which joining is performed is an effective way of reducing processing costs and minimizing base materials degradation. The prospect of joining Ti6Al4V to itself and to a γ-TiAl alloy (Ti-47Al-2Cr-2Nb, at.%) at relatively low temperatures, using aluminum-copper fillers composed of stacked Al/Cu thin foils, is the main drive of the study presented in this work.
Ti6Al4V/γ-TiAl alloy and Ti6Al4V/Ti6Al4V joints were diffusion brazed in vacuum (10^{-4} mbar), with a bonding pressure of 4 and 8 MPa, respectively, using two different stacking sequences of Al/Cu thin foils as filler: Cu/Al/Cu (34.5 Cu, wt.%) and Al/Cu/Cu/Al (93 Cu, wt%). For each filler foil, joining was carried out at 625 and 725 ºC, with a dwelling stage of 60 minutes. The microstructure and chemical composition of the interfaces resulting from joining under the different processing conditions tested in this investigation were analyzed by scanning electron microscopy (SEM) and by energy dispersive x-ray spectroscopy (EDS), respectively.
Several defects, such as cracks and unbounded zones, were observed at the interfaces of Ti6Al4V/γ-TiAl and Ti6Al4V/Ti6Al4V joints when Cu/Al/Cu (34.5 Cu, wt.%) stacking sequence was used as filler, regardless of the processing temperature. As it can be observed in Figure 1a, Ti6Al4V/γ-TiAl interfaces present cracks that are parallel to the surface of the Ti6Al4V alloy along with large unbounded zones. Concerning Ti6Al4V/Ti6Al4V interfaces, cracks that are developed perpendicularly to the base materials surfaces are a characteristic feature (Fig. 1b). The detection of such defects at the interfaces clearly indicates that the mechanical properties of joints produced under the set of processing conditions tested when Cu/Al/Cu multifoil was used as filler would be inadequate for practical applications.
Changing the chemistry of the filler, by using a Al/Cu/Cu/Al (93 Cu, wt.%) foil stacking sequence, allowed reducing substantially the defects detected at the interfaces, after joining at 725 ºC, as it can be observed in Figure 2. For Ti6Al4V/γ-TiAl joints, EDS analysis indicate that bonding to both base materials is promoted by the formation of a reaction layer (23Al-27.9Ti-49.1Cu, at.%) essentially composed of $AlCu_2Ti$. Between the $AlCu_2Ti$ layer and the central zone of the interface, which consists in (Cu), a layer (22.9Al-5.4Ti-71.7Cu, at.%) composed of a mixture of phases that should comprise mainly Al_4Cu_9 and (Cu) was detected. Only some zones of the interfaces, located near the Ti6Al4V alloy surface, display pores or microcracks. Figure 2a shows a microcrack running along the interface between the Al_4Cu_9 + (Cu) layer and (Cu). In the case of Ti6Al4V/Ti6Al4V joints (Fig. 2b), bonding is ensured by a reaction layer mainly composed of Al_4Cu_9 (31.9Al-1.9Ti-66.2Cu, at.%) and (Cu); scarce microcracks may be observed at this layer. The remaining interface is apparently defect free and consists in (Cu).

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The results obtained in this investigation indicate that Al/Cu/Cu/Al (93 Cu, wt.%) multifoil may be envisaged as suitable filler for processing Ti6Al4V/γ-TiAl alloy and Ti6Al4V/Ti6Al4V joints. Further work is needed to optimize the processing conditions in order to produce sounder interfaces and to evaluate the mechanical properties of the resulting joints.

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[2] Zadpoor A. *et al.*, *Journal of Materials Processing Technology*, **200**, 288–299, 2008.

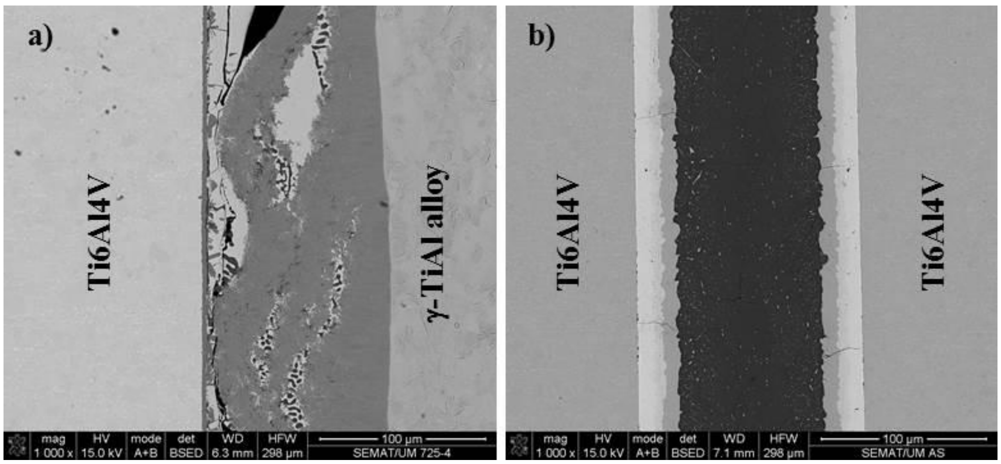

Figure 1. SEM images of the interfaces for joining with Cu/Al/Cu filler. a) Ti6Al4V/γ-TiAl alloy joint, processed at 725 ºC; b) Ti6Al4V/Ti6Al4V joint, processed at 625 ºC.

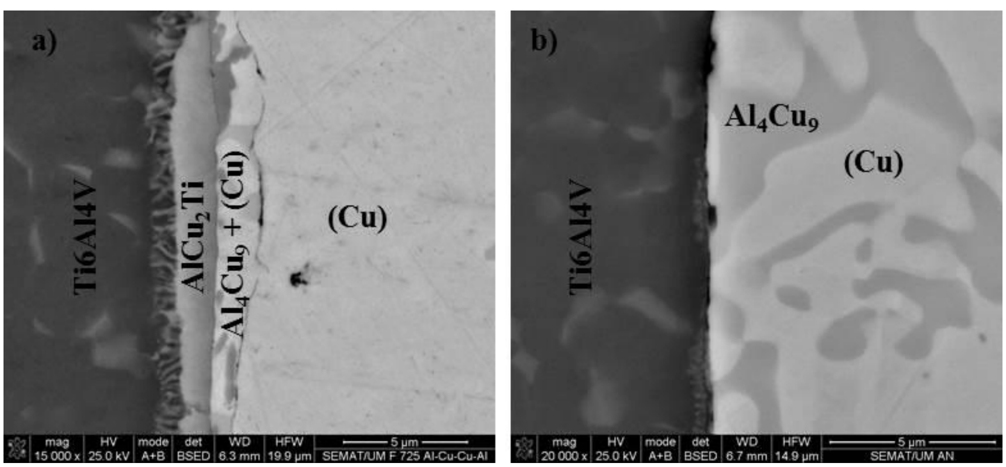

Figure 2. SEM images of the interfaces near the base materials for joining with Al/Cu/Cu/Al filler at 725ºC. a) Ti6Al4V side of a Ti6Al4V/γ-TiAl joint; b) Ti6Al4V/Ti6Al4V joint.

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