



Explosive welding of aluminium and copper: effect of the base plate material



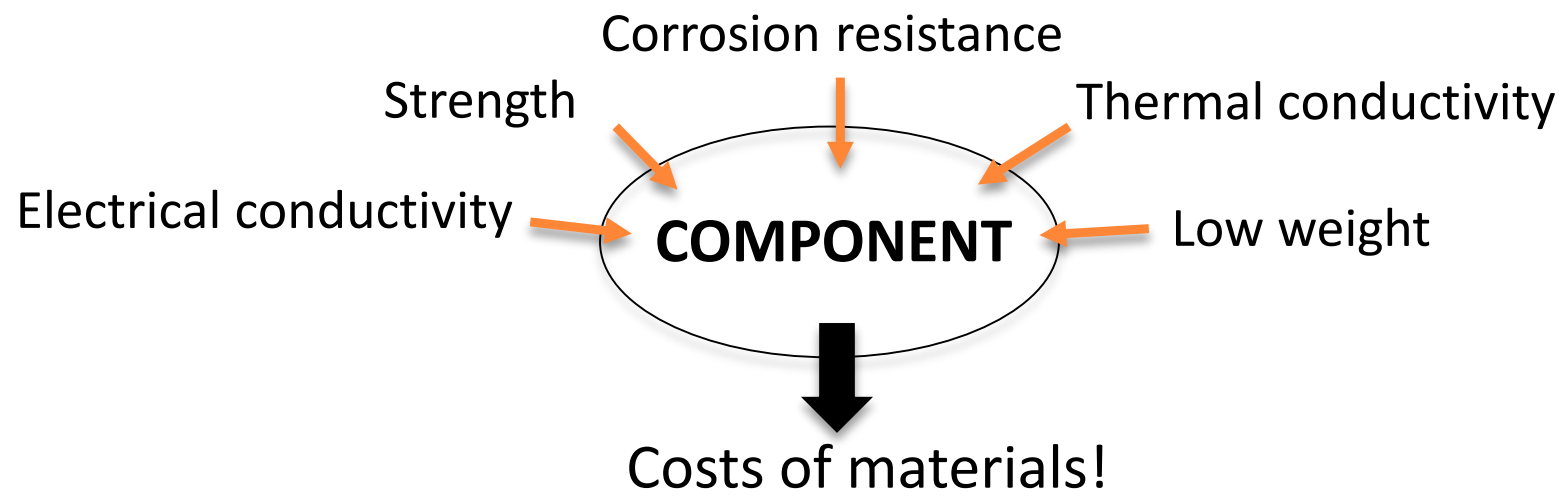
XIII International Symposium on Explosive
Production of New Materials: Science,
Technology, Business, and Innovations

Gustavo Senna Carvalho - PhD. Student at University of Coimbra

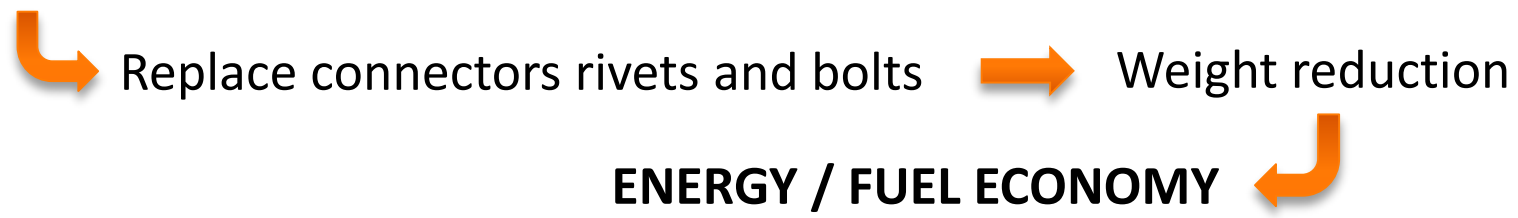
G. Carvalho, R. M. Leal, I. Galvão, R. Mendes, J. B. Ribeiro and A. Loureiro

Joining different materials

Joining different materials → it's a necessity!



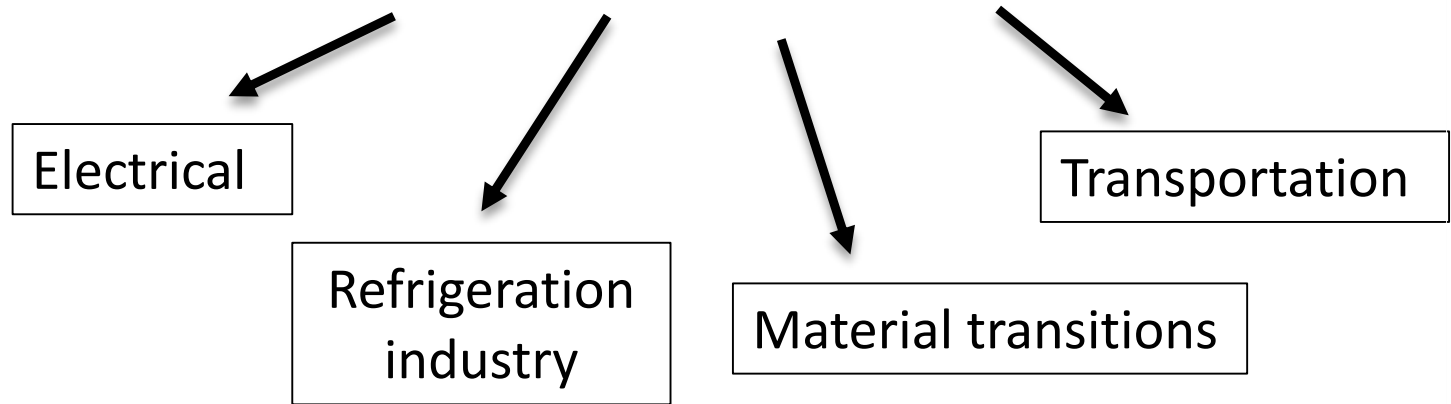
Joining by welding → **STRATEGIC**



Copper - aluminium joining

Interesting joining → Copper and aluminium are two of the three most used metals on earth

