An observation of the overflow of Ag–Cu–Ti filler metal on the surface of nickel-base alloy Inconel 600

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Mizuhara and Heubel [1] indicated that the joining of two materials (for example ceramics to Kovar) with different brazing filler metal contact angles is difficult. The wettability may cause the filler metal to blush over the metal, thus leaving insufficient filler metal to wet the ceramics.

In the present work Inconel ($C < 0.15\%$, $Mn < 1.0\%$, $Ni > 72\%$, Fe 6–10% and Cr 14–17%) cubes (10 mm × 10 mm × 10 mm) were brazed to Si_3N_4 (sintered with additive Al_2O_3 and Y_2O_3) plates (12.5 mm × 20 mm × 5 mm) with $Ag_{71}Cu_{27}Ti_2$ filler metal at 900 °C (holding for 30 min, heating rate 15 °C min^{-1}).

Most parts of the filler metal overflowed and wetted the side surface of the Inconel cube for up to 5 mm, as shown in Fig. 1. The layer of filler metal wetting the side surface of the Inconel cube could be distinguished into two parts: the upper part and the lower part. The upper part was of reddish colour and the lower one of white colour.

The micropattern and the linear distribution of Ag and Cu at the interface of these two parts are shown in Fig. 2. From the figure it is apparent that the two parts of the wetting layer mentioned above resulted from the separation of the liquid of filler metal. The reddish part was of higher Cu content and wetted the Inconel at a faster speed than the white part with lower Cu content.

Because most parts of the filler metal flew up to blush the side surface of the Inconel cube, the remaining part was sufficient to form a integrated joint. Fig. 3 shows the micropattern and area element distribution on the surface of ceramics that failed to be brazed. As shown in Fig. 3, the surface of the ceramics was covered by a thin foil of TiN, but failed to be continuously wetted by the Ag–Cu filler metal. Small particles of the Ag–Cu alloy dispersed on the surface. Large particles were formed by dendritic crystals growing from separated liquid. The core of dendrites with high melting temperature was rich in Ti, Cu and Ni and was covered by the alloy rich in Ag with lower melting temperature.

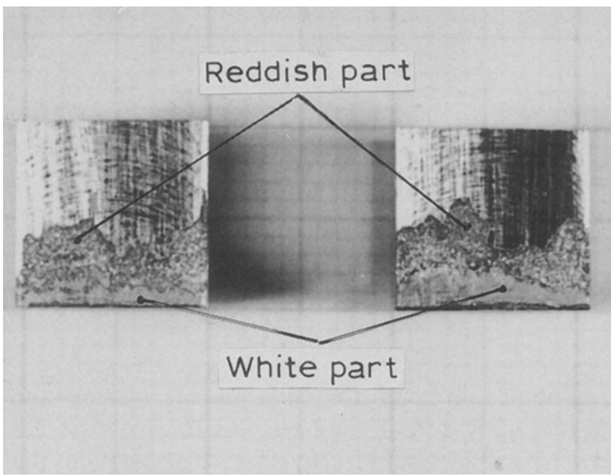

Figure 1 Overflow of filler metal wetting the side surface of Inconel cubes.

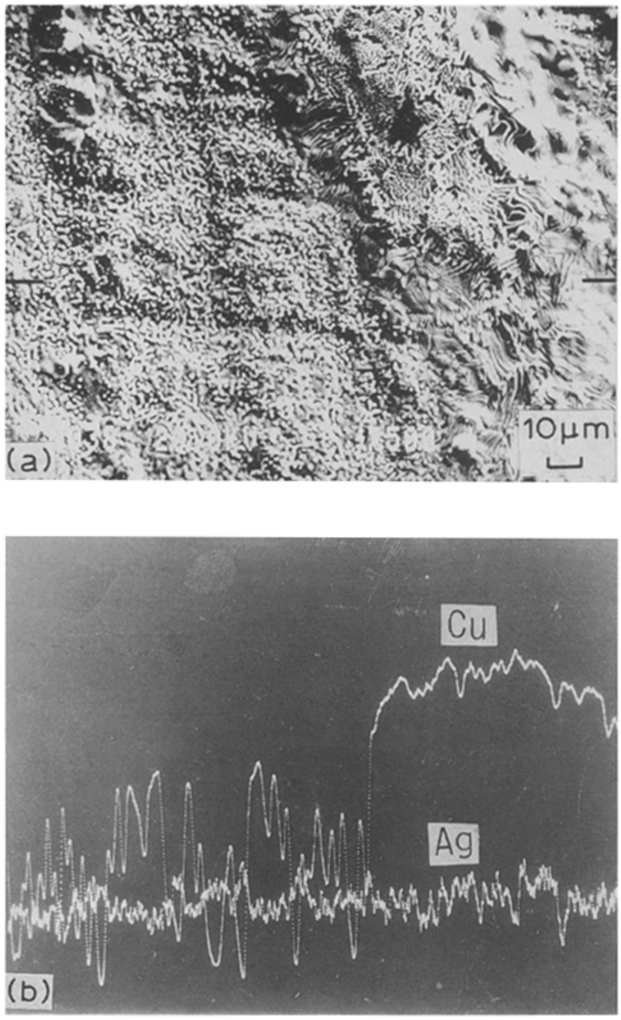

Figure 2 (a) Micropattern and (b) linear element distribution of filler metal layer wetting up the side surface of an Inconel cube.

