Interfacial Microstructure of WC-6wt.%Co Torch Brazed Joints using Ag-based Filler Alloy

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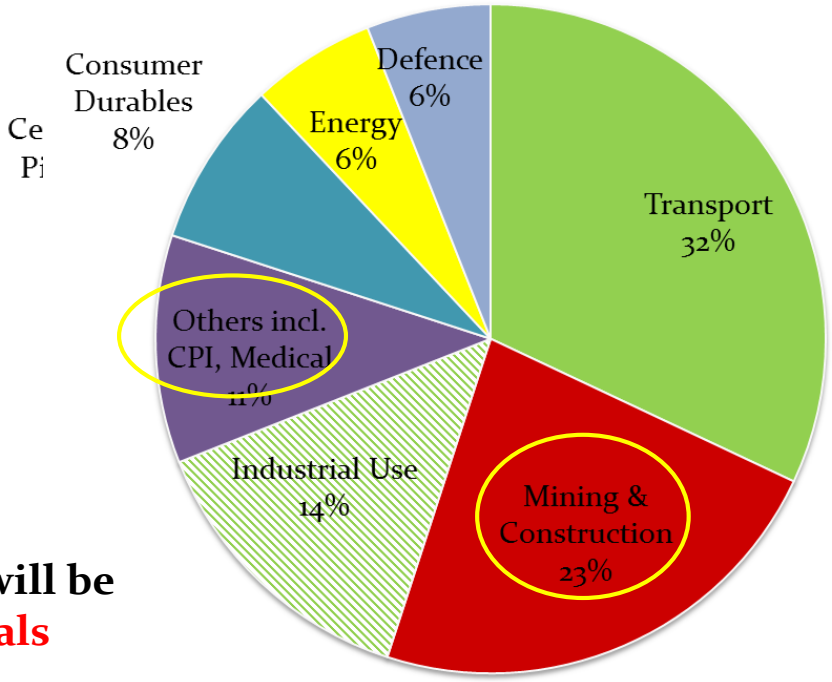
Motivation

- Cobalt and Tungsten Applications:



HARDMETALS

1 Tonne of Co, 80kg will be used in Hardmetals

End use industries, 2017

Cobalt: End use, 2016

[International Tungsten Industry Association (ITIA)]

[Global Energy Metals Corp]

Motivation

- Increased worldwide concerns around W and Co ore shortages

British Geological Survey

Risk list 2015—Current supply risk for chemical elements or element groups which are of economic value.

Element or element group	Symbol	Relative supply risk index	Leading producer	Top reserve holder
rare earth elements	REE	9.5	China	China
antimony	Sb	9.0	China	China
bismuth	Bi	8.8	China	China
germanium	Ge	8.6	China	
vanadium	V	8.6	China	China
gallium	Ga	8.6	China	
strontium	Sr	8.3	China	China
tungsten	W	8.1	China	China
molybdenum	Mo	8.1	China	China
cobalt	Co	8.1	DRC	DRC
indium	In	8.1	China	
arsenic	As	7.9	China	

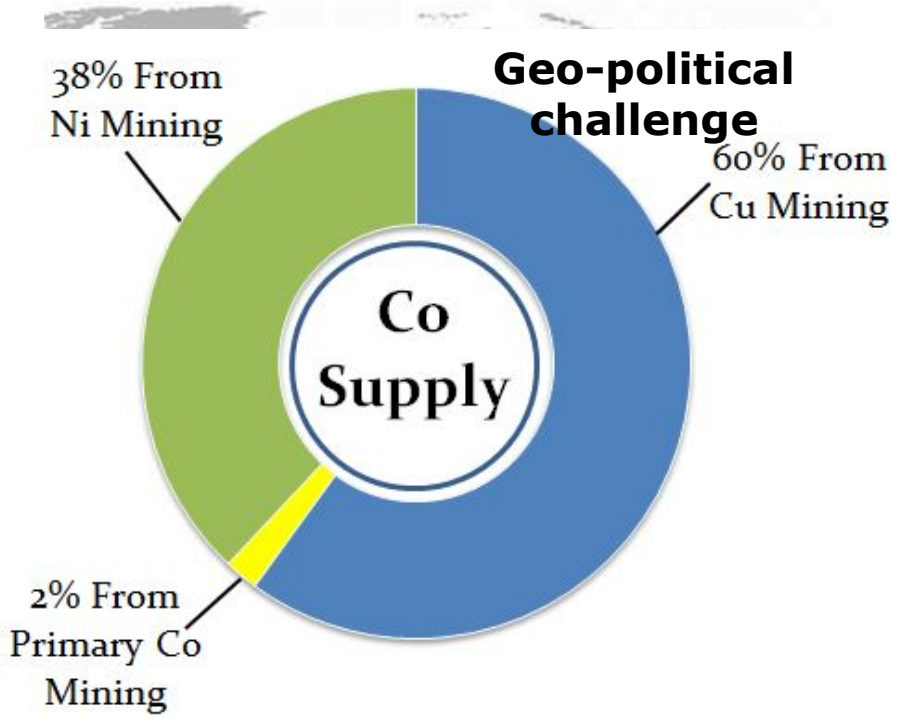
WC

Co

(http://www.bgs.ac.uk)

Motivation

- Problematic **Cobalt (Co)** supply chain:



[Global Energy Metals Corp, 2016]

Purpose

The purpose of this paper is study the effect of filler alloy thickness on the interlayer microstructural evolution of WC-6wt%Co brazed joints.

- Exploring torch brazing at a common interface using a Ag-based filler alloy.

