DOI: 10.1017/S1431927605501326
Microsc Microanal 11(Suppl 2), 2005

Scavenging of Ti by Fe-Ni-Co in Ag-Cu-Ti Active Metal Braze Joints [1]

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Active metal braze alloys (such as CusilABA, 63Ag-35.25Cu-1.75Ti) produce strong and hermetic joints directly between metallic components and alumina ceramic substrates without requiring a protracted sequence of metallization, sintering, and plating operations. During the brazing operation Ti removes oxygen from the alumina, forming complex, Ti-bearing oxides that are apparently more stable than the alumina. These oxides wet the alumina surface allowing braze alloy to flow and bond to the ceramic.[2] (Reduced Al dissolves into the braze alloy and concentrates in the Cu-rich phase.)

Kovar™ (54Fe-29Ni-17Co) is an alloy often used in electronic devices or as a stress-reducing material in metal/ceramic braze joints. Braze test buttons of alumina ceramic with Cusil ABA and a Kovar™ spacer exhibit lower strengths and reduced hermeticity. Electron microprobe studies of these joints reveal the formation of a $(Fe,Ni,Co)_3Ti$ intermetallic compound that appears as a highly puckered layer or "lace-work" within the body of the braze alloy. This scavenging of the Ti by the ferrous metals that have dissolved from the Kovar™ and diffused through the braze alloy reduces the amount available for reacting with the alumina and the braze quality is seriously compromised.[3]

We produced a series of test buttons with pure metal spacers to determine which metal was most responsible for scavenging Ti. Test buttons with pure Ni exhibit extensive formation of large Ni_3Ti particles throughout the braze region and no Ti oxide reaction layer at the alumina interface. The braze joints with the Ni spacer were 0% hermetic. Buttons with pure Co spacers show the formation of a "lace-work" of Co_3Ti similar to that seen with $(Fe,Ni,Co)_3Ti$ in the Kovar™ bearing samples (Figs. 1 & 2). A partial reaction layer of Ti oxide was formed and 75% of these joints were hermetic. Buttons with pure Fe produced no intermetallic compounds. The Ti oxide reaction layer was quite robust and the joints were 100% hermetic (Figs. 3 & 4).

Because of the need to use Kovar™ along with CusilABA in a number of applications because of its controlled thermal expansion behavior, we pursued a barrier layer approach to circumventing the problem. By sputtering a thin layer of Mo on the surfaces of the Kovar™, the Fe, Ni, and Co are isolated from the braze alloy and the Ti is free to react with the alumina substrates to form the desired strong and hermetic joints.[4]

References

[1] This work was conducted at Sandia National Laboratories, a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

[2] J. J. Stephens et al., Metallurgical and Materials Trans. 34A (2003), pp. 2963-2972.

[3] P. T. Vianco et al., Weld. Journ. Res. Suppl. 82 (2003), pp. 268s-277s.

[4] P. T. Vianco et al., Weld. Journ. Res. Suppl. 82 (2003), pp. 252s-262s.

We would like to acknowledge the contribution of the following SNL staff to this paper: C. A. Walker, furnace brazing operations; M. J. Rye, TEM sample preparation; T. B. Crenshaw, tensile button testing, and A. C. Kilgo, metallographic sample preparation.

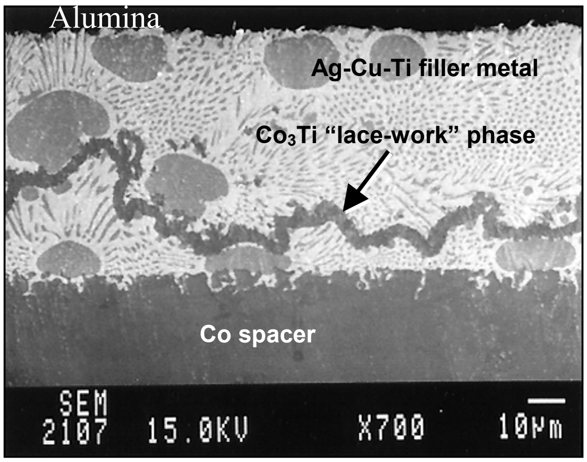

Fig. 1. SE image of CusilABA braze between alumina and a pure Co spacer showing the IMC "lace-work" much like that in the original Kovar™ samples.

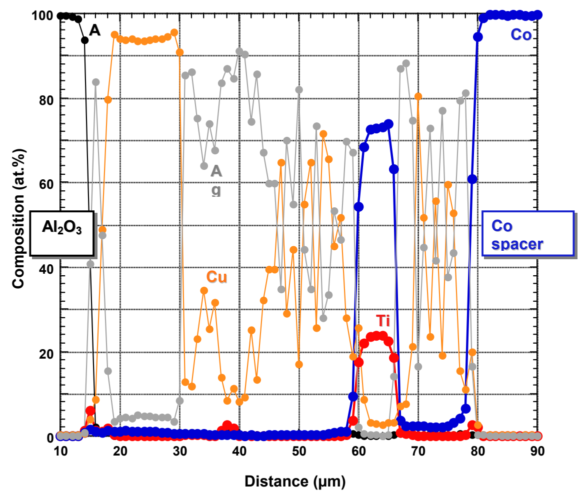

Fig. 2. Plot of the quantitative probe analyses from the alumina, across the braze alloy, and into the Co spacer showing the well developed layer of Co_3Ti IMC. Note the small Ti signal at the surface of the alumina

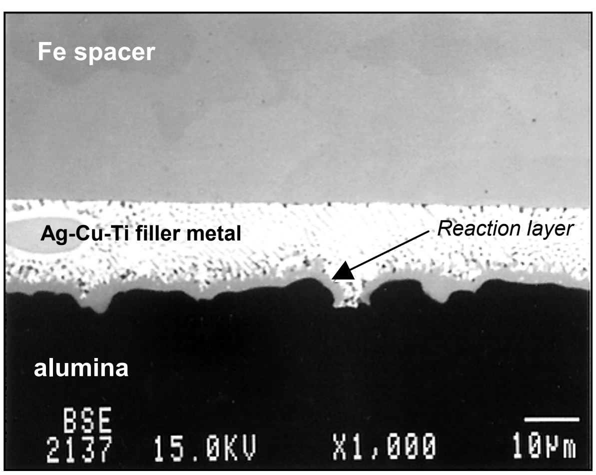

Fig. 3. SE image of CusilABA braze between alumina and a pure Fe spacer showing no IMC formation and a robust Ti oxide reaction layer.

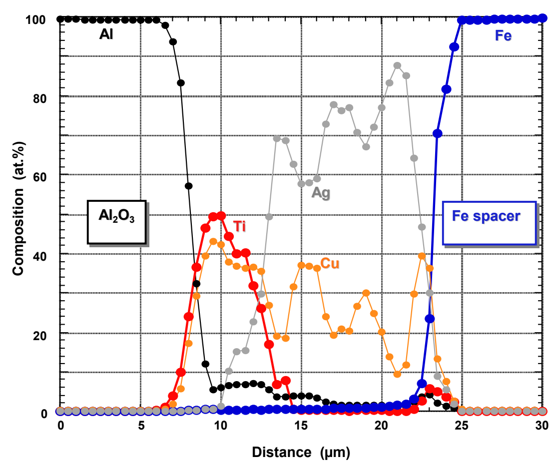

Fig. 4. Plot of the quantitative probe analyses from the alumina, across the braze alloy, and into the Fe spacer showing the well developed layer of Ti oxide but no IMC.

https://doi.org/10.1017/S1431927605501326 Published online by Cambridge University Press