Applications / Industries



<http://forhomematerials.en.made-in-china.com/product/qvqQRXwTrMMWd/China-Explosive-Clad-Copper-Aluminum-Bimetal-Transition-Joint.html>

Copper - Aluminium joining

Physical properties of Cu and Al with steel as reference (1.0)

	<u>Copper</u>	<u>Aluminium</u>
Melting temperature	0.7	0.4
Thermal expansion	1.5	2.1
Thermal conductivity	5.9	3.1

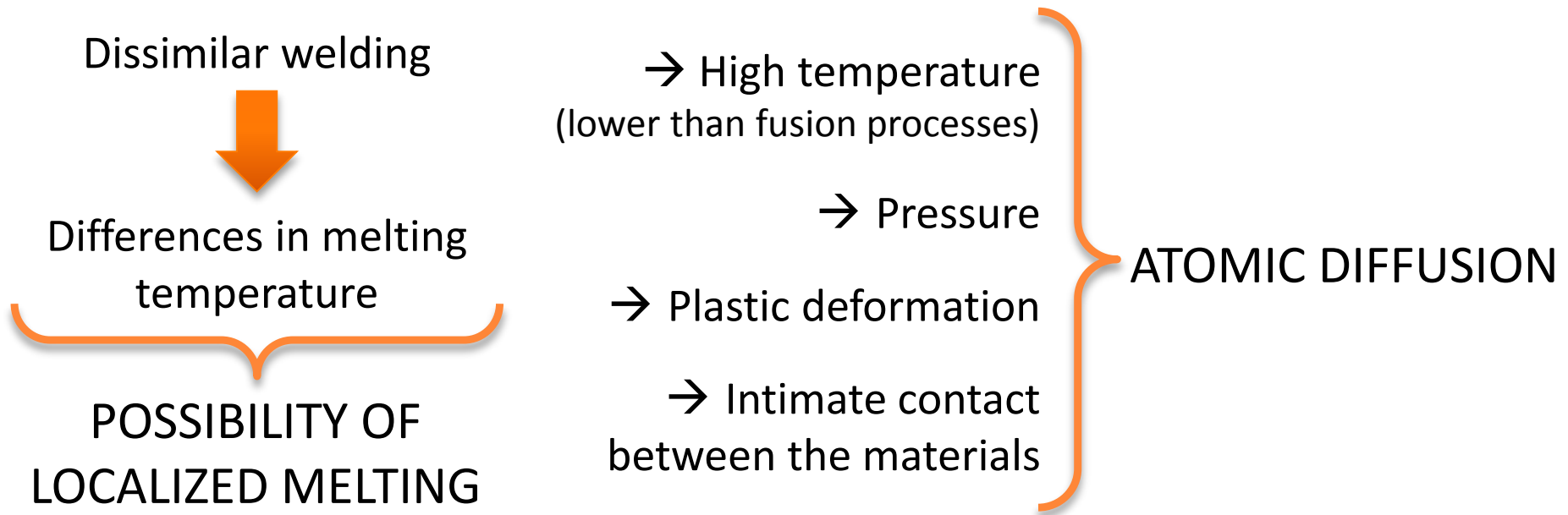
MATTHEWS, S. J., et al. (1997) Dissimilar Metals in "AWS Welding Handbook – Metals and Their Weldability" Cap 12. American Welding Society EUA.

Differences in:

- Melting temperature
 - Thermal conductivity
 - Thermal expansion
- Metallurgical problems: hot cracks
- Heat directed at only one of the materials
- Difficult combination!**
- High residual stresses

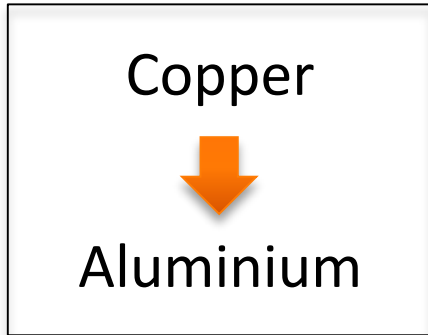
Solid-state welding (EXW) for Cu-Al joining

EXW is a viable way to join this combination but it's not easy because of the formation of brittle intermetallic phases and defects related to localized fusion.