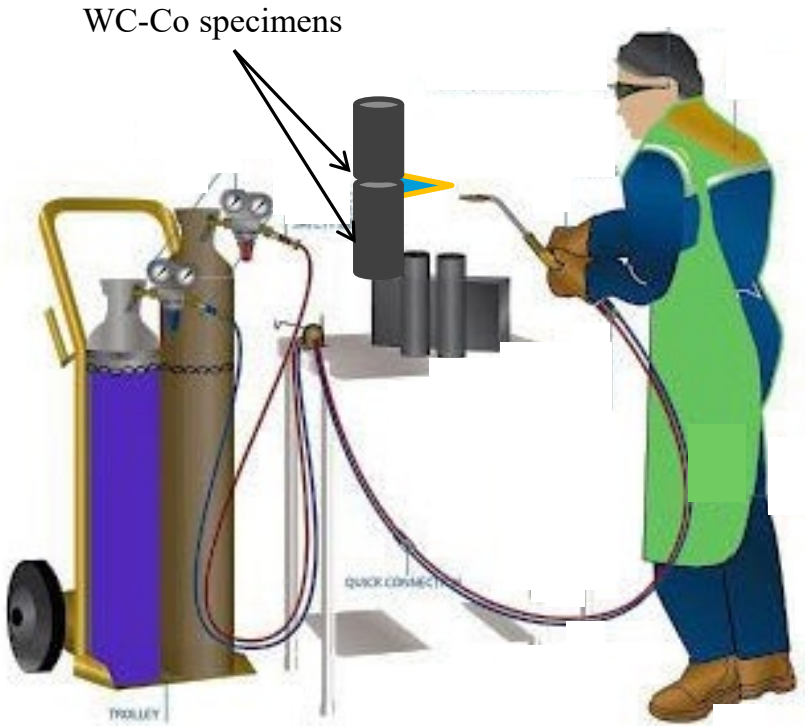
Why brazing?

- Brazing: Heating of parent material to $T \geq MP_{\text{filler alloy}}$ and apply a filler alloy.
- Filler alloy flows into joint by capillary action.

- Very simple ✓
- High joint strength ✓
- Good repeatability ✓
- Low cost ✓

How was it done?

- Oxyacetylene (Torch) brazing of WC-6wt%Co at a common interface:

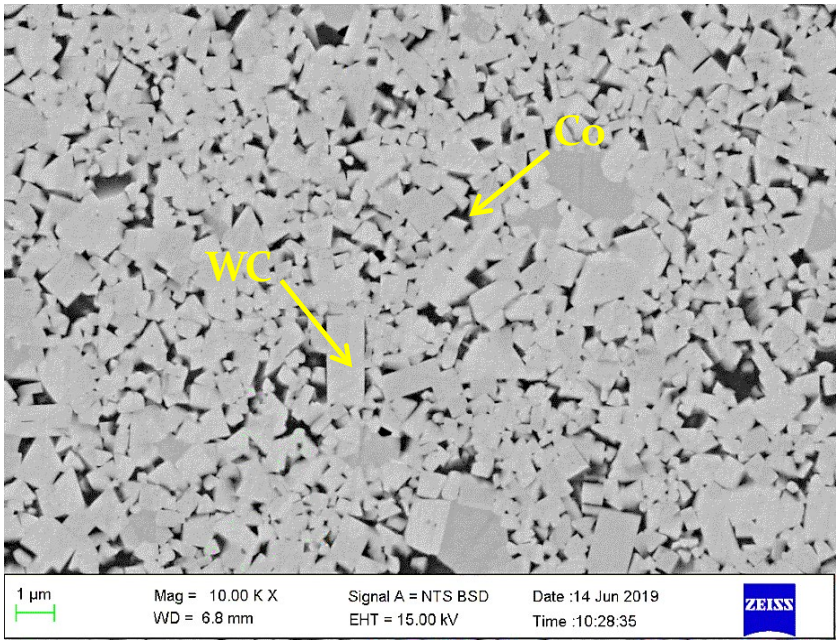


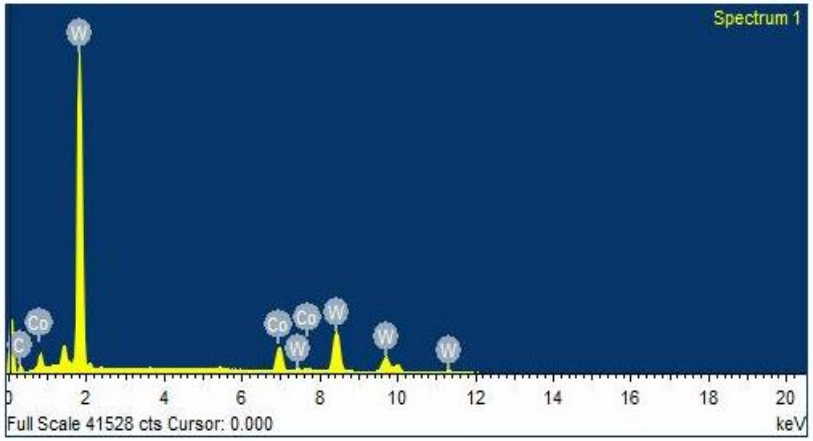
Oxyacetylene brazing process

	Condition
Sample Dimensions	T = 10mm, Ø = 20mm
Surface Finish	1µm
Brazing Temp	710 °C, under atmospheric conditions
Holding Time	30 sec, followed by air cooling

