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Wetting and Reactivity of Active Metal Braze Alloys on Tungsten Carbide

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Background

- Tungsten carbide is useful because of its hardness and strength
- Joining of dissimilar materials especially non-metallic materials is very challenging
- Active metals such as titanium can be added to a ductile filler metals such as copper to get wetting via a reduction reaction

Procedure

- Alloys were weighed and mounted on a tungsten carbide 13wt% cobalt (WC-Co) substrate (Figure 1)
- Sample underwent a thermal cycle under an argon overpressure in a vacuum furnace
- Sessile drop diameter was measured and contact angle was calculated (table 1)
- Microstructural analysis was performed with scanning electron microscopy on the cross-sections

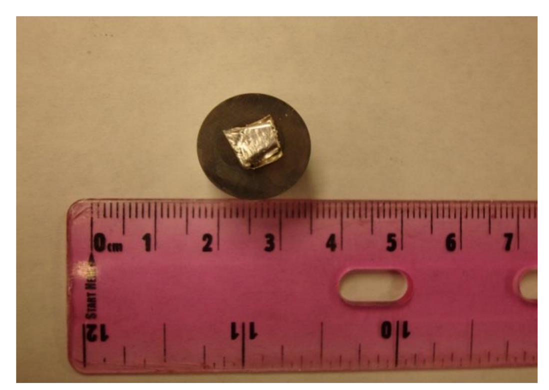


Figure 1. Sample that is prepped for the furnace (top view)

Table 1 Sessile drop test matrix

Base Alloy	Active Metal Addition (wt%)	Hold Temp (°C)	Hold Time (min)	Apparent contact angle
Ag-Cu (72-28)	None	810	30	X
Ag-Cu (72-28)	2% Ti	810	30	X
Ag-Cu (72-28)	5% Ti	810	30	X
Ag	None	1010	30	X
Ag	2% Ti	1010	30	X
Ag	5% Ti	1010	30	X
Ag	2% Zr	1010	30	X
Cu	None	1130	30	X
Cu	2% Ti	1130	30	X
Cu	5% Ti	1130	30	X
Cu	2% Zr	1130	30	X
Cu	1% V	1200	30	X

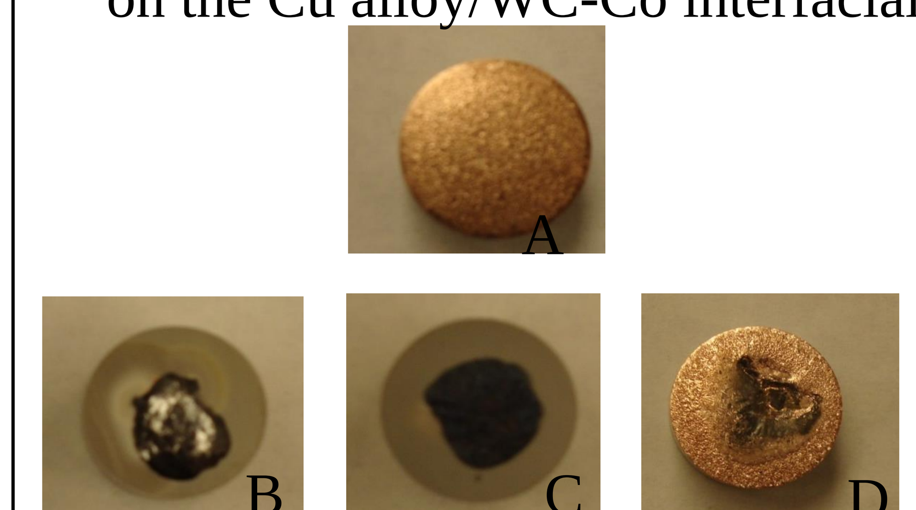
Results

- Results identified that all brazes wet the
- (WC-Co) substrates and that two different types of interfacial reactions occur: dissolution and/or reduction
- Tables 2, 3, and 4 have the apparent contact angle results for all of the tests

Table 2. Sessile drop test results for copper base alloys. Alloys with two results were repeat tests

Base Alloy	Active Metal Addition	Hold Temp (°C)	Hold Time (min)	Apparent contact angle (degrees)
Cu	None	1130	30	< 8
Cu	2% Ti	1130	30	14, 43
Cu	5% Ti	1130	30	8, 60
Cu	2% Zr	1130	30	10, 51
Cu	1% V	1200	30	< 8

