INTERFACE CHARACTERISTICS OF ALUMINUM-COPPER OBTAINED BY EXPLOSIVE WELDING

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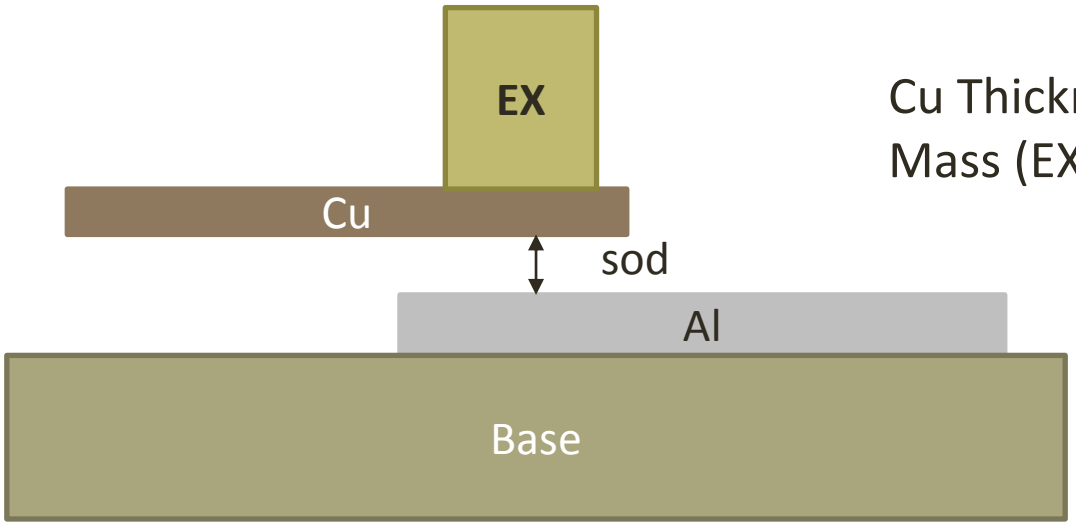
Content

- Objective
- Explosive characteristics
- Results
- Conclusions

Objective

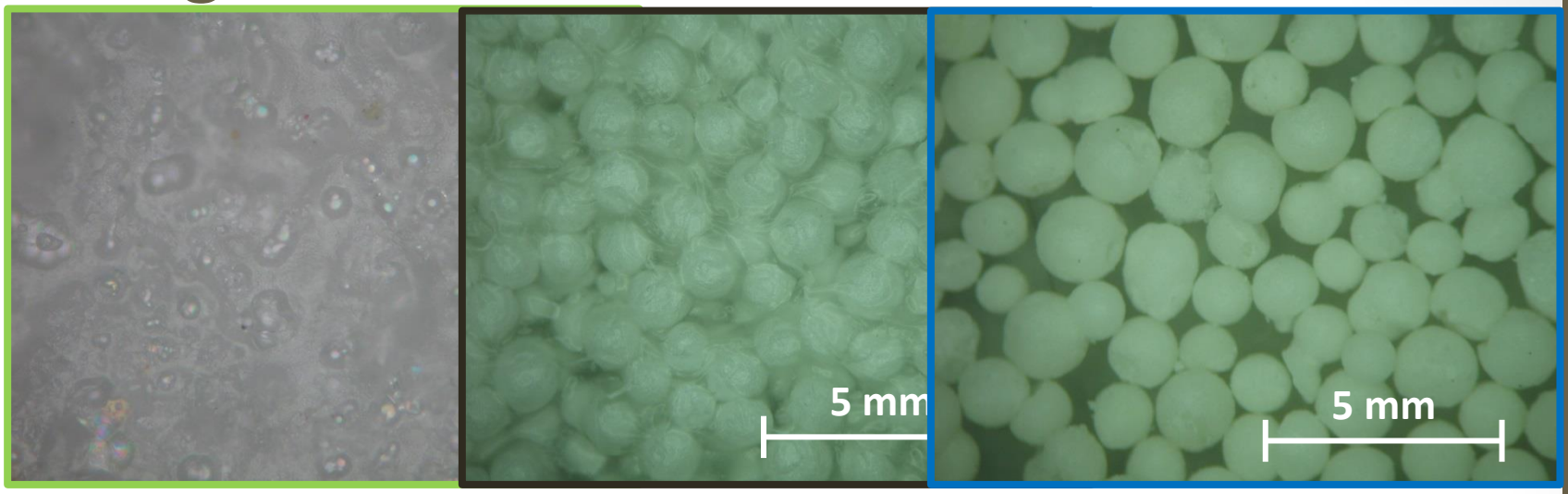
1. Preparation of Cu/Al full lap joint by explosive welding.

