
# FAST-DB: A New Approach of Joining Dissimilar Titanium Alloys in the Solid State.

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***Highlights***

- Dissimilar powder titanium alloys have been successfully diffusion bonded using FAST
- The bond is free of cracks, unbonded regions and voids
- Hardness profiles reveal a hard phase at the interface when a metastable beta alloy is bonded
- Elemental diffusion occurs across the bond which can be modelled using commercial software

## 1. Introduction

Field assisted sintering technology (FAST) combined with subsequent cold and hot forging steps could enable titanium powder to be manufactured into components in 2 or 3 steps, providing a step change in the economics of titanium alloys. FAST-Diffusion Bond (or FAST-DB) is a new solid state approach to joining dissimilar titanium alloys.

Dynamic components are often subjected to a diverse range of stresses depending on the region of the component. For example, a compressor blade requires good fatigue properties at the root and creep resistance in the aerofoil section. To improve the performance of these components, dissimilar titanium alloys can be used in different regions to optimise the mechanical properties and also reduce material use.

## 2. Methods

Three different combinations of dissimilar titanium alloys were bonded including metastable beta, alpha-beta and alpha titanium alloys. The alloys were bonded using FAST with a dwell temperature of 1200°C and a pressure of 35 MPa to produce 20 mm samples. A combination of microstructure, hardness and X-EDS analysis was used to assess the bond interface between the alloys. Microstructural analysis was carried out using optical microscopy and with an SEM when necessary. The hardness profiling used diagonal lines of indents to provide the highest resolution possible. X-EDS analysis assessed the elemental diffusion across the bond interface, highlighting the elemental diffusion behaviour in a multicomponent system. Finally, a commercial software package was used to predict the elemental diffusion and was compared to the X-EDS data.

## 3. Results and discussion

All three combinations of dissimilar titanium alloys were successfully bonded together and were free from voids, cracks and unbonded regions. The hardness profiles revealed a hard phase at the interface for alloy combinations containing the metastable beta alloy. However, in the combinations absence of the metastable beta alloy a smooth hardness profile was seen, suggesting there are no new phases being formed at the interface. The X-EDS data showed smooth transitions of elemental diffusion across the bond, with no spikes in element concentration observed. Thermodynamic predictions of diffusion showed excellent agreement with the X-EDS data, demonstrating that diffusion in FAST processing of titanium alloys can be predicted with confidence.

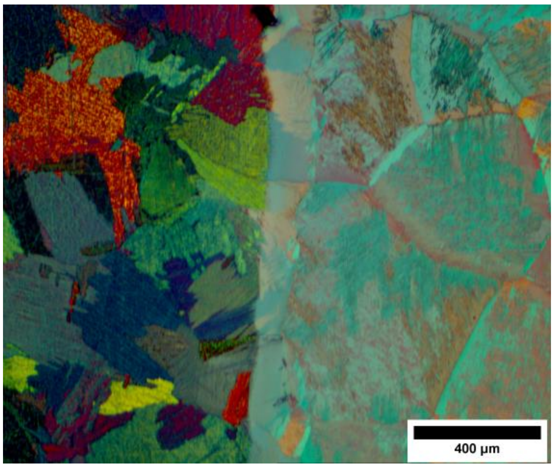


**Figure 1.** An HF etched FAST-DB sample consisting of an alpha and alpha-beta alloy.

## 4. Conclusions

- FAST-DB has been shown to be an effective, new approach to diffusion bonding dissimilar titanium alloys.
- A commercial software package was shown to closely predict the diffusion behaviour of individual elements across the bond interface.
- With future development, FAST-DB has the potential to be a competitor with other solid state processes such as linear friction welding (LFW).

***Keywords***
FAST; Titanium alloys; Diffusion Bonding, Solid state