- Representative sessile drops for each alloy provided in Figures 2, 3, and 4
- Figures 5 and 6 are an example of the effect that the addition of Ti had on the Cu alloy/WC-Co interfacial microstructure



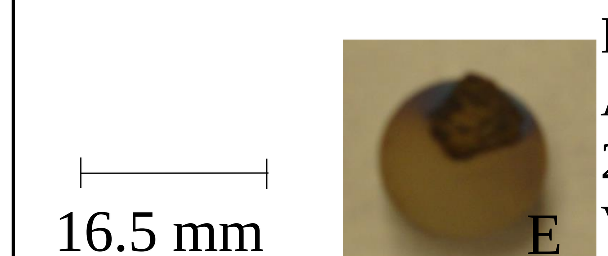


Figure 2. Base Copper Alloy Results. **A**. Cu **B** 2% Zr **C**. 2% Ti **D**. 1% V E. 5% Ti

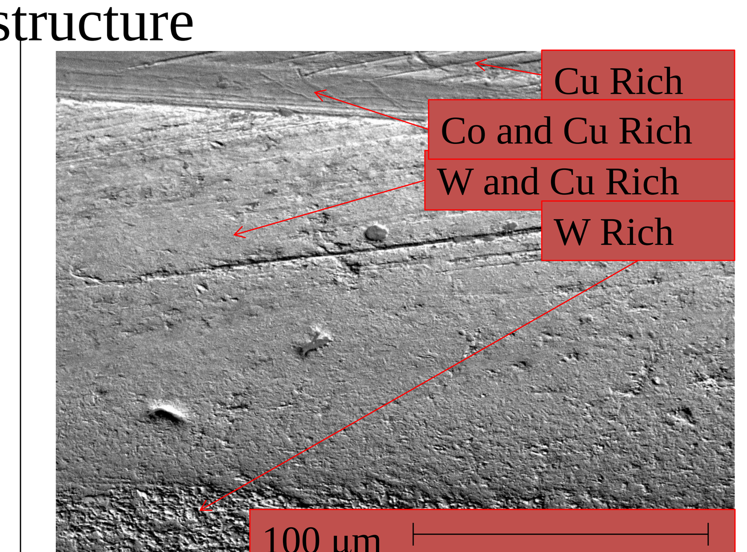


Figure 5. Cu/WC-Co interface microstructure exhibiting a dissolution reaction

Table 3. Sessile drop test results for silver –copper based eutectic

Base Alloy	Active Metal Addition	Hold Temp (°C)	Hold Time (min)	Apparent contact angle (degrees)
Ag-Cu (72-28)	None	810	30	36, 21
Ag-Cu (72-28)	2% Ti	810	30	9
Ag-Cu (72-28)	5% Ti	810	30	<7

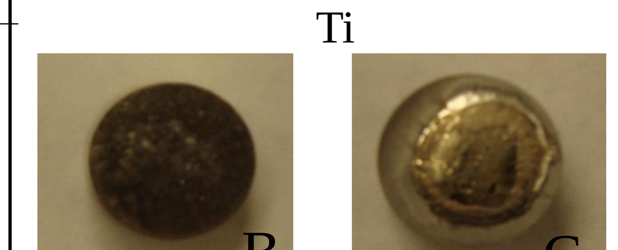


Figure 3. Silver Base Alloy Results. **A**. Pure Ag **B**. 2% Zr C. 2% Ti D. 5% Ti

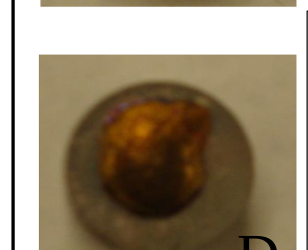


Figure 4 Silver – Copper Base Alloy Results. **A**. Pure Ag-Cu **B**. 2 **C**. 2% Ti **D**. 5% Ti