2. Study of the explosive nature and explosive/flyer mass ratio on the characteristics of the bonding interface.



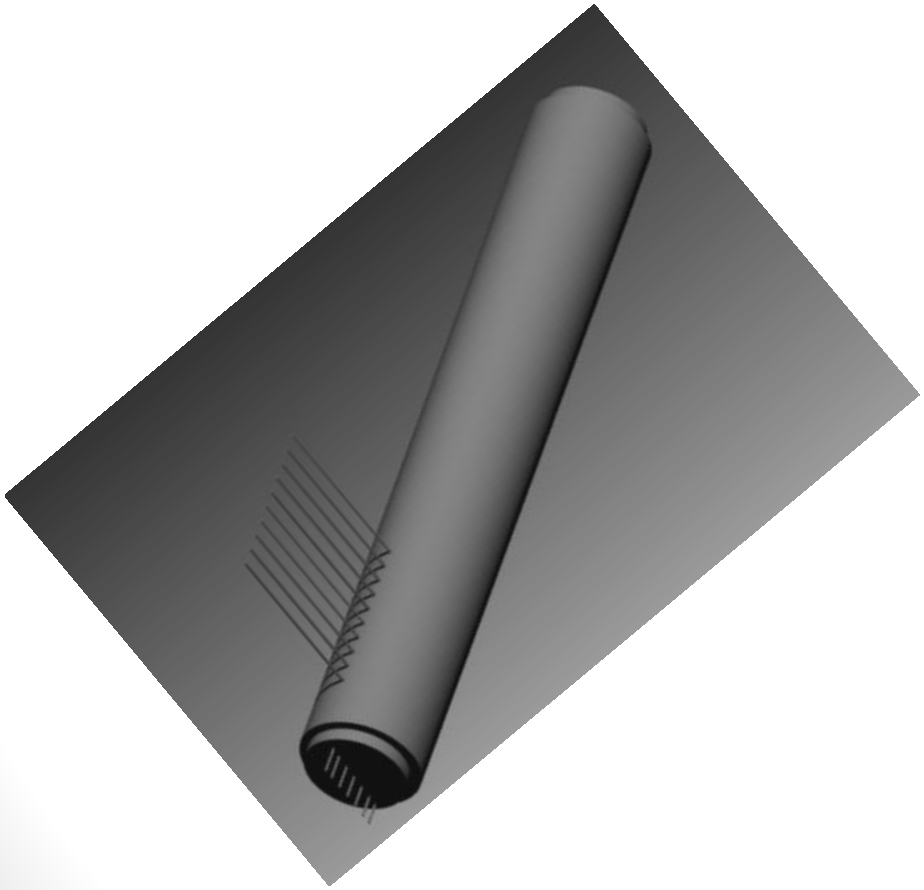
Cu Thickness – 1mm
Mass (EX/flyer) **R**: 1 - 3

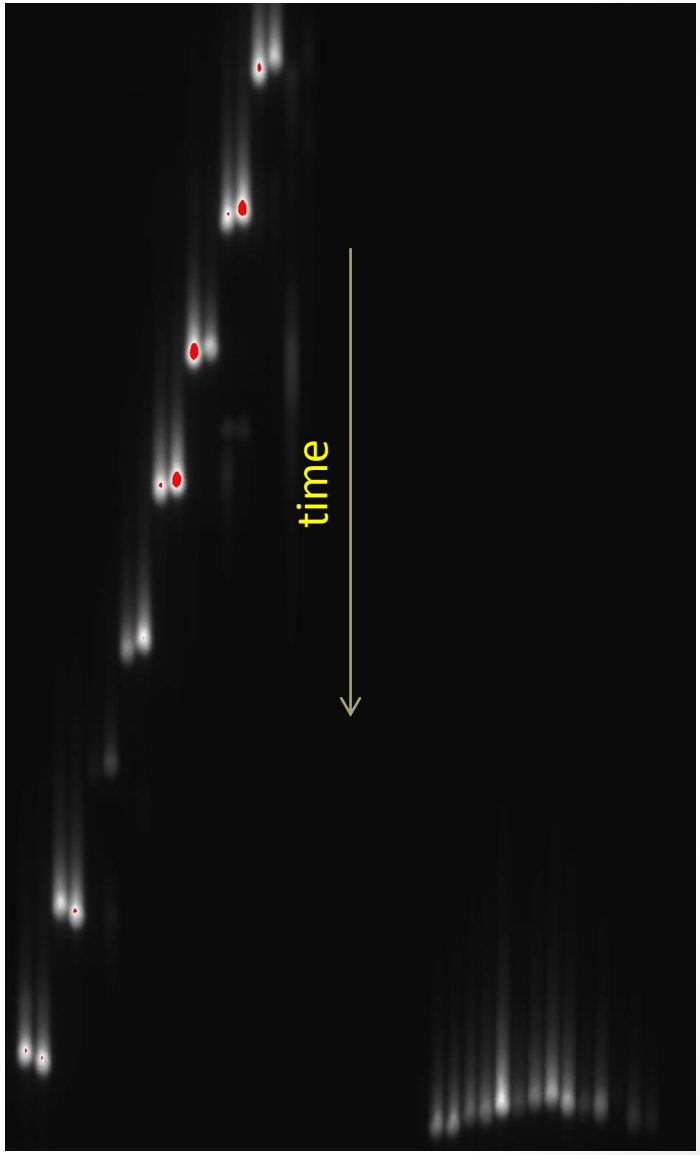
Energetic Material



Emulsion Matrix	EPS (%)	HGMB (%)	ANFO (%)	ρ_0 (g/cm^3)
85	-	15	-	0.76
98	1.2	-	-	0.90
20	-	-	80	0.82
-	-	-	100	0.80

