Brazing Alumina to Ti6Al4V and γ-TiAl Alloys Using Ag-Cu Sputtered Coated Ti Filler Foil

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Background:

Application
- Thermal stability, stiffness and wear resistance of advanced ceramic materials are attractive
- Examples involve aerospace, automotive, and chemical industries industries, etc.

Joining
- Replacing a part of a metallic component by ceramic at which specific properties are required
- Laser welding, diffusion bonding and brazing are some examples
- It is a difficult task because the properties of metals and ceramics are completely different, e.g. wettability & coefficient of thermal expansion

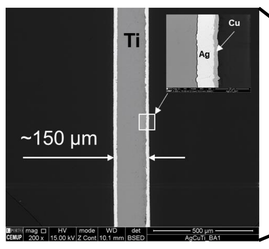
Diffusion Brazing
- This technique can reduce the unwanted phases which lead to low service temperature and softness
- It requires adequate heating system (apparatus, temperature and time) and a proper brazing filler

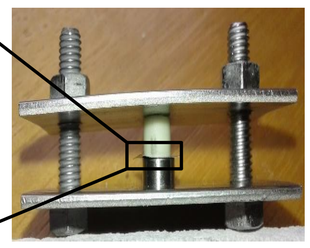
Procedure:

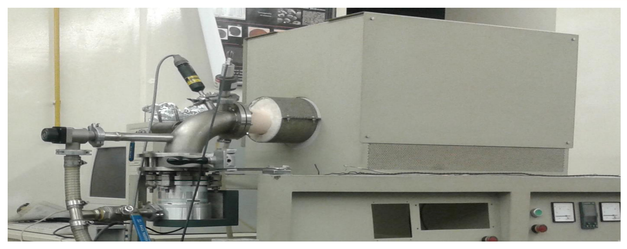
Surface preparation:
- Silicon carbide emery until 1000 mesh for metal
- Aka disk until 6 µm for Alumina

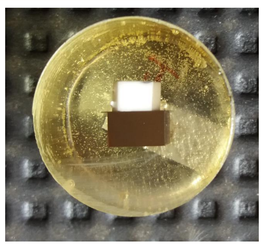
Brazing:
- Applying 980 ℃
  - 10 minutes
  - ~8×10^{-4} Pa

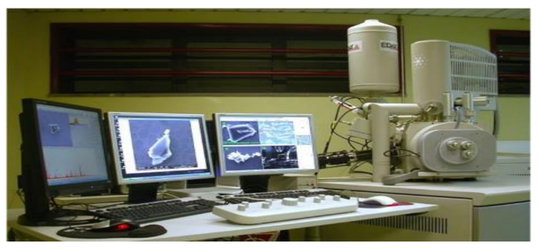
Evaluations:
- Microhardness map
- Microstructure analyses