Microstructure: WC-6wt%Co cemented carbides

- Angular WC grains cemented in a Co matrix

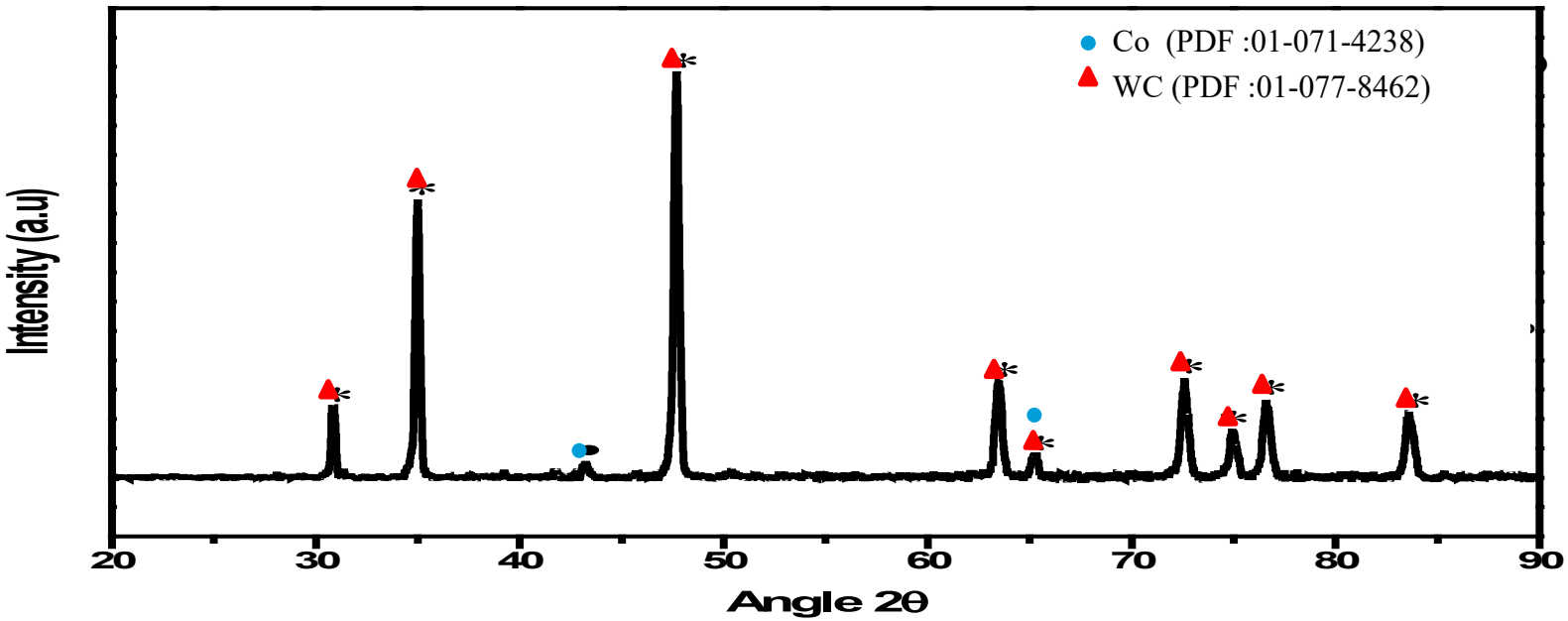




W	C	Co	Mean grain size (µm)	Density (g/cm³)
wt%				
86.64	7.36	5.92	1.84	14.97±0.12

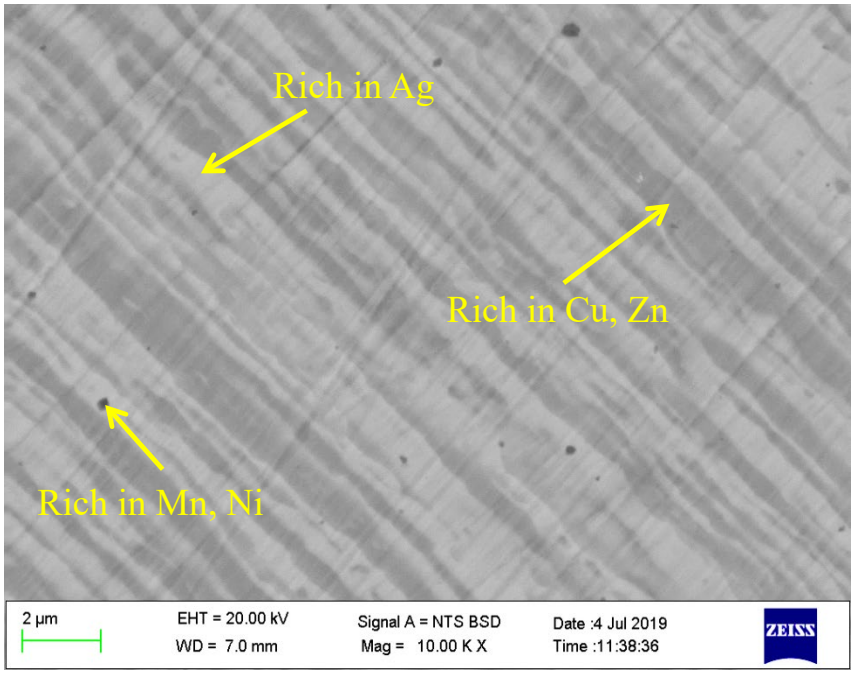
Phase Analysis:

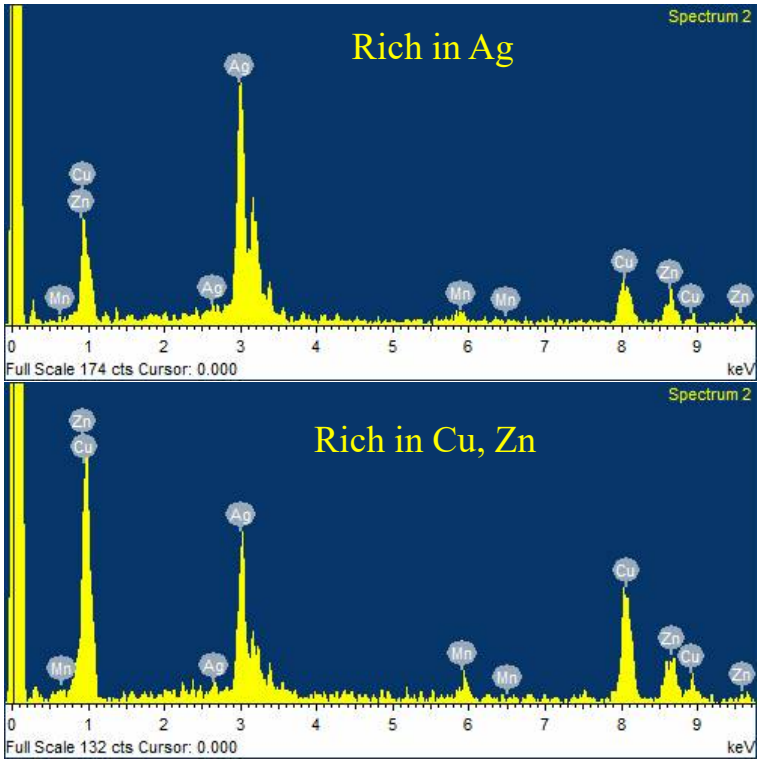
- XRD pattern of as-received WC-6wt%Co cemented carbides