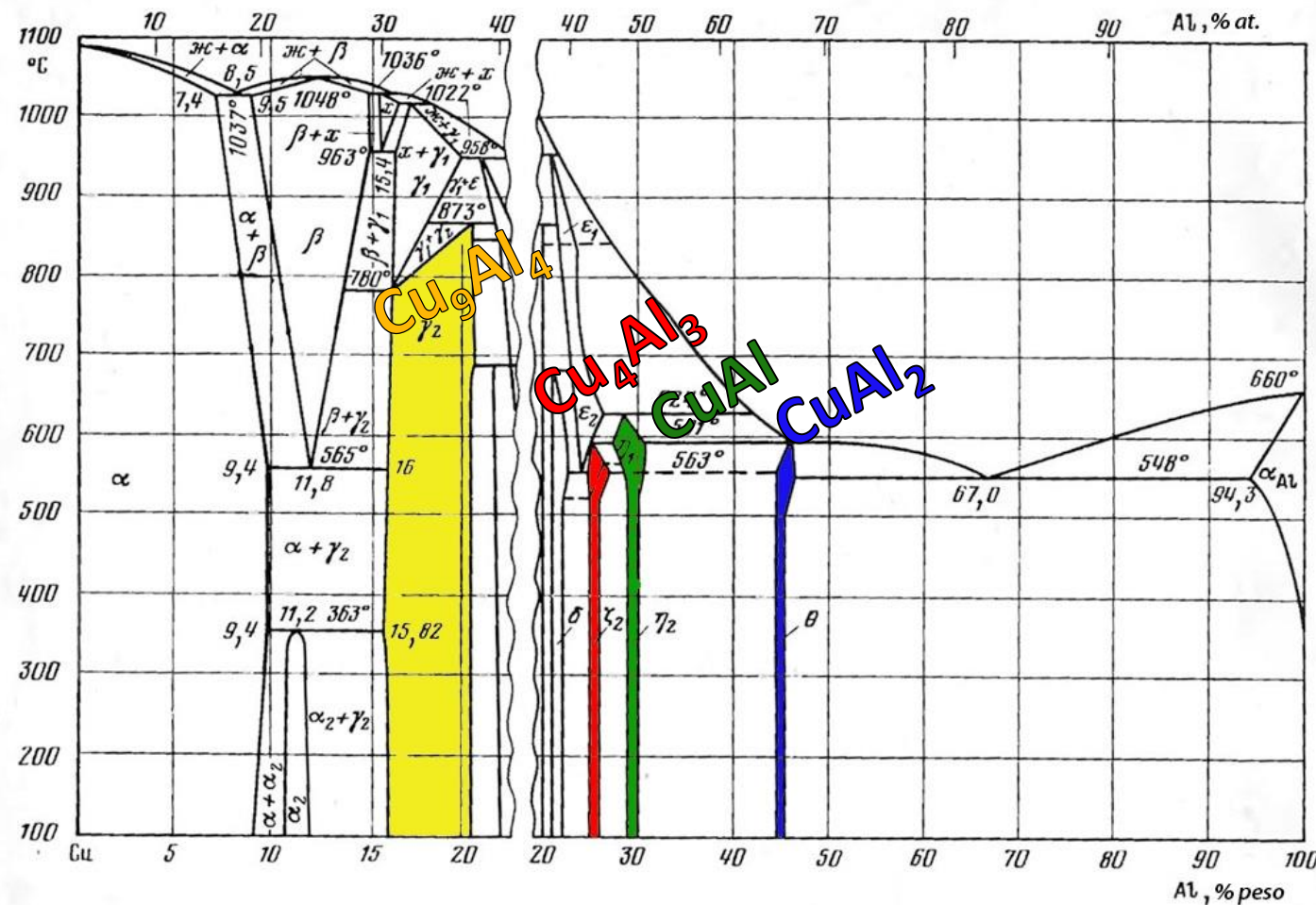
Possibility of localized fusion and some diffusion is almost inevitable in this process.

The diffusion issue



Formation of brittle intermetallic phases.

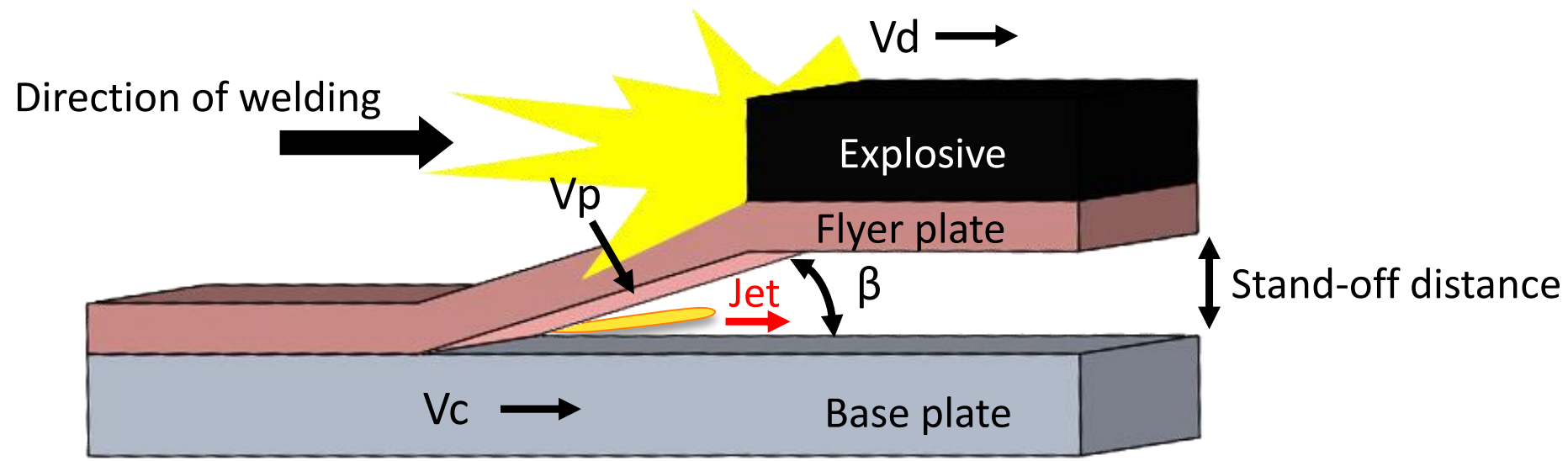
Harmful to the mechanical properties.