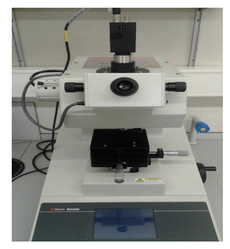






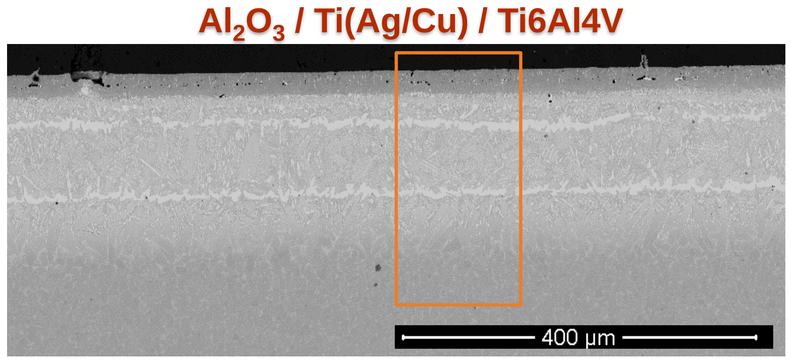


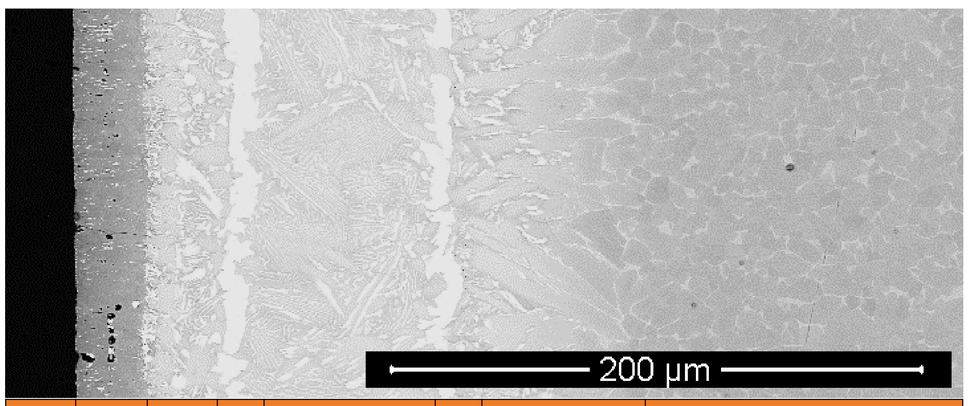


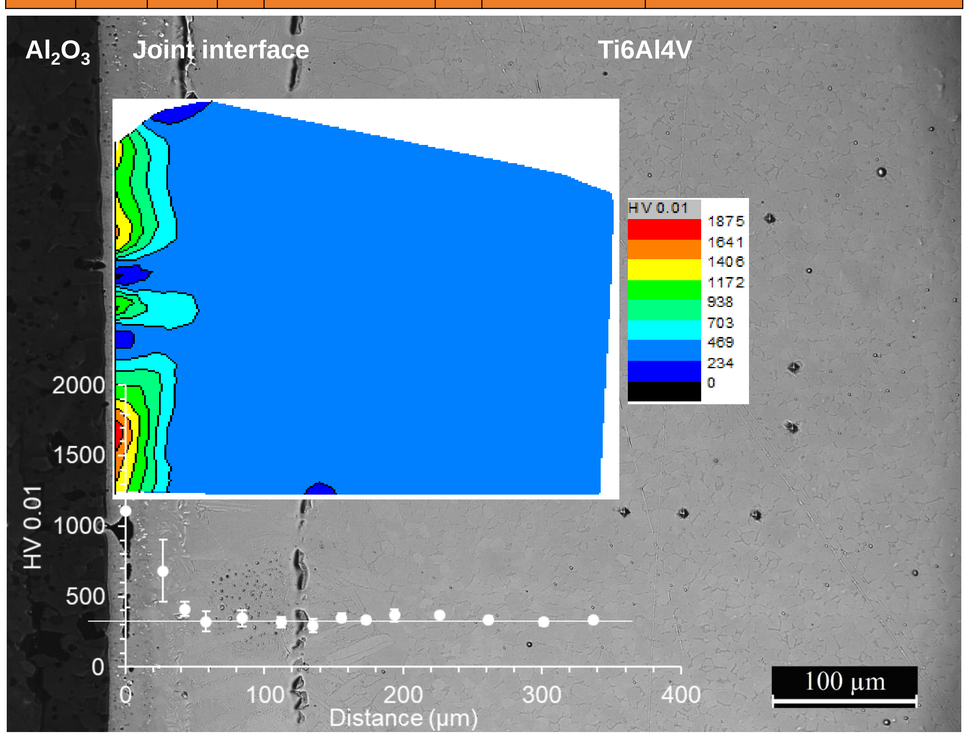


Results:

Al_2O_3 / Ti(Ag/Cu) / Ti6Al4V



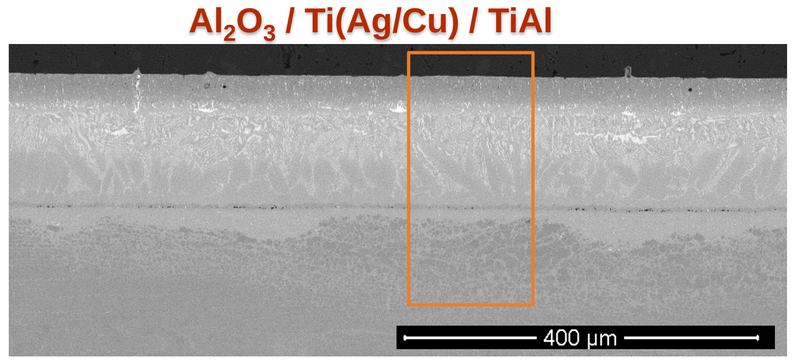


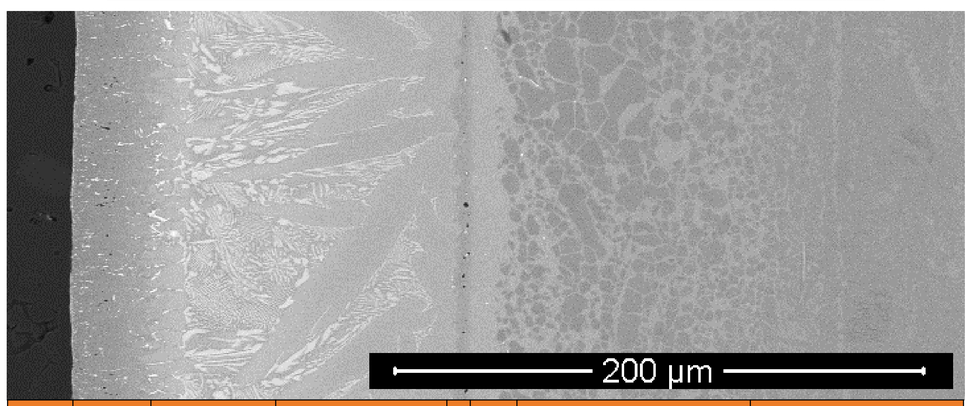


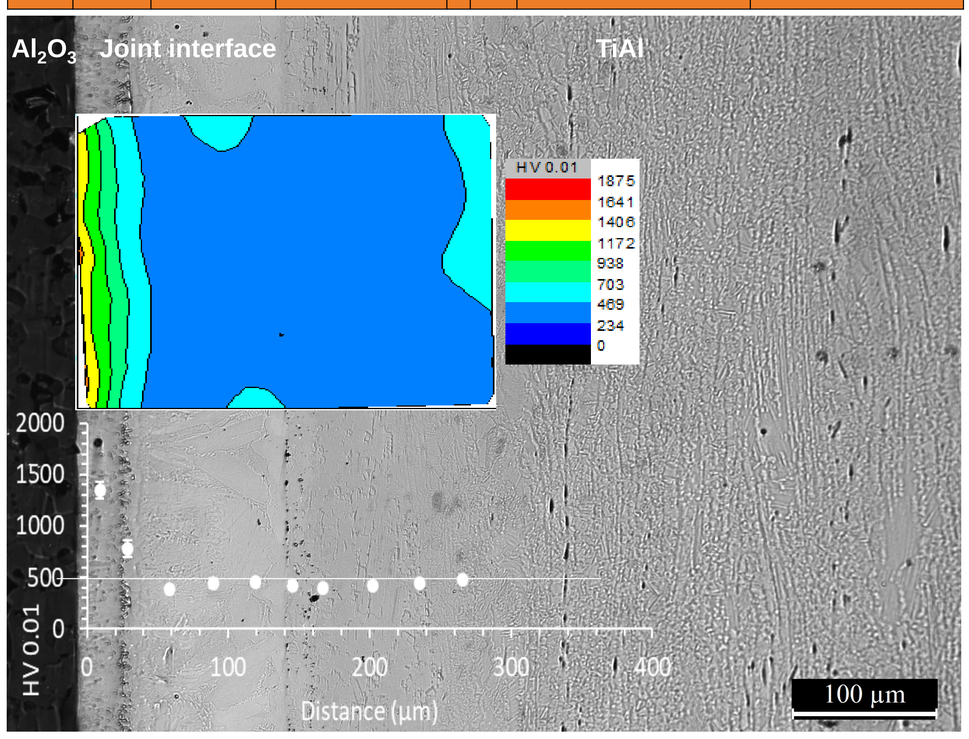
Possible phases formed between the base materials		
Layer	Al_2O_3 to Ti6Al4V	Al_2O_3 to TiAl
I	Alumina	Alumina
II	Ti(α)	Ti(α)
III	Ti(α) + TiAg	Ti(α) + TiAg + Ti_2(Ag,Cu)
IV	TiAg	Ti(α) + Ti_2(Ag,Cu)
V	Ti(α) +TiAg + Ti_2(Ag,Cu)	Ti_3Al + Pores
VI	TiAg	Ti_3Al
VII	Ti(α) + Ti_2Ag	TiAl base
VIII	Ti6Al4V	TiAl

Base material	Ti6Al4V	TiAl
HV 0.01	331 ± 8	482 ± 12

Al_2O_3 / Ti(Ag/Cu) / TiAl







Conclusions & Outlooks:

- Diffusion brazing process was successfully performed for joining Al_2O_3 to Ti6Al4V & TiAl alloys by using a Ti(Ag/Cu) brazing filler at 980 ℃ at high vacuum
- The brazing process did not cause any sever defect (such as crack) at the joint interfaces; however, some porosities were left
- For the Al_2O_3/Ti6Al4V joint the interface was essentially composed of Ti(α), Ti_2(Ag,Cu), and TiAg. In the case of Al_2O_3 /TiAl joint, Ti(α), Ti_2(Ag,Cu), TiAg, and Ti_3Al were the main phases formed at the interface
- The formation of (Ag), which compromises the maximum operating temperature of joints, was prevented for both systems of materials
- The hardness transition from the alumina towards the Ti alloy occurs in both systems, and according to the hardness maps most of both interfaces present similar hardness values to those of the corresponding metallic alloy base materials. The substantially higher hardness values presented by the thin layers formed near alumina may be resulting from the formation of Ti and/or Ti-Al rich oxides
- This study will be further developed by carrying out shear strength test of joints, fracture surfaces analysis and transmission electron microscopy analysis of the interfaces

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