

Transient Liquid Phase Bonding of Titanium Aluminide Alloys – A Microstructural Investigation

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Transient liquid phase (TLP) bonding [1] is widely used in the aerospace industry for both initial fabrication and pre- and post-service repairs. TLP bonding is derived from high-temperature brazing [2]. However, unlike conventional brazing, extensive diffusion of bond-line and/or substrate constituents is allowed to occur during bonding. This induces compositional changes at the bond-line, which in turn raise the melting temperature of the interlayer used to form the bond. Thus, TLP bonds undergo isothermal re-solidification at the bonding temperature. If a suitable post-isothermal-solidification homogenization treatment is applied, the remelt-temperature, microstructure and hence properties of TLP bonded components can match those of the parent materials. Given that TLP bonding is conducted under isothermal conditions, well below the melting temperature of the substrates and can reproduce parent-metal microstructures, this process is well suited to the joining of damage-sensitive materials, with carefully tailored microstructures, such as structural intermetallic compounds.

The present paper forms part of an investigation, including both microstructural and processing issues, of the suitability of TLP bonding to the joining of γ -TiAl alloys. These materials are candidates for use in gas-turbine engines and other applications where a combination of low-density and reasonable elevated temperature performance is desirable. The paper concentrates on studies of microstructural development, using light, scanning-electron and edge-on transmission electron microscopy techniques. The paper considers the microstructural implications of the limited solubility, in TiAl, of possible melting-point depressants required for TLP interlayers. The paper examines the effects on microstructural development of the addition of non-melting phases to the interlayer material (these serve both to reduce the volume of liquid that must be formed and provide an efficient diffusional sink). The results presented in this paper show that, with suitable processing, microstructures extremely similar to those of the parent material can be achieved in TLP bonded TiAl alloys, as can be seen in the bond shown in figure 1. The detailed microstructure of a bond that has isothermally solidified by epitaxial growth, in this case from one of the substrates, can be seen in figure 2.

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References

- [1] D.S. Duvall et al., *Weld. J.* 53 (1974) 203-14.
- [2] G.E. Sheward, *High Temperature Brazing in Controlled Atmospheres*, Pergamon Press, Oxford, UK, 1985.
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FIG. 1. Light micrograph showing a cross-section of a TLP bond between Ti – 48 at.% Al – 2 at.% Cr – 2 at.% Nb (“48–2–2”) substrates. This bond was prepared using a 48–2–2 + Cu composite interlayer and was imaged following bonding and post-bond heat-treatment. The approximate original location of the original bond center-line is marked with arrows.

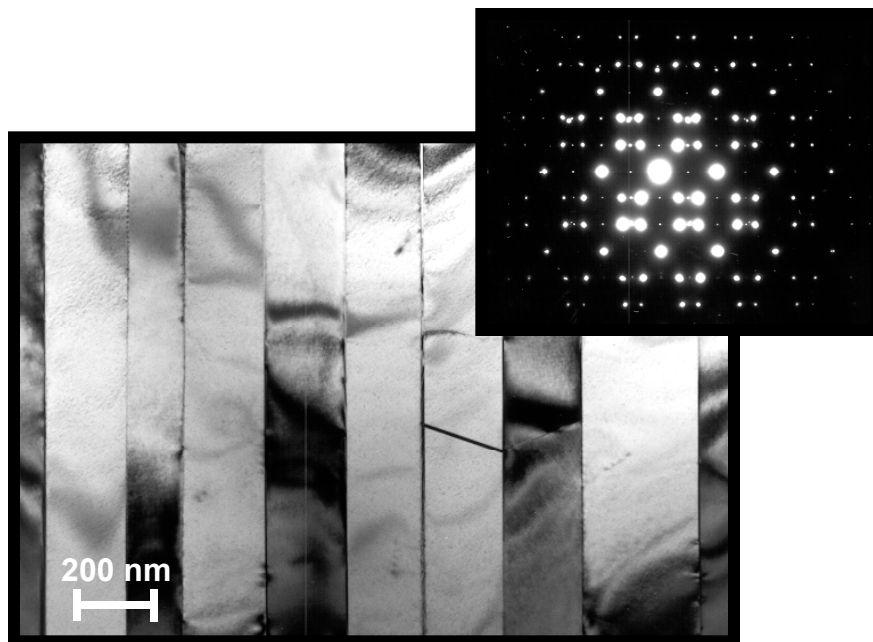


FIG. 2. Bright-field image and selected area diffraction pattern ($\mathbf{B} = [1\bar{1}0]_1 // [11\bar{2}0]_2$) acquired from an edge-on TEM specimen prepared from a bond between 48–2–2 substrates (in the as-bonded condition). This bond employed a copper foil interlayer and the figure shows a region of epitaxial growth of the lamellar microstructure of the substrates into the bond-line.