DRITS, M.E., BOCHAR, N.R., GUZEI, L.S., LYSOVA, E.V., PADEZHNOVA, E.M., ROKHLIN, L.L., TURKINA, N.I., (1979) Cu-Al in "Binary and Multicomponent Copper-Base Systems" [in Russian], p.8. Ed. Nauka. Moscou, União Soviética.

Explosive Welding - EXW

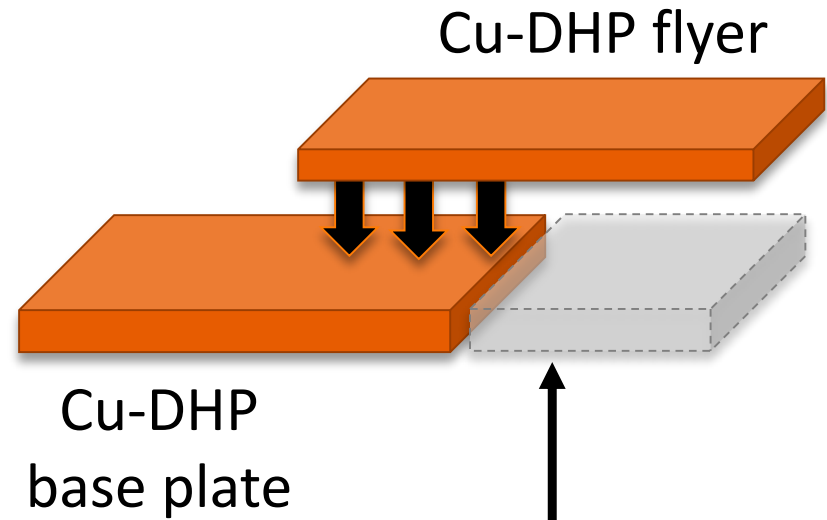
Explosion welding is a solid-state process characterized by a high-velocity impact between two materials as the result of controlled detonation of an explosive.



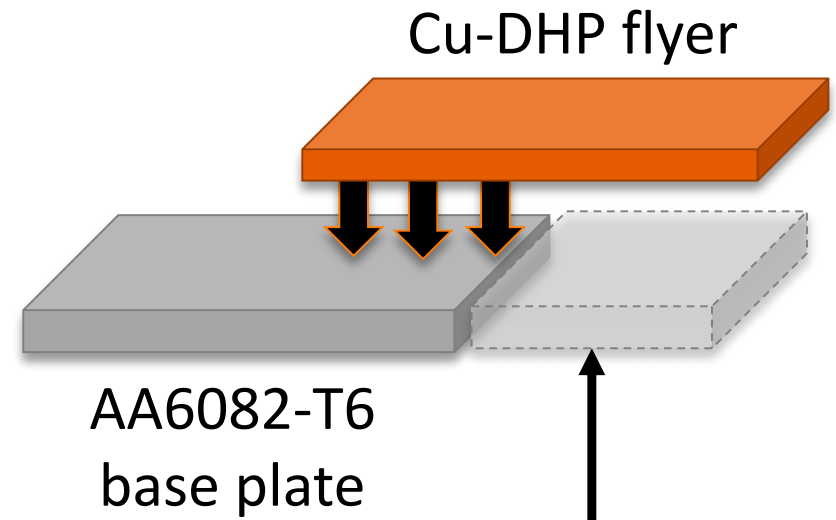
Objectives

The purpose of this investigation was to compare welds with different base plate alloys and the same flyer alloy: a similar Cu-Cu weld and a dissimilar Cu-Al weld. Both partially overlapped.

SIMILAR WELD



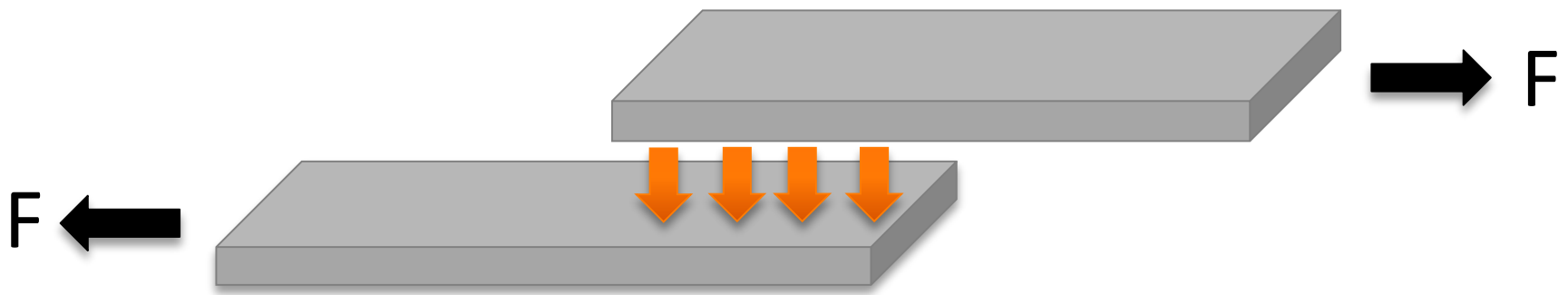
DISSIMILAR WELD



Support for the flyer

Objectives

The purpose of this investigation was to compare welds with different base plate alloys and the same flyer alloy: a similar Cu-Cu weld and a dissimilar Cu-Al weld. Both partially overlapped.