Microstructure: BrazeTec4900 filler alloy

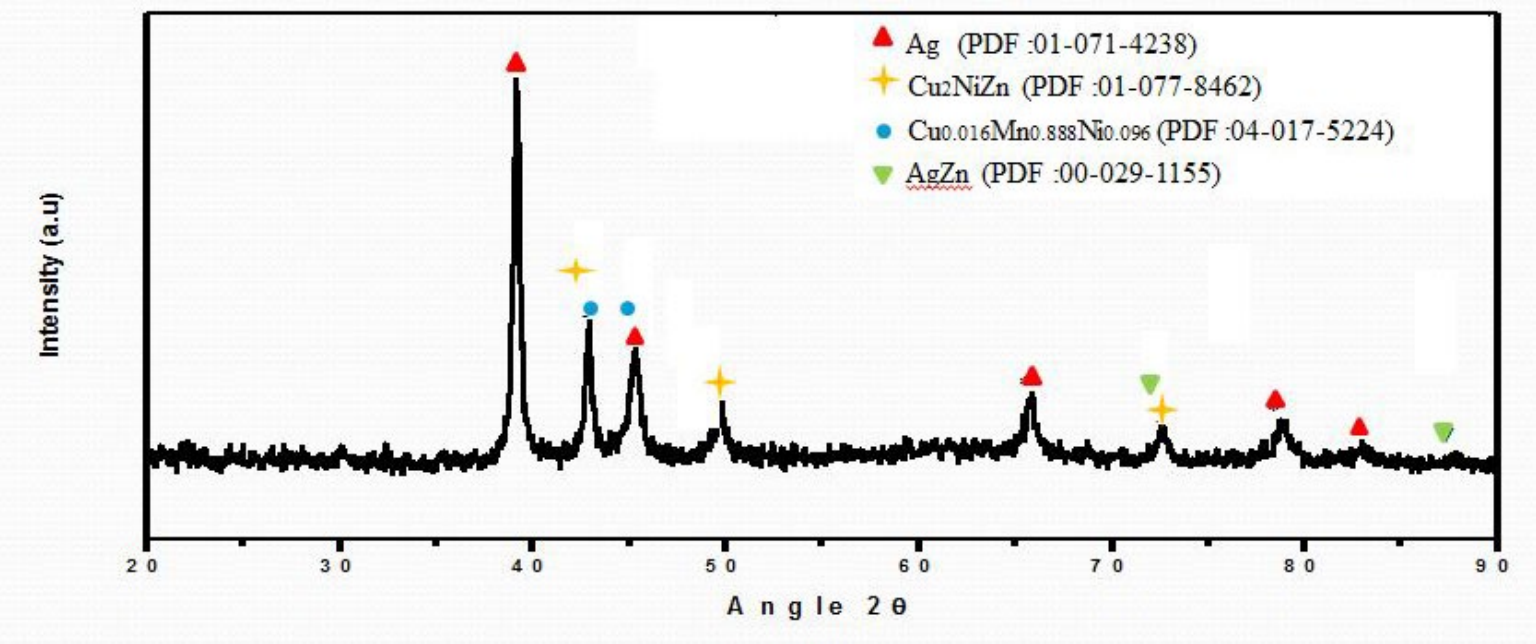
- Phase analysis and chemical composition of filler alloy:





Phase Analysis:

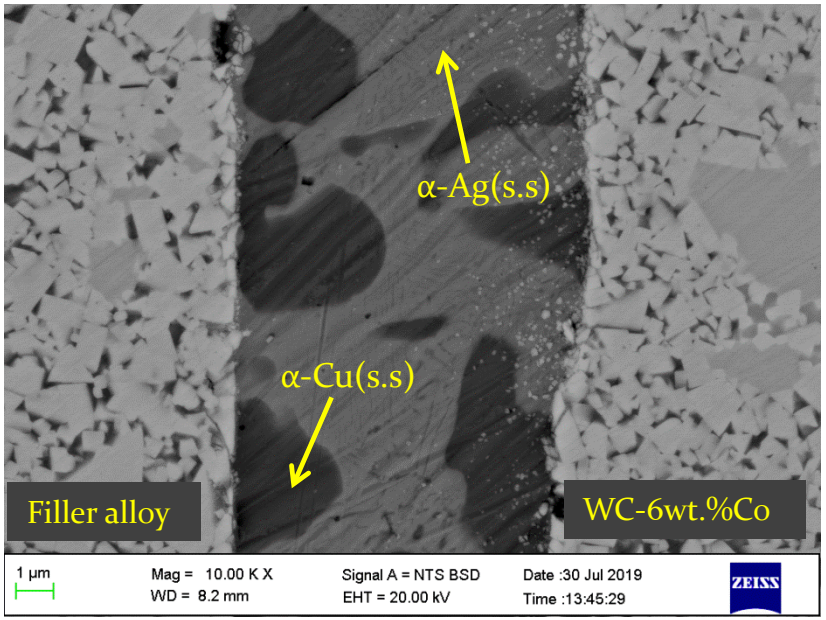
- XRD patterns of as-received filler alloy