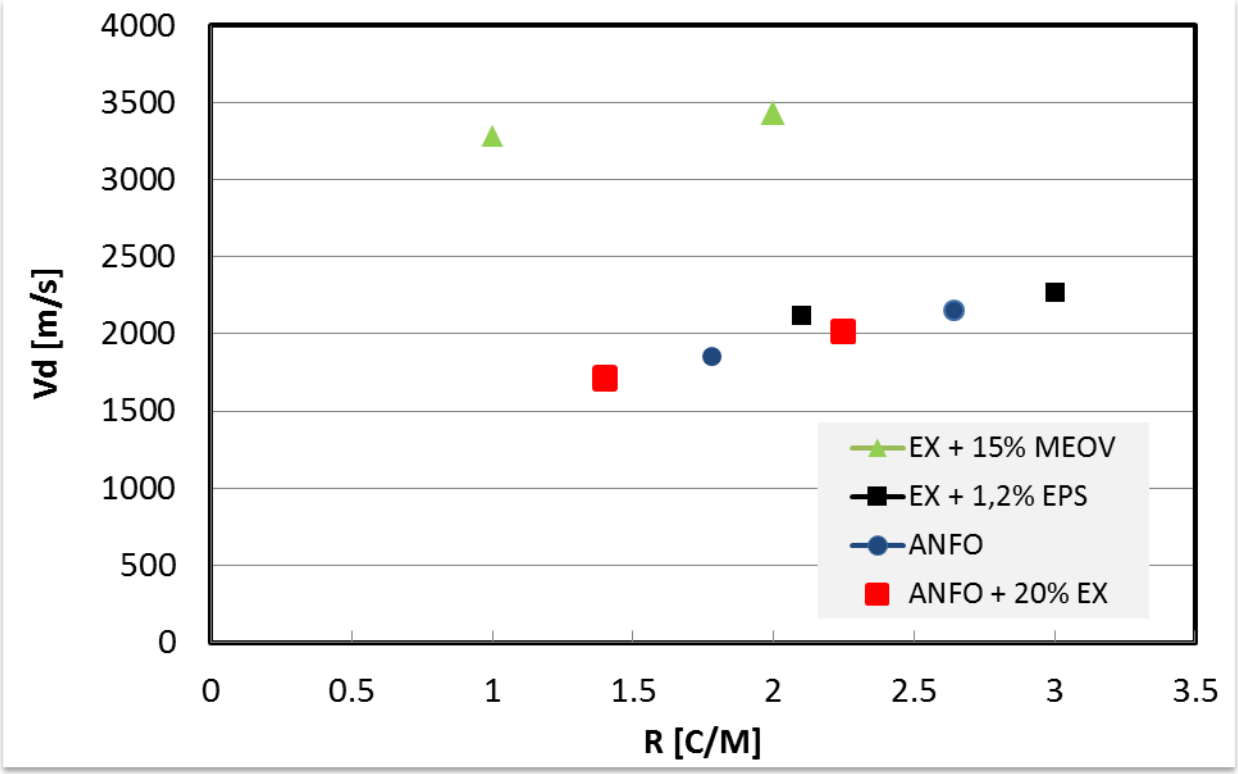
Long charge teste- Detonation velocity





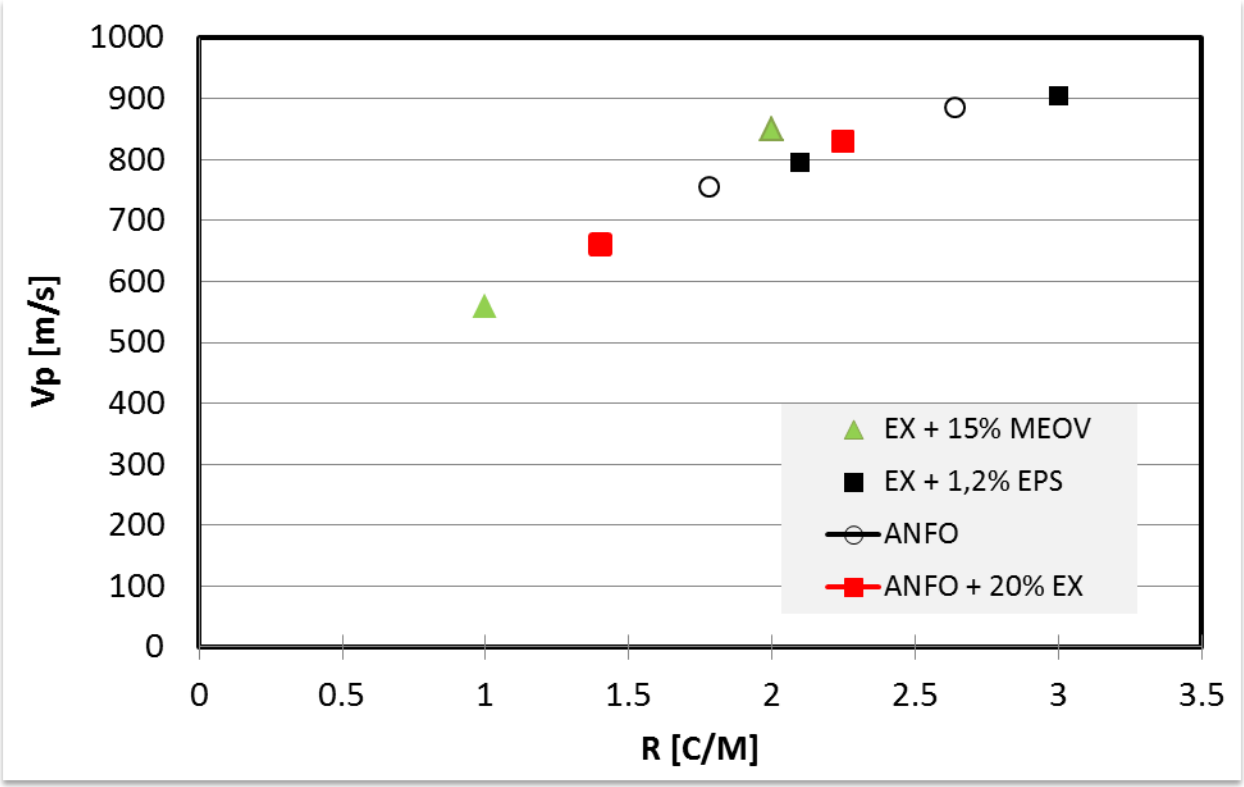
Detonation velocity

Detonation velocity vs Explosive/flyer mass ratio (R)