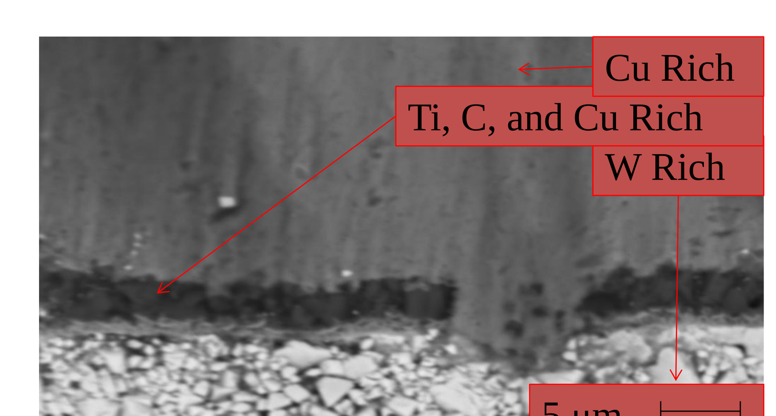


Figure 6. Cu + 2% Ti/WC-Co interface microstructure exhibiting a reduction reaction

Table 4. Sessile drop test results for silver base alloys

Base Alloy	Active Metal Addition	Hold Temp (°C)	Hold Time (min)	Apparent contact angle (degrees)
Ag	None	1010	30	10, 16
Ag	2% Ti	1010	30	19
Ag	5% Ti	1010	30	29
Ag	2% Zr	1010	30	8

- Figures 7 and 8 illustrate of the effect that the addition of Ti had on the silver-copper alloy/WC-Co interfacial microstructure

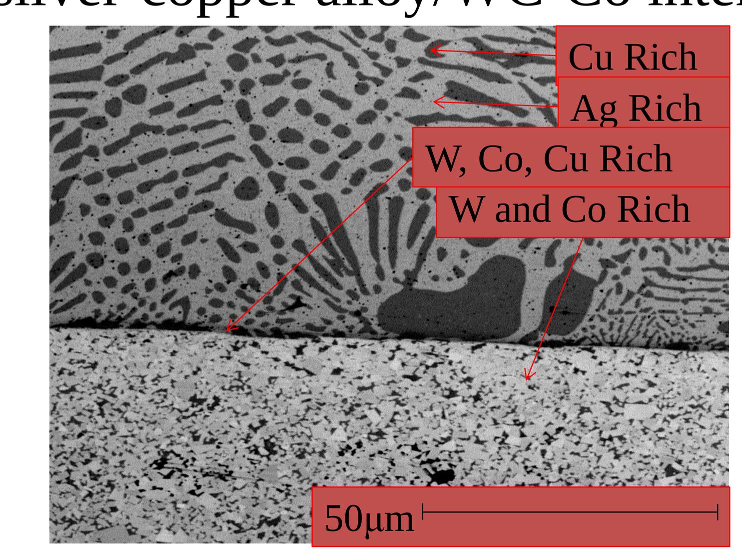


Figure 7. Ag-Cu/WC-Co eutectic interfacial microstructure exhibiting dissolution reaction

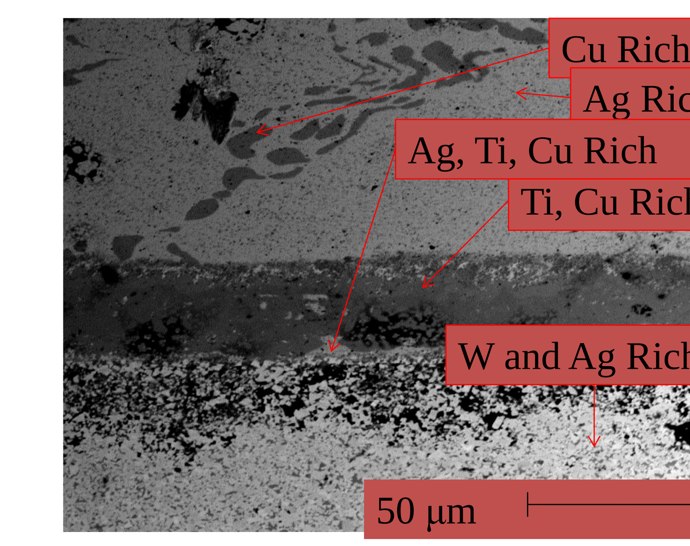


Figure 8. Ag-Cu + 5% Ti/ WC-Co interfacial microstructure exhibiting dissolution reaction

Conclusions

- All alloy conditions wet the tungsten carbide/cobalt substrates
- Two different interfacial reaction types were observed: dissolution and reduction reactions
- An important issue has been identified: the braze interface reactions change the chemistry of the braze alloy which change the interaction between the braze alloy and the other material substrate

Future work

- Varying furnace times to understand kinetics
- Braze to other covalent materials

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