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Characterization of nanolayers at TiAl diffusion bonds

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Aerospace and automotive industries dedicate a special attention to the developments of TiAl alloys, especially to those contributing to the advance toward structural application [1]. Joining technology will be required in nearly all applications of these alloys, processes that balance performance and cost need to be establish. The bonding of these alloys is very difficult due to their high reactivity and tendency to form brittle intermetallic phases. Several techniques are reported in literature to join TiAl [2]. Nevertheless diffusion bonding is the most promising technique as avoids hot cracking, the main problem of fusion welding process [3].

To diffusion bond TiAl alloys with less demanding conditions, the authors use an alternative approach that consist in the deposition of NiAl multilayers on the joining interfaces that modifies the interface, improving the diffusivity and reactivity by promoting nanocrystallinity and increasing the number of interfaces [4].

In this study, the characterization of the TiAl diffusion bonds assisted by NiAl multilayers was performed by scanning transmission electron microscopy (STEM), transmission electron microscopy (TEM), high-resolution transmission electron microscopy (HRTEM) and analyzed by energy dispersive X-ray spectroscopy (EDS) and electron energy loss spectroscopy (EELS). NiAl multilayers with a total thickness of 2.5 μm and a bilayer thickness of 14 nm were deposited by dc magnetron sputtering on TiAl surfaces. The bonds were produced at 900 ºC during 60 minutes under a pressure of 5 MPa in vacuum. The diffusion bonding procedure and apparatus is described elsewhere [4].

AlNiTi and Al_2NiTi intermetallics are identified in an interdiffusion area, Zone 1, and grow perpendicular to the interface as columnar grains, in the diffusion flux direction, with an average grain size of 534 ± 320 (Fig. 1 (a) and (b)). At the centre of the interface Ni and Al nanolayers transform into B2-NiAl equiaxed grains with an average size of 450 ± 254 nm. The transition between these two zones, Zone 2, shows nanometric B2-NiAl grains (114 ± 76 nm). HRTEM images and correspond FFT (Fig. 2) and EELS analyses revealed that nanometric Ti aligned grains compose the bonding line; these grains are probably the result of Ti segregation during cooling from the bonding temperature.

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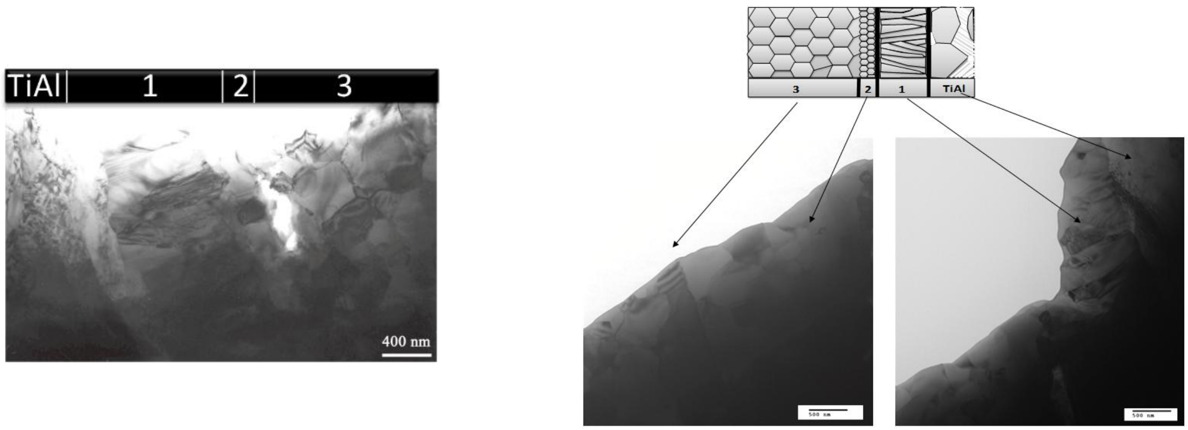
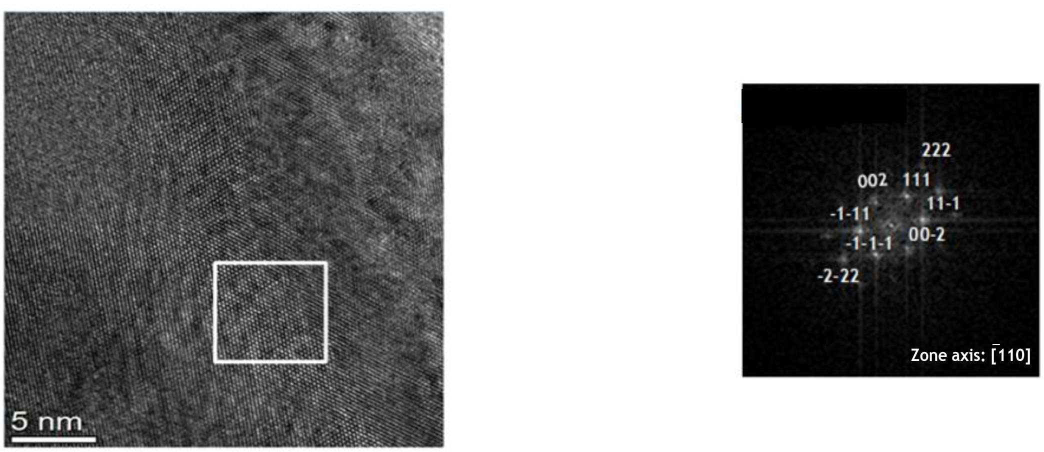


(a) (b)

Figure 1. TEM images of interface obtain at 900 ºC during 60 min under a pressure of 5 MPa with a multilayer period of 14 nm: (a) low magnification and (b) high magnification of zones 1, 2 and 3.



(a) (b)

Figure 2. (a) HRTEM image and (b) FFT of the bonding line showing the presence of titanium grains.

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