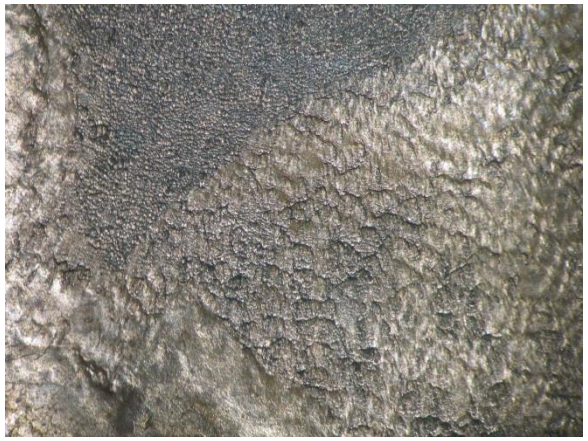
Impact velocity

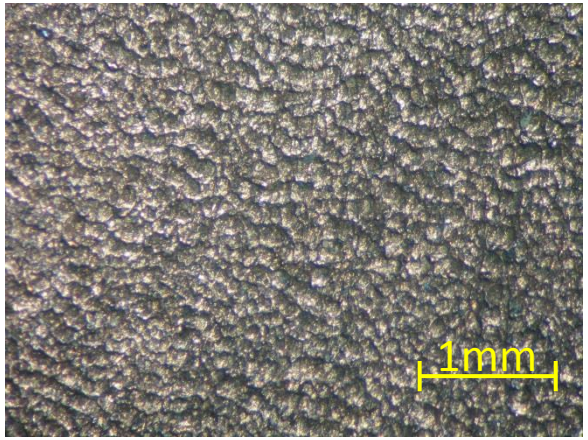
- Impact velocity vs Explosive/flyer mass ratio: Vp(R)



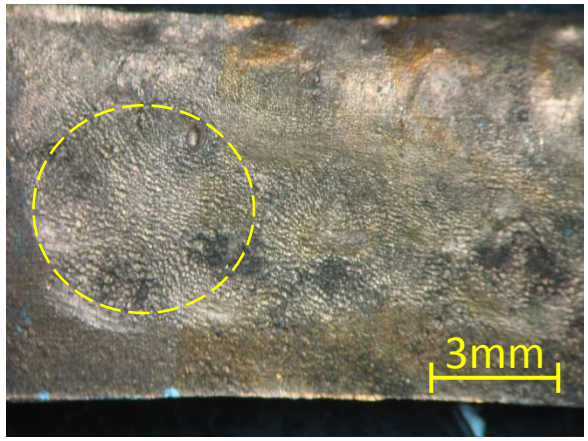
Copper surface in contact with explosive- I