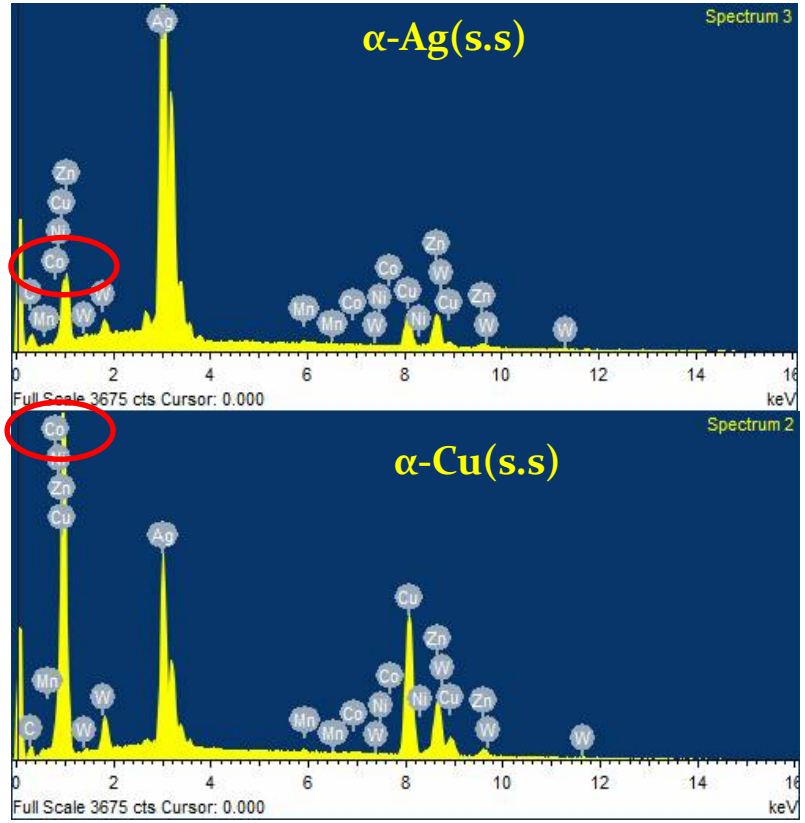


Ag	Cu	Zn	Mn	Ni	Density (g/cm³)
wt%					
49.00	27.50	20.50	2.50	0.50	8.90±0.013

Interlayer thickness: 9µm

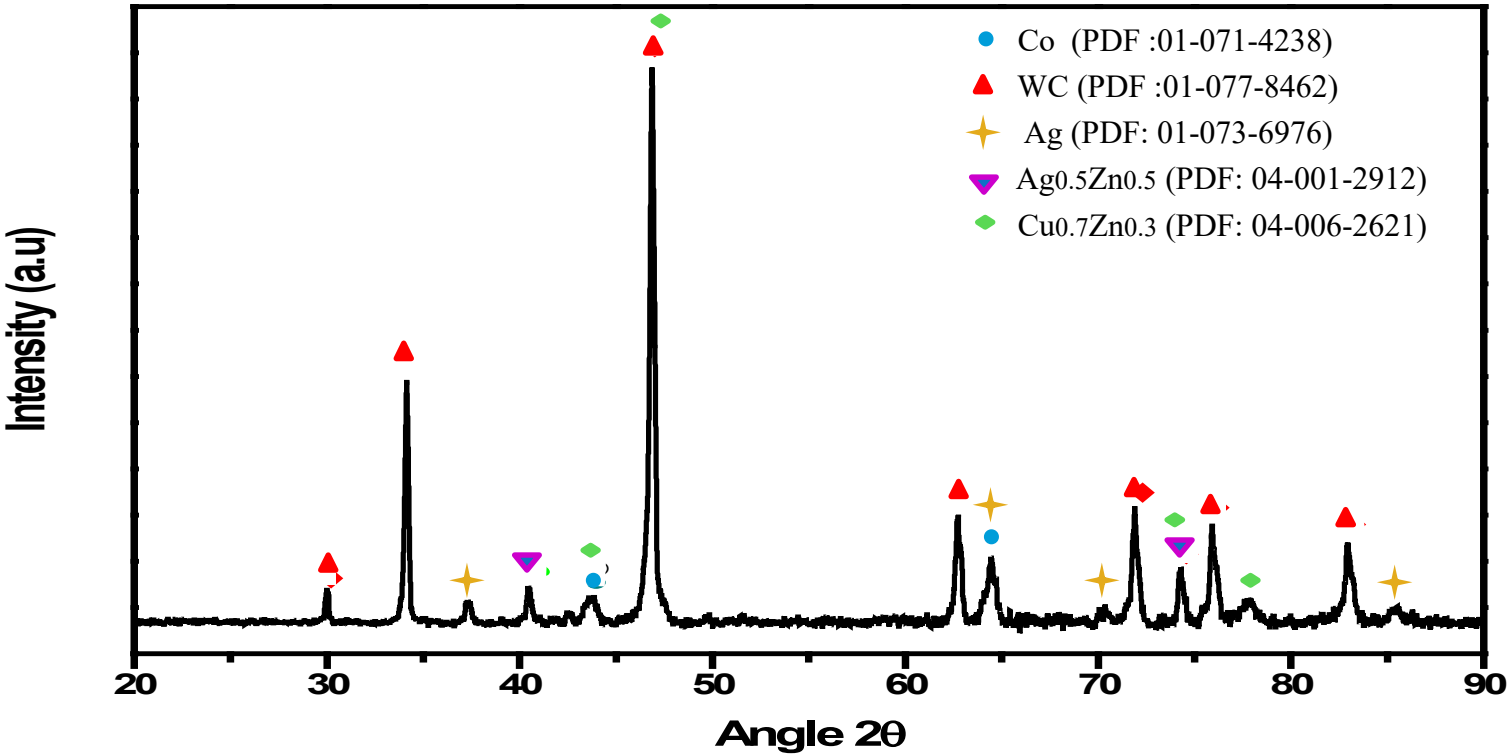
- Interlayer microstructure of joint brazed at 710°C for 30 sec.