For load transfer applications

Materials and Conditions

SAME WELD PARAMETERS

Explosive composition and density

Ammonium nitrate-based explosive emulsion + with hollow glass microspheres

STD

1,35 mm

plates thickness

Flyer (Cu): 1 mm
Base plate : 3mm

DIFFERENT MATERIALS

Different base plates

Cu-DHP (C12200) → Similar weld

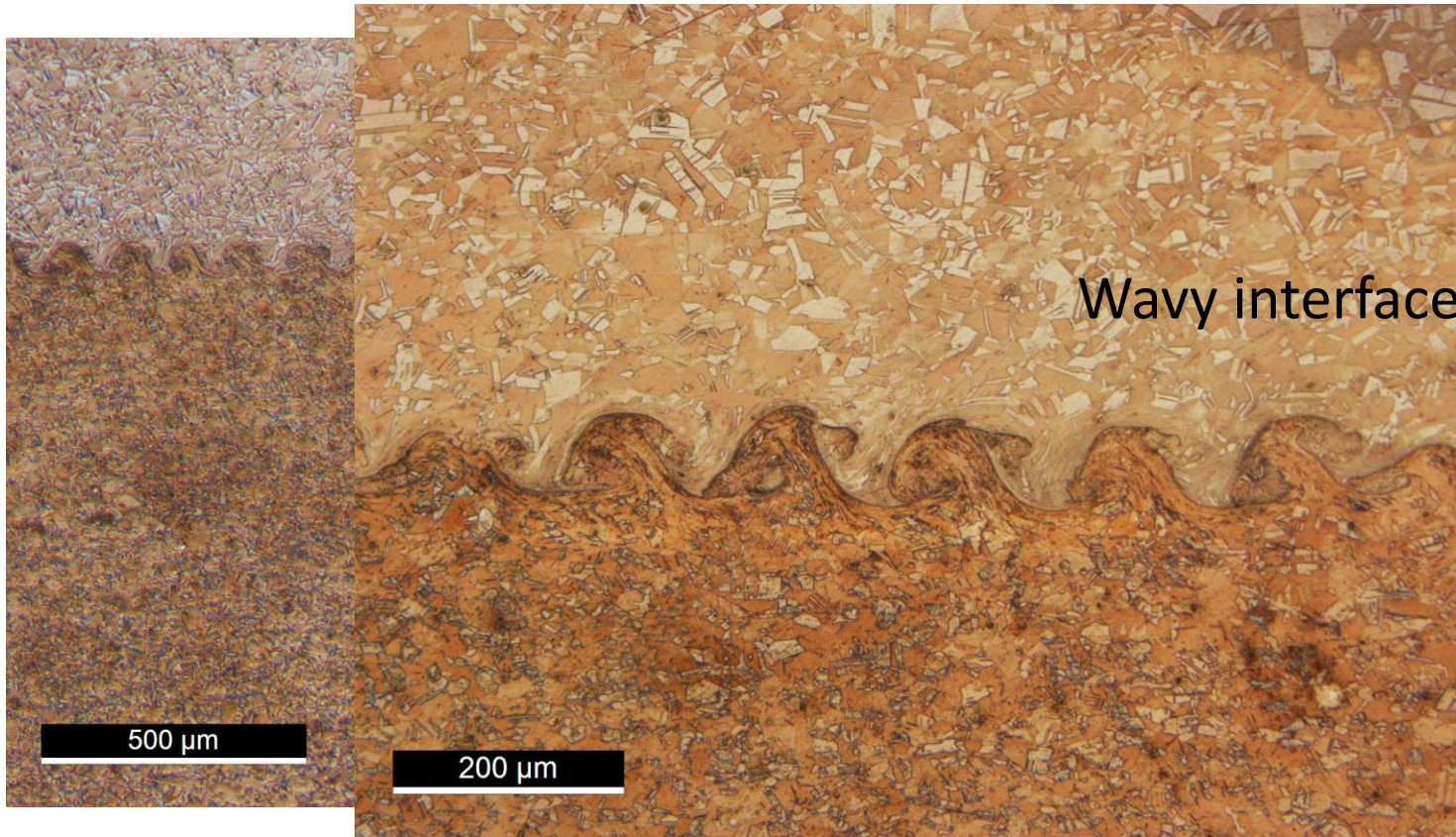
AA 6082-T6 → Dissimilar weld



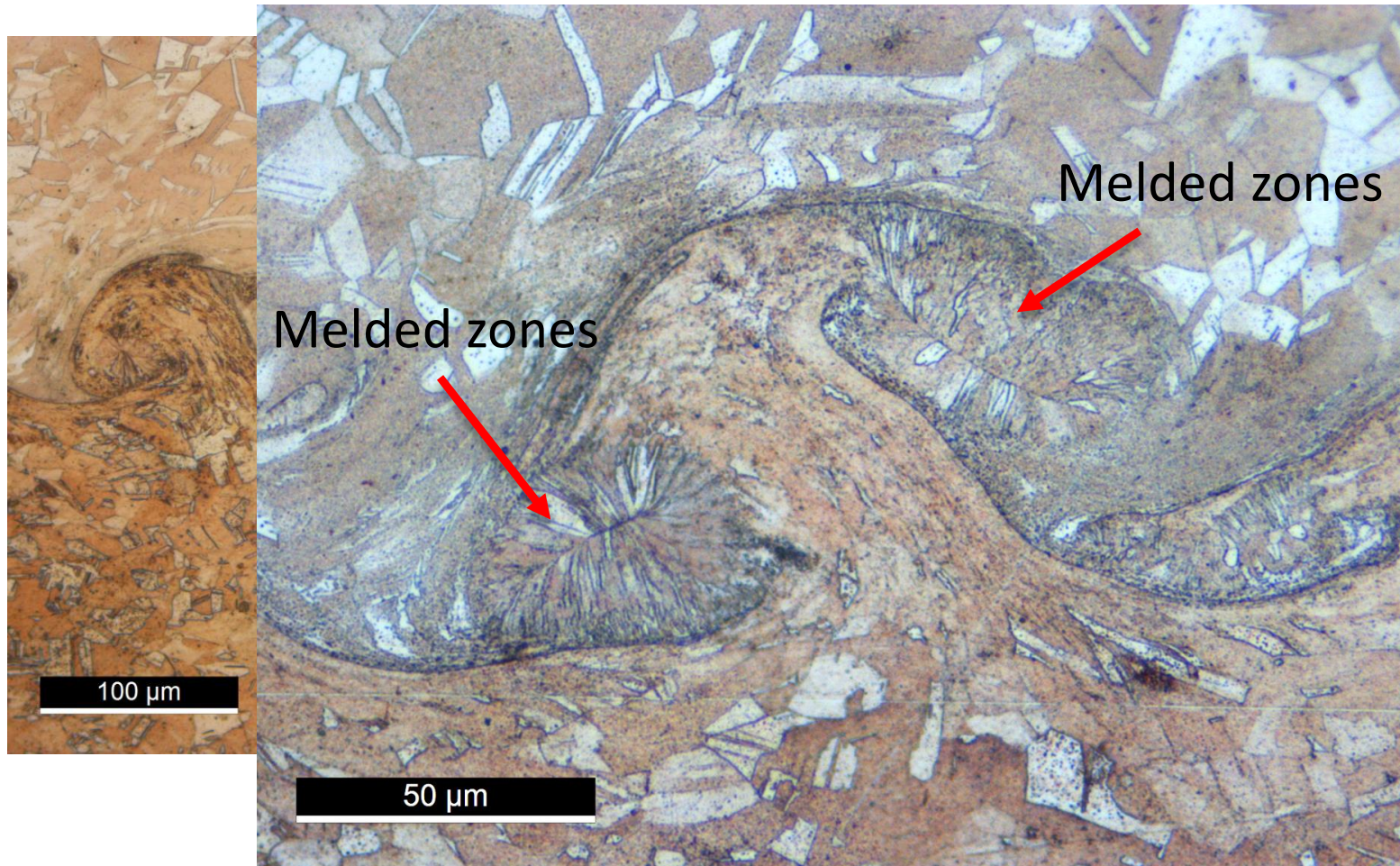
RESULTS

Results – Interface analysis - Microstructure

Similar: Copper → Copper

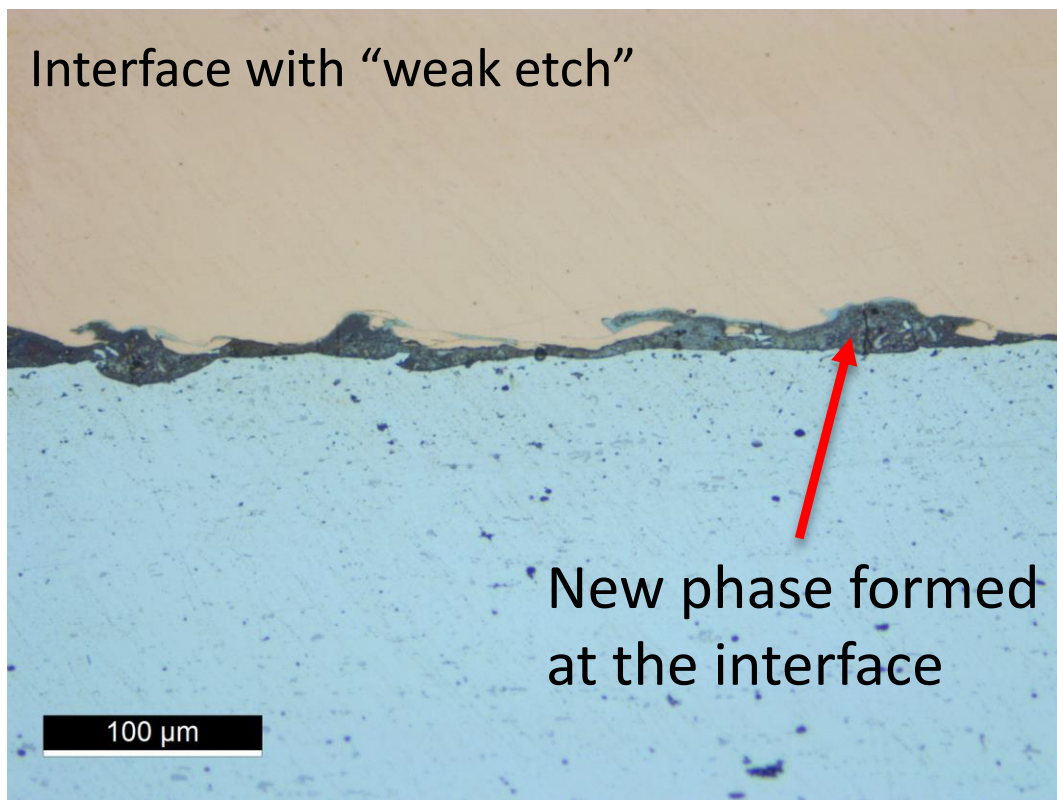