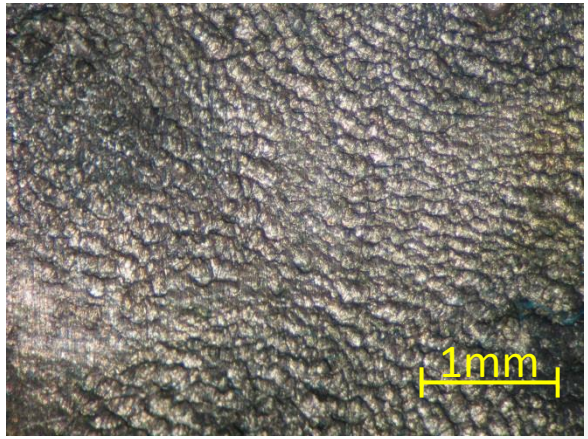
EX + 15% HGMB





EX + 1.2% EPS

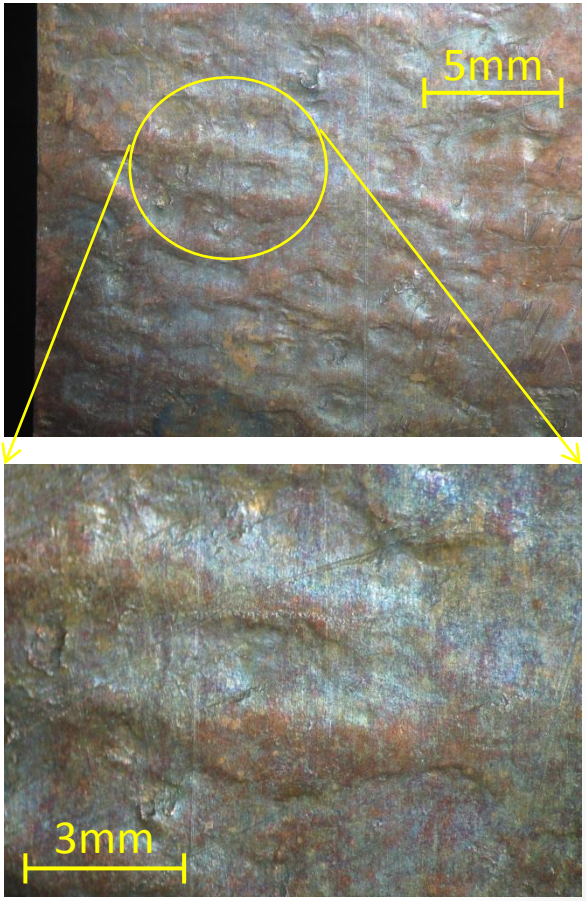




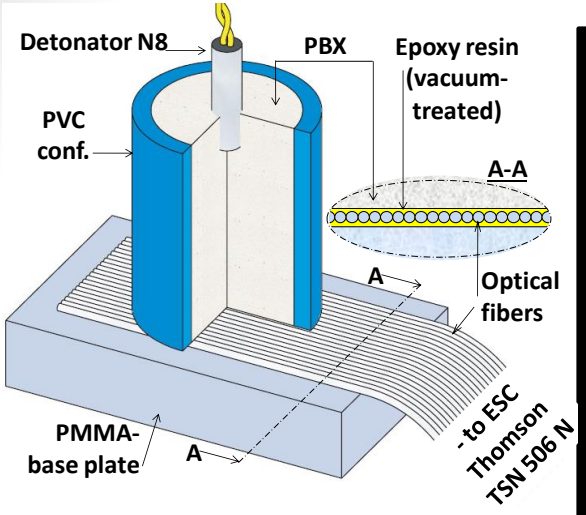
Copper surface in contact with explosive- II

ANFO + 20% EX

ANFO

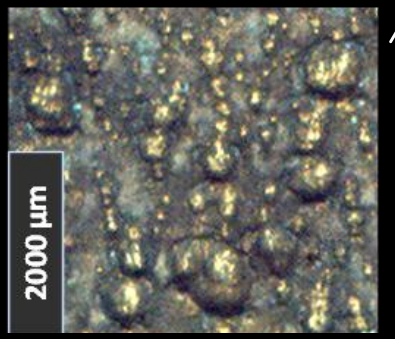


Effect of Ejecta-driven detonation cells on the boundary layer of copper confinement



HMX(203.7 µm) / HMX(10.40 µm) / GAP 65.6/16.4/18 wt.%:
ρ_0 =1.704 g/cm³; 0.974 TMD; D = 8.56 mm/µs, $d_{failure}$ =1.65 mm

PBX long charge, 28 mm diameter



Copper confinement recovered

DW

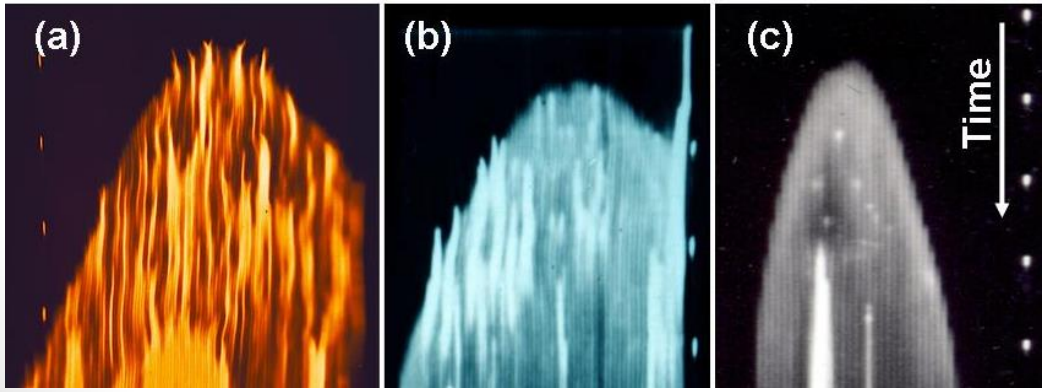
Ejecta:
Δt = 60 ns (max)
Length: 0.5 mm

Cells : Ø1.2 mm

➔Spatially-resolved registration of the DRZ-localizations was performed with application of 96-channel optical analyzer MCOA-UC.

➔Bright spots are corresponding to high-Temperature localizations (visible and near-IR radiation);

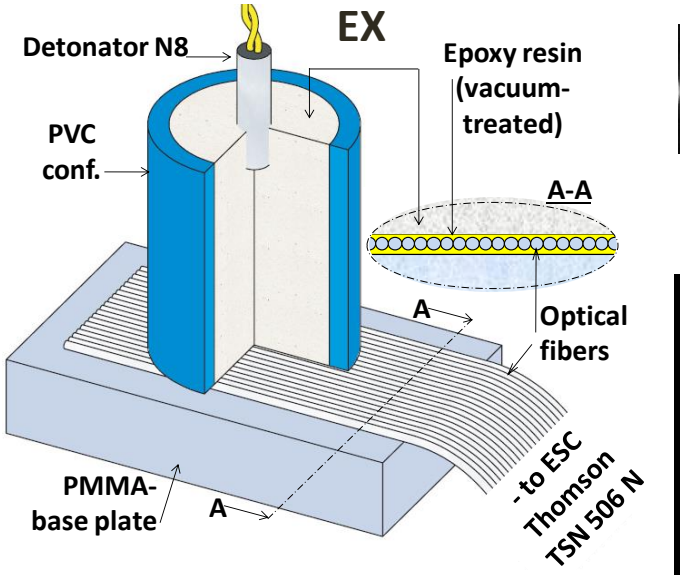
➔Reaction localizations produce significant perturbations in the boundary layer of copper-confinement & PBX-driven liner (recovered copper-confinement is shown in the left image)