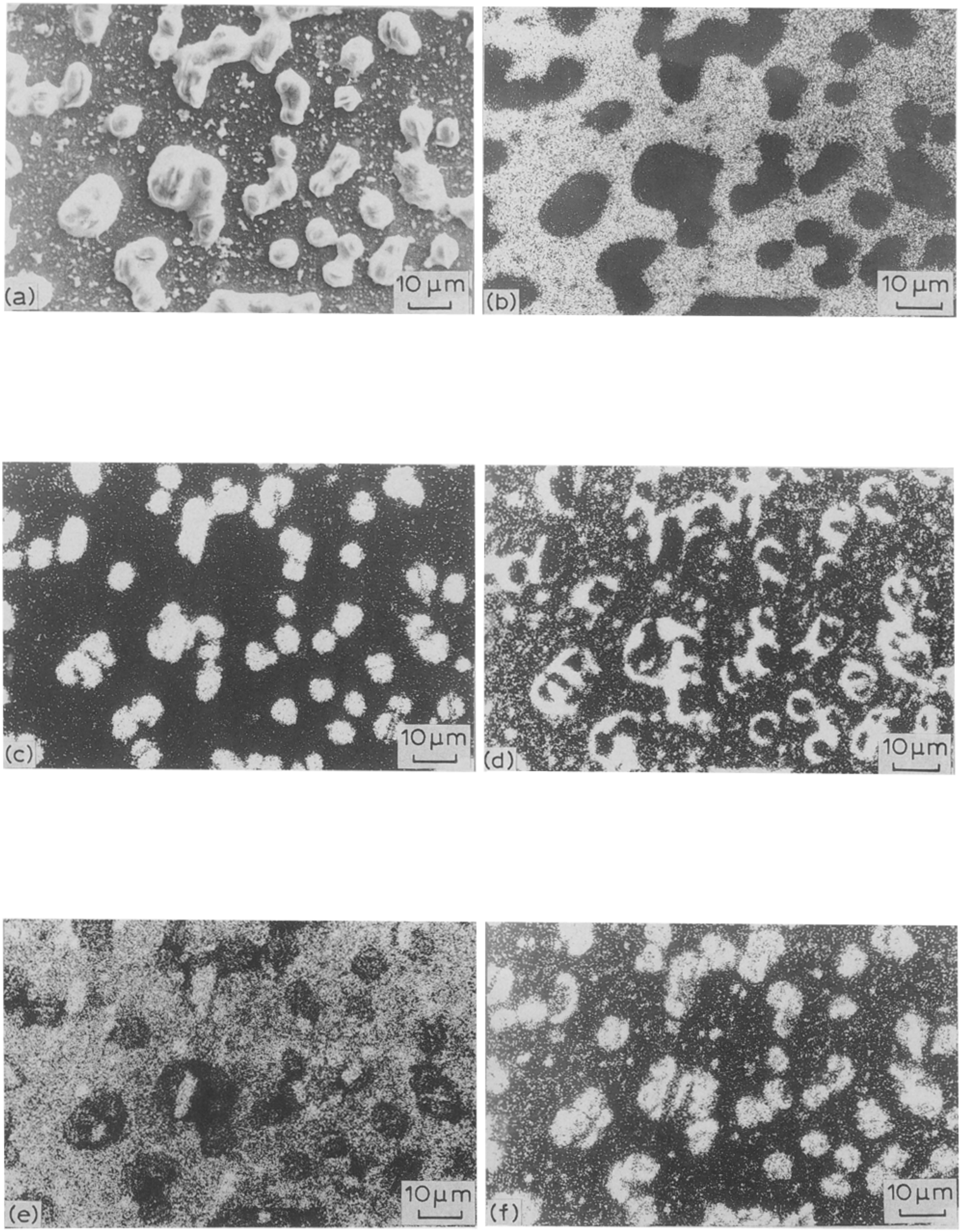

Figure 3 Micropattern and area element distribution on the surface of ceramics which failed to be brazed (a) micropattern, (b) Si, (c) Ni, (d) Ag, (e) Ti and (f) Cu.

It is interesting to note that in the dendritic core, the region rich in copper is poor in Ti and vice versa, but the Ni is uniform.

Fig. 4 shows the micropattern and area element distribution on the surface of Inconel. As shown in Fig. 4, the surface of Inconel is covered by a continuous layer of fine crystals of Ag-rich and Cu-rich alloy with Ti and Ni. Some large particles have a similar pattern to that observed on the ceramic surface.