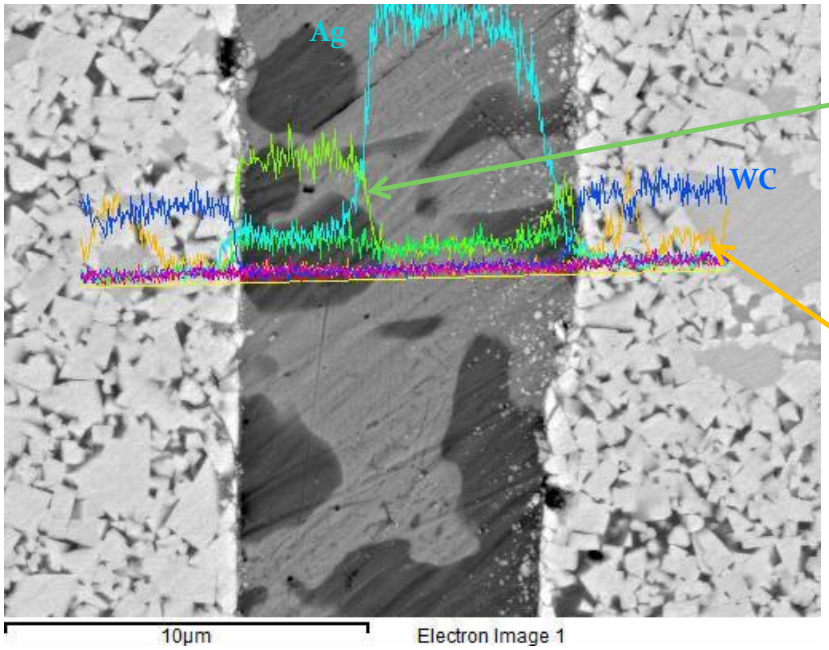
Phase analysis: 9µm

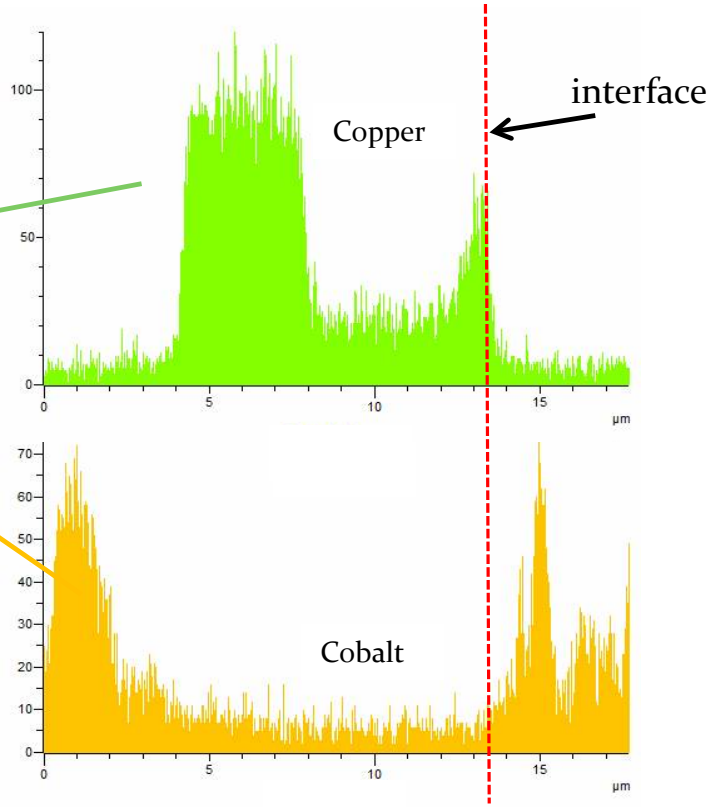
- XRD pattern of joint brazed at 710°C for 30 sec with filler alloy of 9µm in thickness.



Inter-diffusion: 9µm

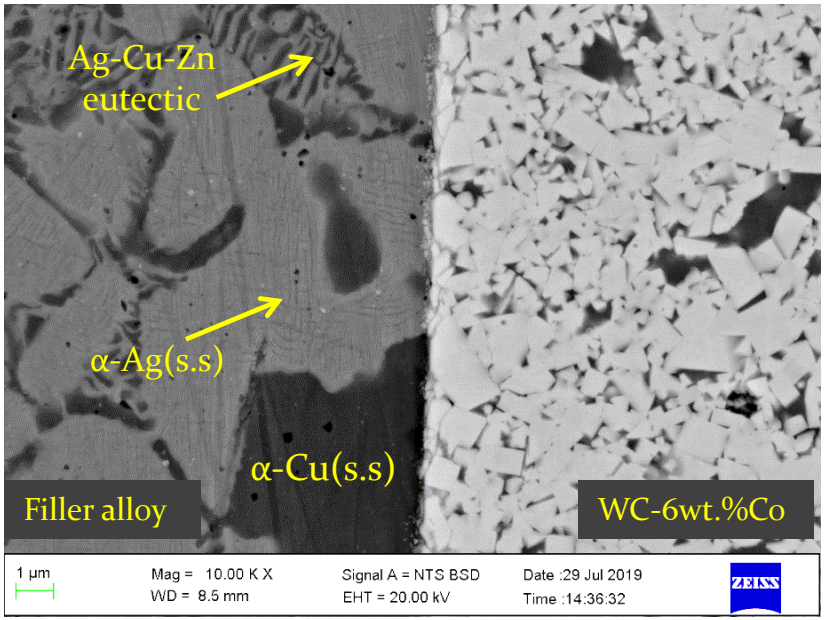
- EDS line scanning of joint brazed at 710°C for 30 sec with filler alloy of 9µm in thickness