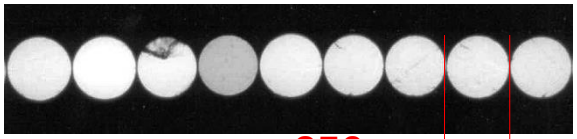


PBX_{st} (a), HMX_L/Water (b) and HMX_F/Water (c). 40ns

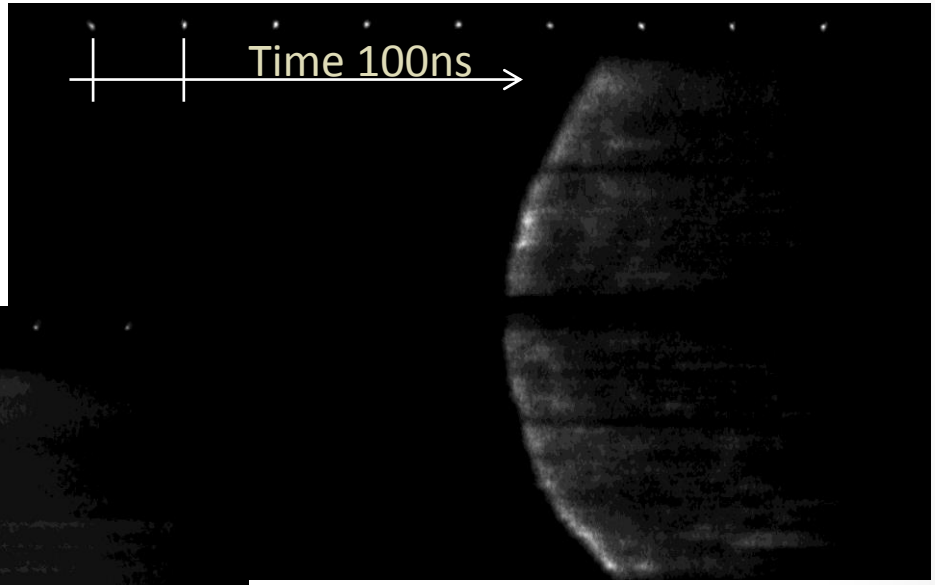
Plaksin et al. 2001, 2003, 2005

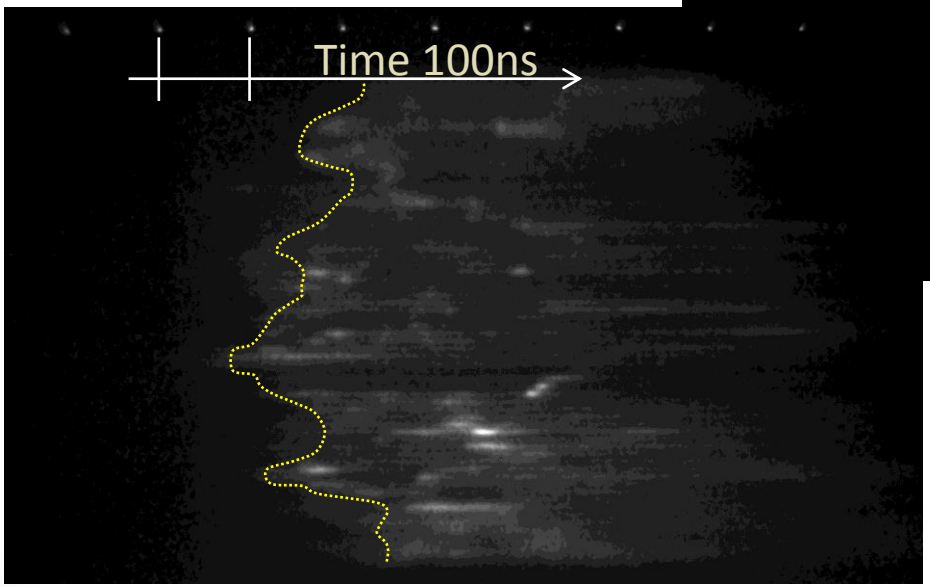
Energetic Material: Detonation Front