Results – Interface analysis - Waves



Results – Interface analysis - Microstructure

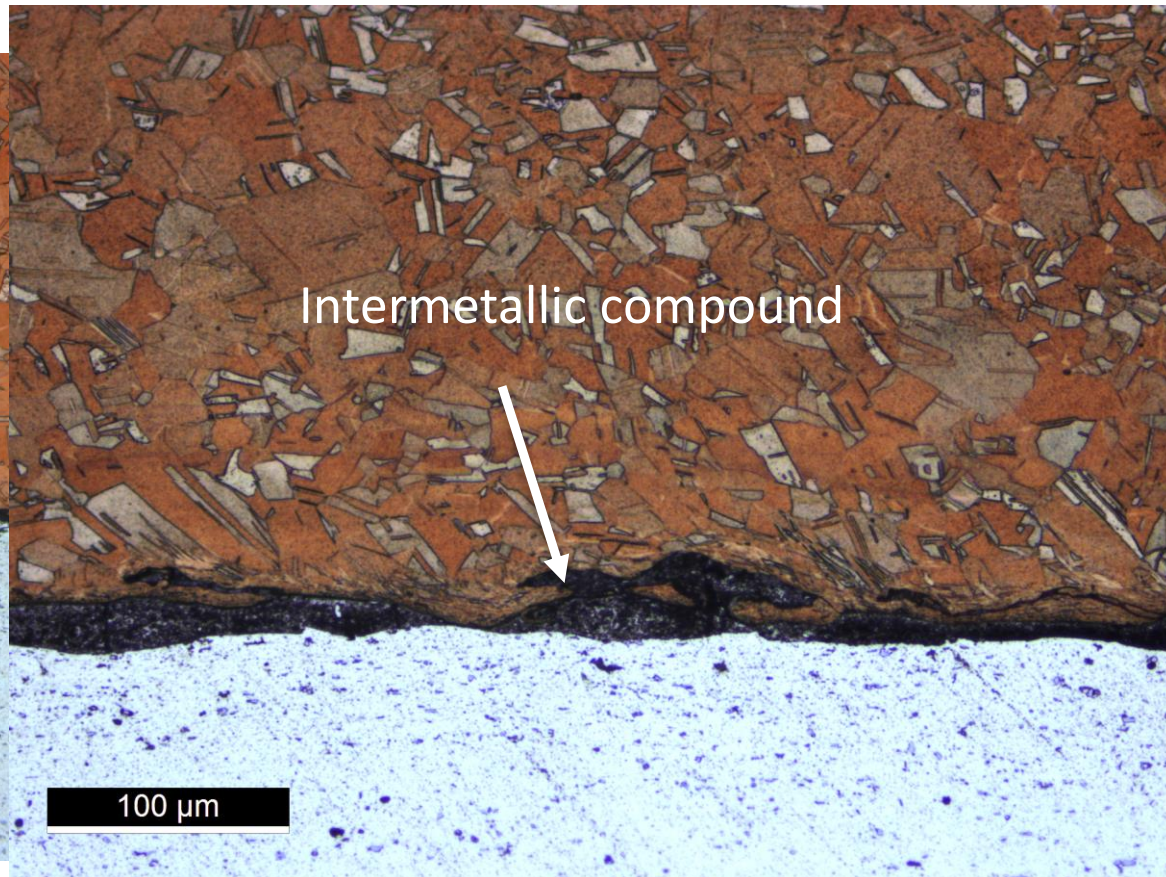
Dissimilar: Copper → Aluminium



No waves!
Plane interface

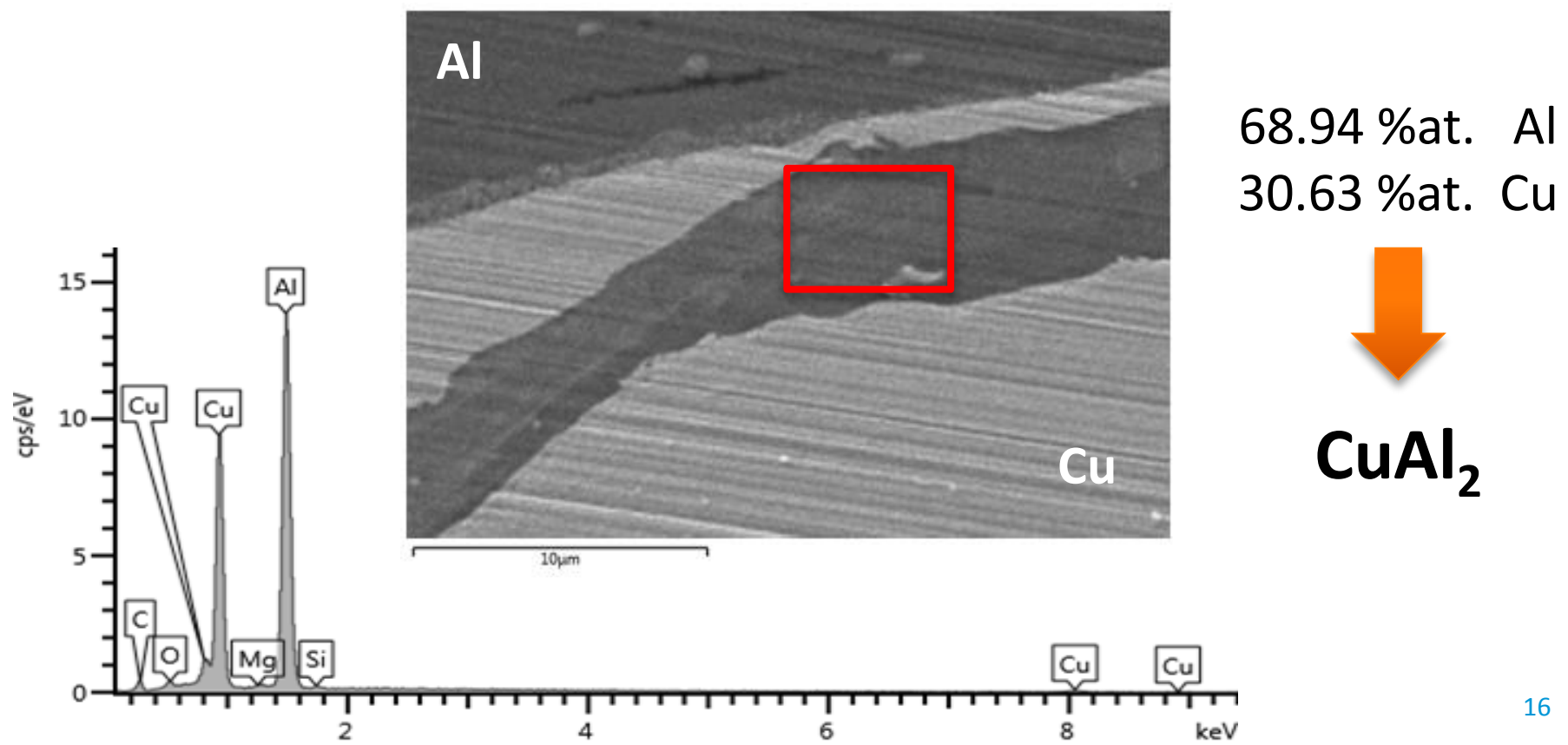
Results – Interface analysis - Microstructure