From this observation it could be found that, besides the problem of production of intermetallic

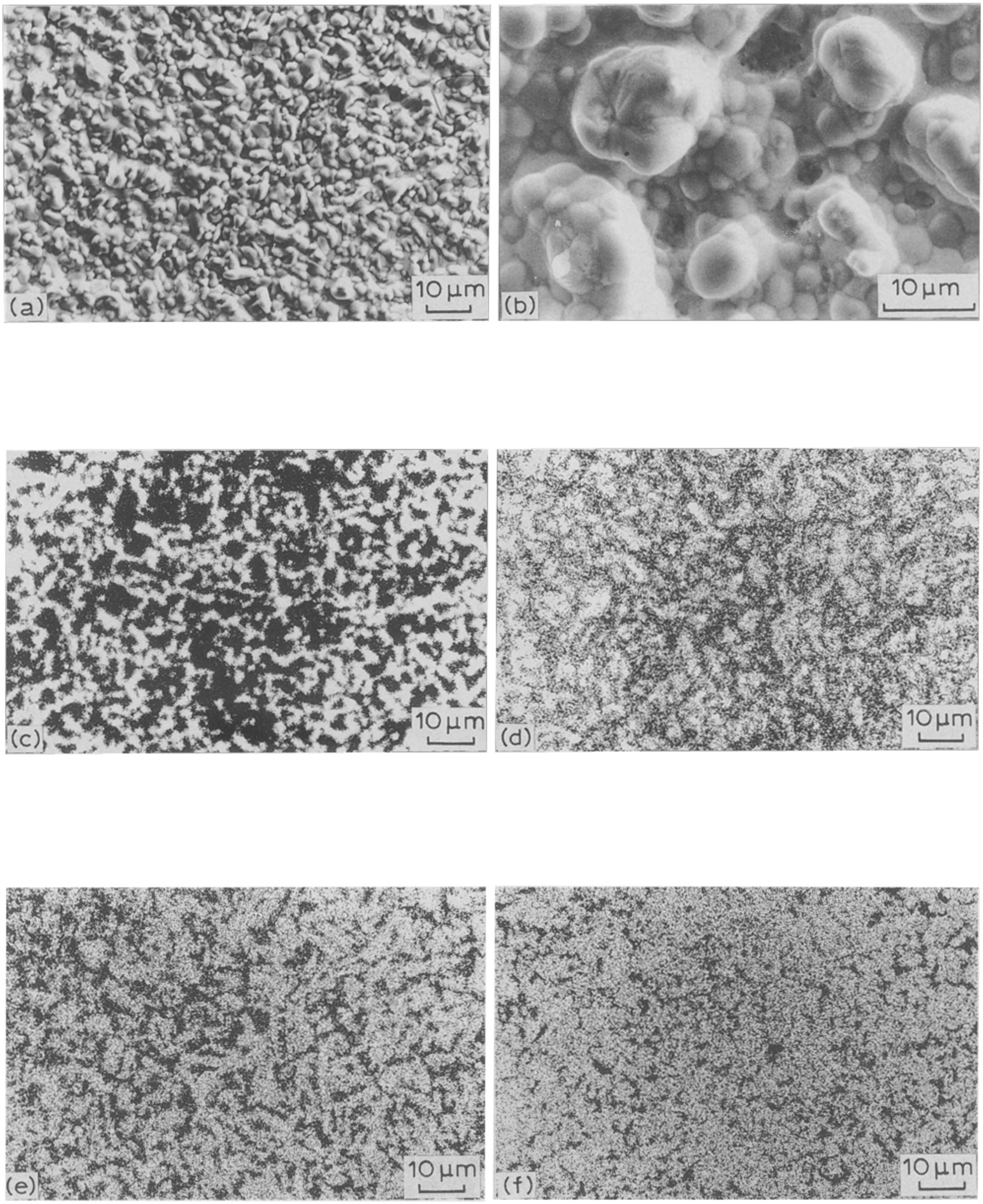

Figure 4 Micropattern and area element distribution on the separated surface of Inconel: (a, b) micropattern, (c) Ag, (d) Cu, (e) Ti and (f) Ni.

compound of Ni and Ti at the interface between Inconel and the filler metal, when brazing Inconel to Si_3N_4 with Ag–Cu–Ti filler metal, there are two potential problems. The first is the overflow of filler metal on the surface of Inconel, due to the high affinity of Cu-rich alloy to the Ni-base metal, and this causes the remaining filler metal to be insufficient to wet the ceramics. The second problem is the separation of the liquid of the filler metal into Ag-rich and Cu-rich parts and makes it impossible to obtain a fine, uniform microstructure and mechanical properties of the filler metal.

References

1. H. MIZUHARA and E. HUEBEL, *Welding J.* **65** (10) (1986) 43.

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