EX + 15% HGMB

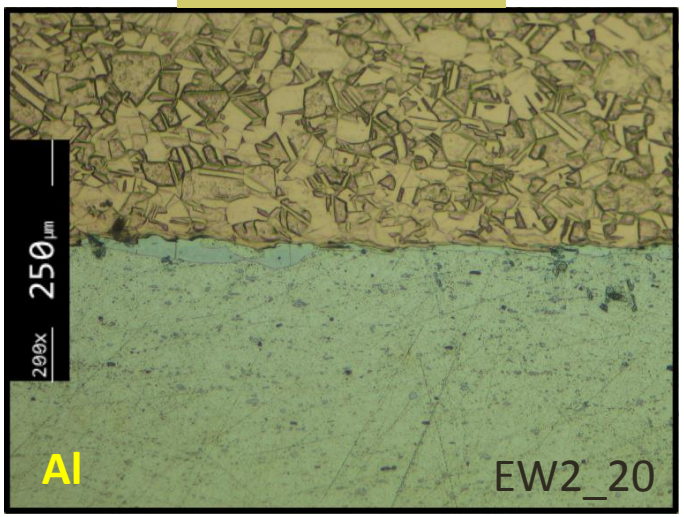


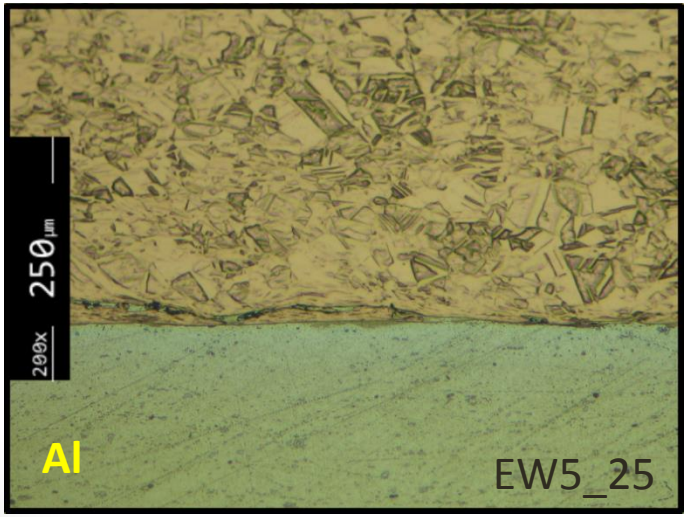


EX + 1.2% EPS

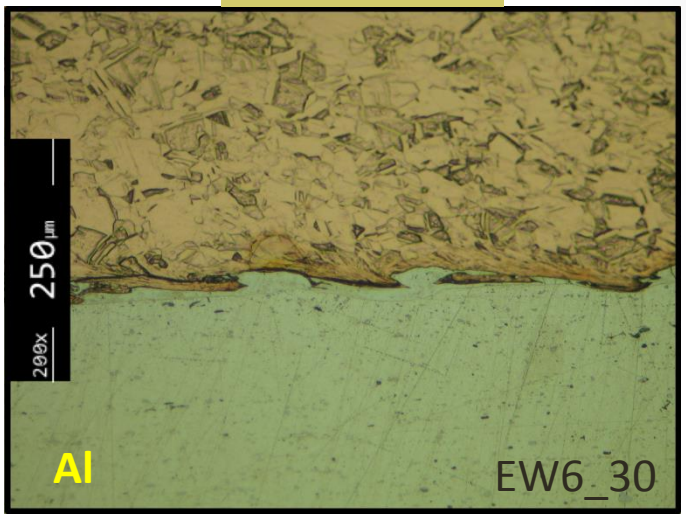
Results: Interfacial waves

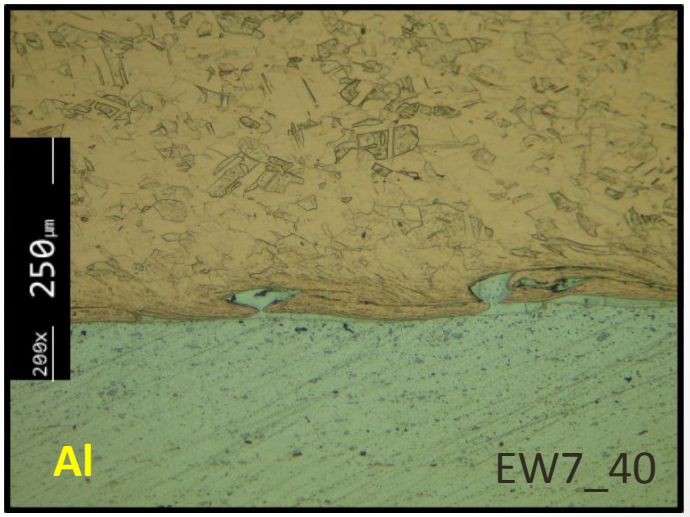
EX+15%HGMB