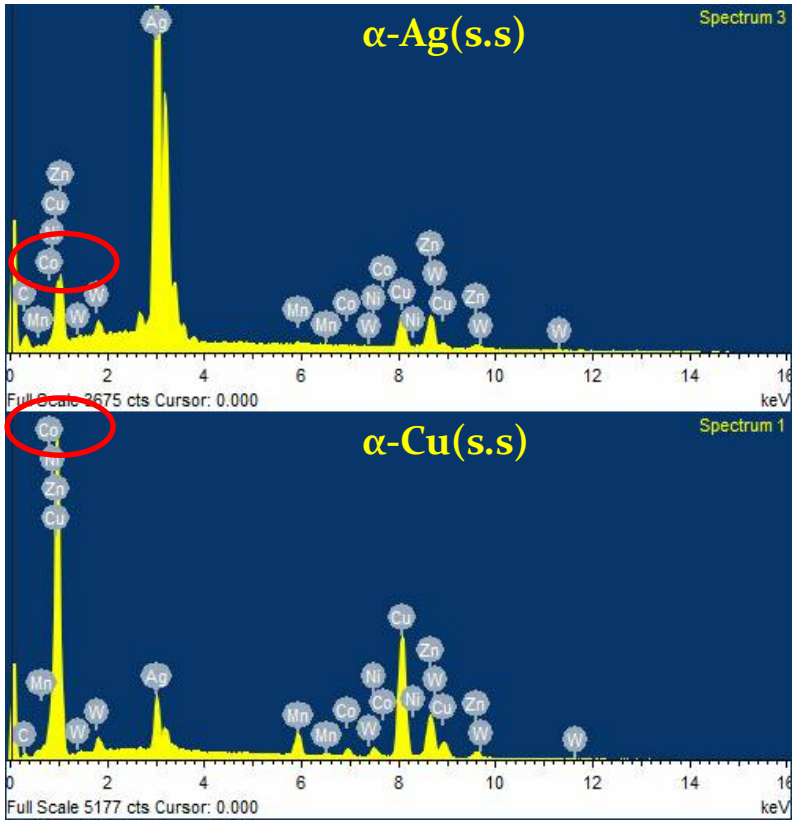




Interlayer thickness: 18µm

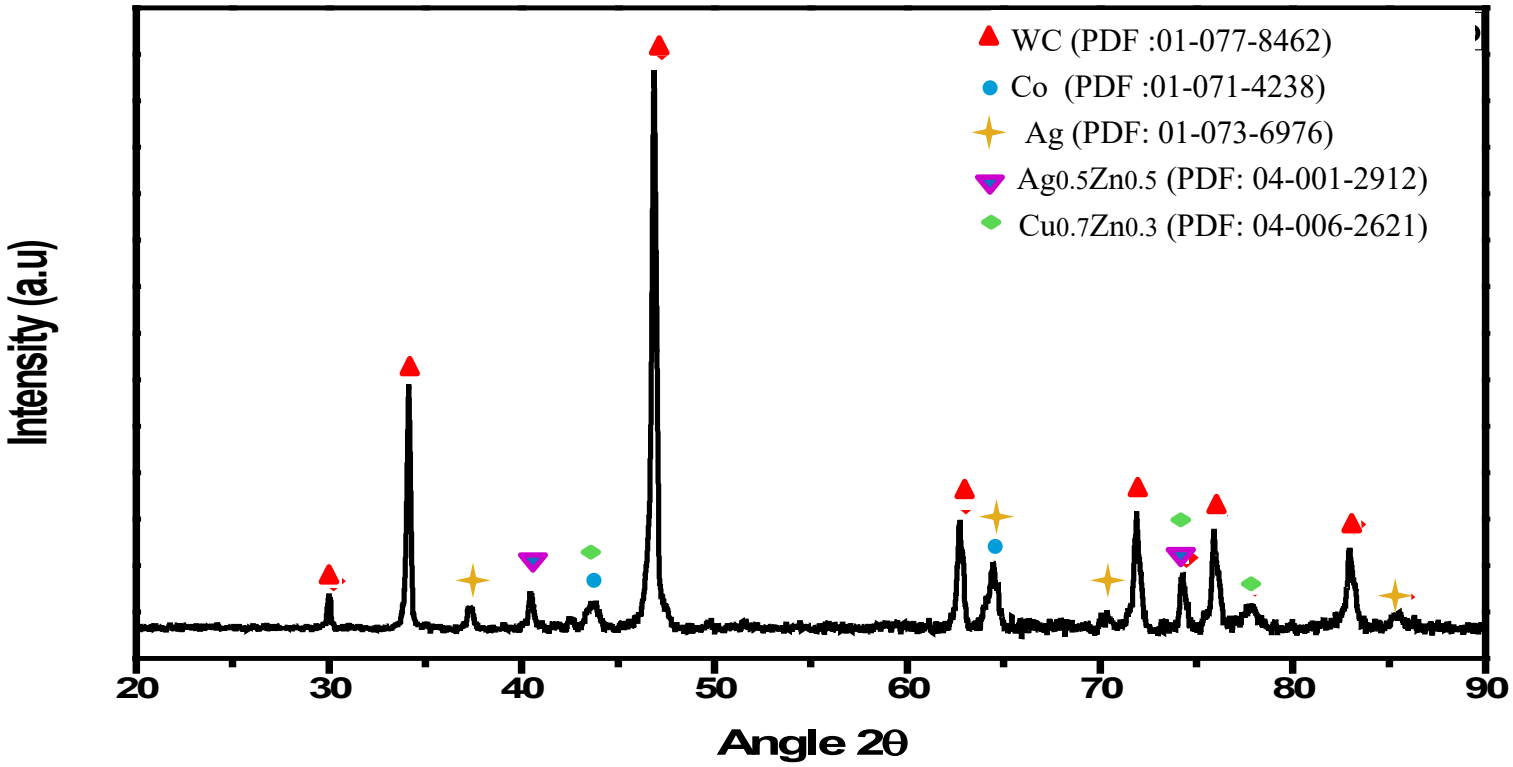
- Interlayer microstructure of **18µm** joint brazed at 710°C for 30 sec.