Dissimilar: Copper → Aluminium

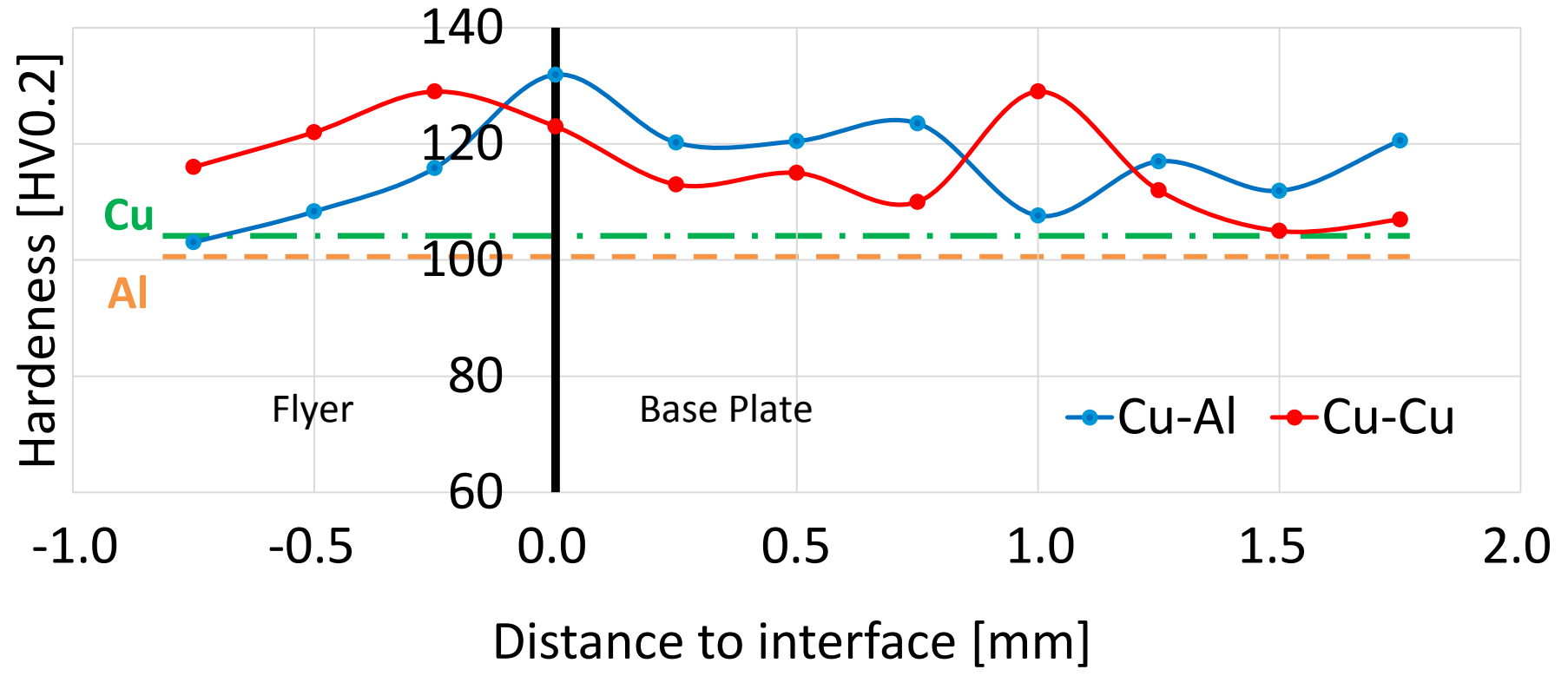


Results – Interface analysis - Microstructure

Dissimilar: Copper → Aluminium [SEM analysis]



Results – Interface analysis - Hardness



The hardness increased for both samples, but it can be seen a slightly greater increase in for the Cu-flyer of the similar weld

Discussion

Waves for the combination Cu-Cu
No waves for the combination Cu-Al



Differences in Yield strength

Yield strength  Wave formation

Wave formation is strongly related with the “Yield Strength” and “density” of the base plate and flyer

Melted regions but no intermetallics → Cu-Cu Weld
Presence of intermetallic phase → Cu-Al Weld



Expected

Conclusions

- Was possible to joining both samples with the same parameters;
- Increase in hardness for both welds but a slightly greater increase in hardness for the Cu-flyer of the similar weld;
- Despite the same parameters, it was found different interface morphologies due differences on the base plate Yield Strength and density;
- Formation of intermetallic phases for the Cu-Al combination related with diffusion of copper to the aluminium plate.



THANK YOU!
OBRIGADO!

*“Paço das Escolas”
University of Coimbra*