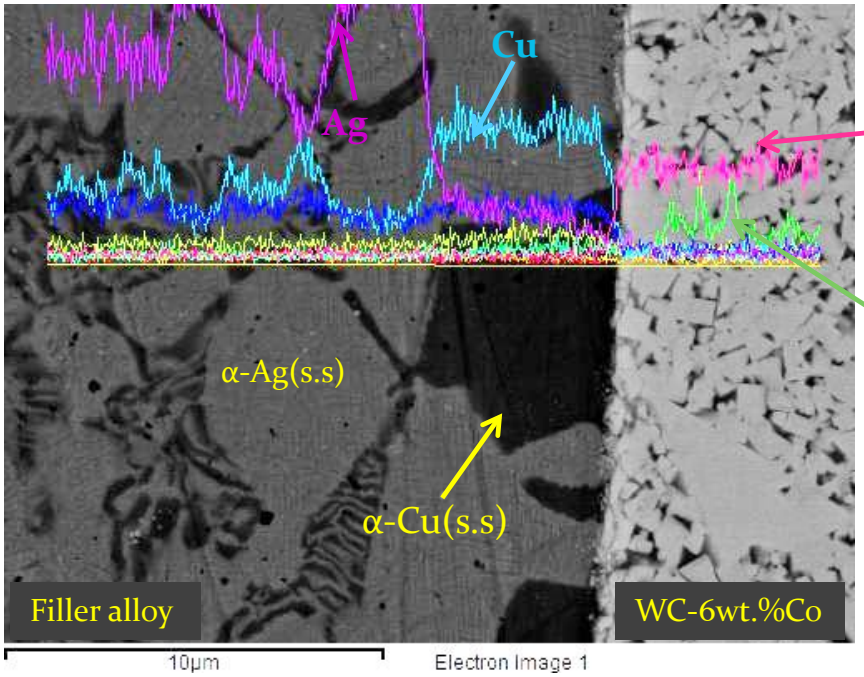
Phase analysis: 18µm

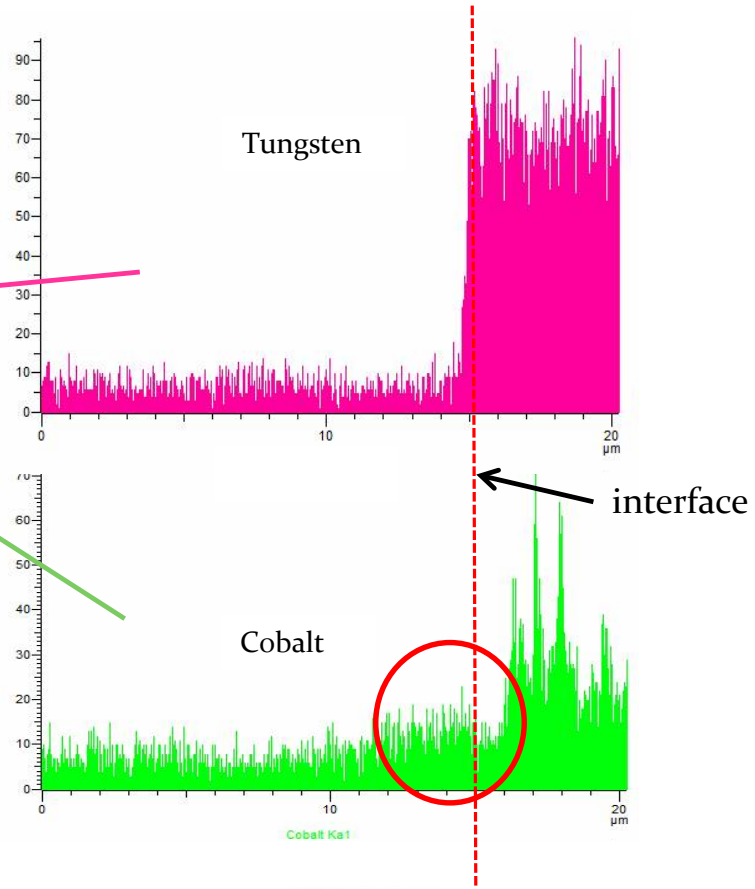
- XRD pattern of joint brazed at 710°C for 30 sec with filler alloy of 18µm in thickness.



Inter-diffusion: 18µm

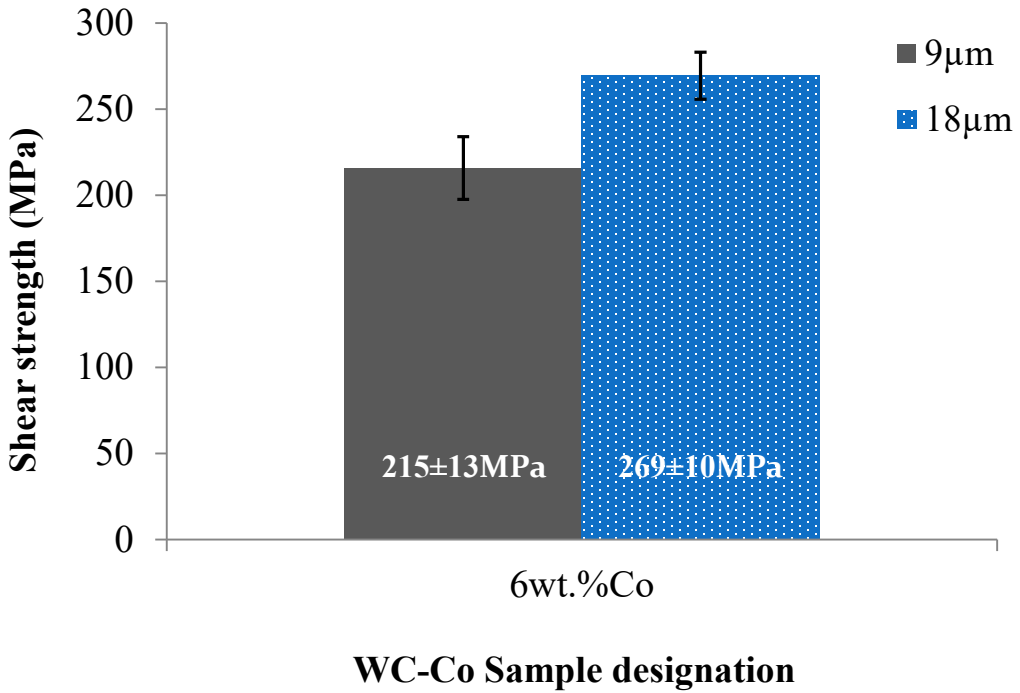
- EDS line scanning of joint brazed at 710°C for 30 sec with filler alloy of 18µm in thickness

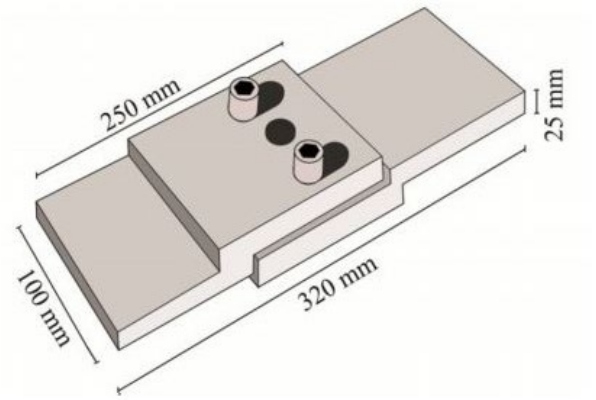




Shear strength:

- Effect of filler alloy thickness (microstructure) on shear strength of joints brazed at 710°C for 30 sec.





Strain rate = 0.5 mm/min

Summary

- Successful brazing of WC-6wt.%Co at a common interface was achieved without cracks and voids.
- Formation of interfacial α-Cu(s.s) phases deteriorated with increasing filler alloy thickness.
- Minimal inter-diffusion of elements, as a result of increased diffusion path, led to formation of Ag-Cu-Zn eutectic phases.
- α-Cu(s.s) phases have a dispersion strengthening effect on the joint strength.

Acknowledgements

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science & innovation
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DSI-NRF CENTRE OF EXCELLENCE IN STRONG MATERIALS

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THANK YOU!

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