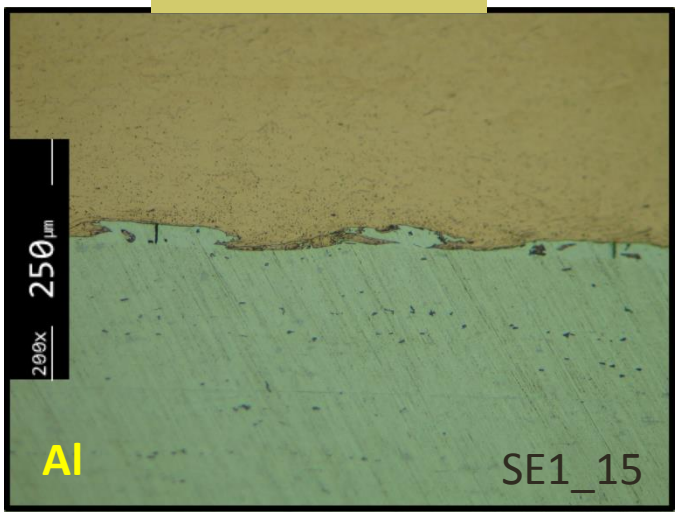
EX+1.2%EPS



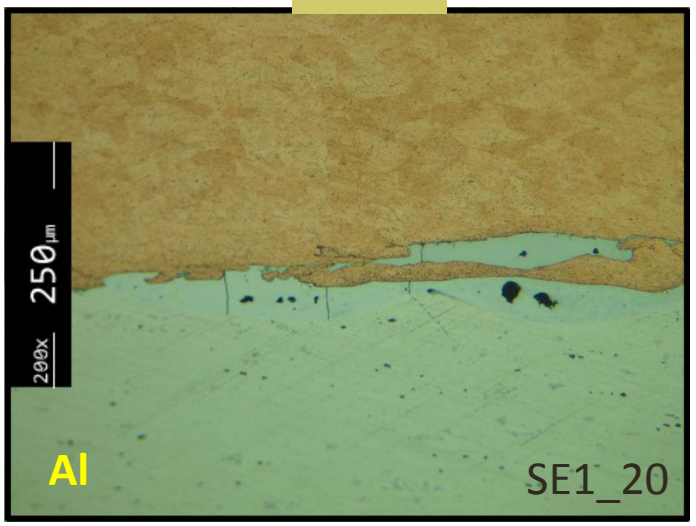


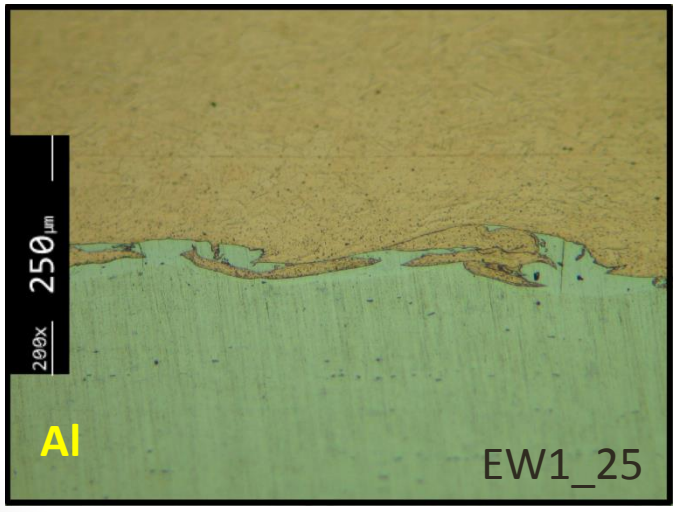
Results: Interfacial waves

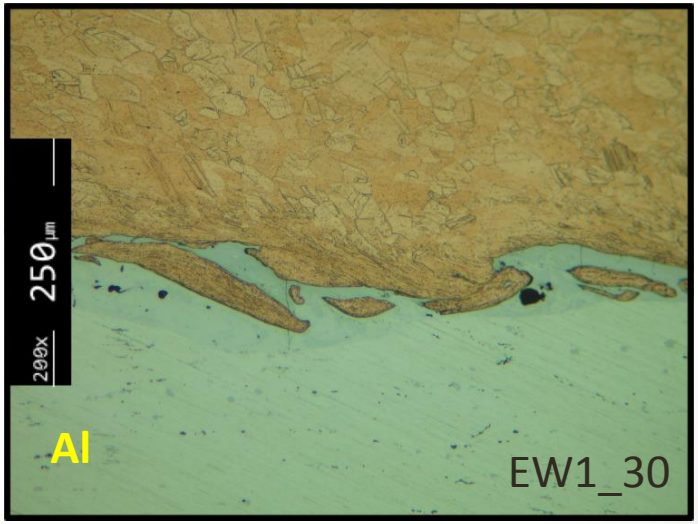
ANFO + 20%EX



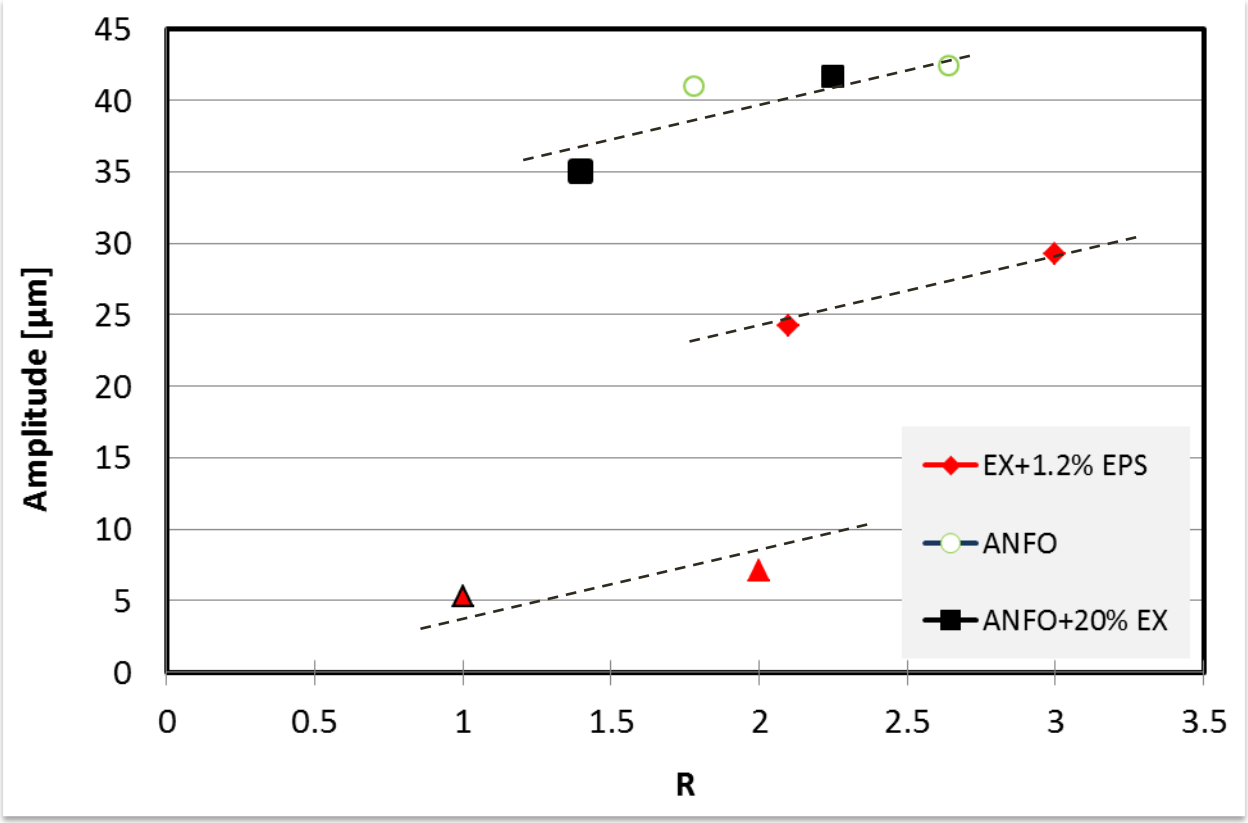
ANFO



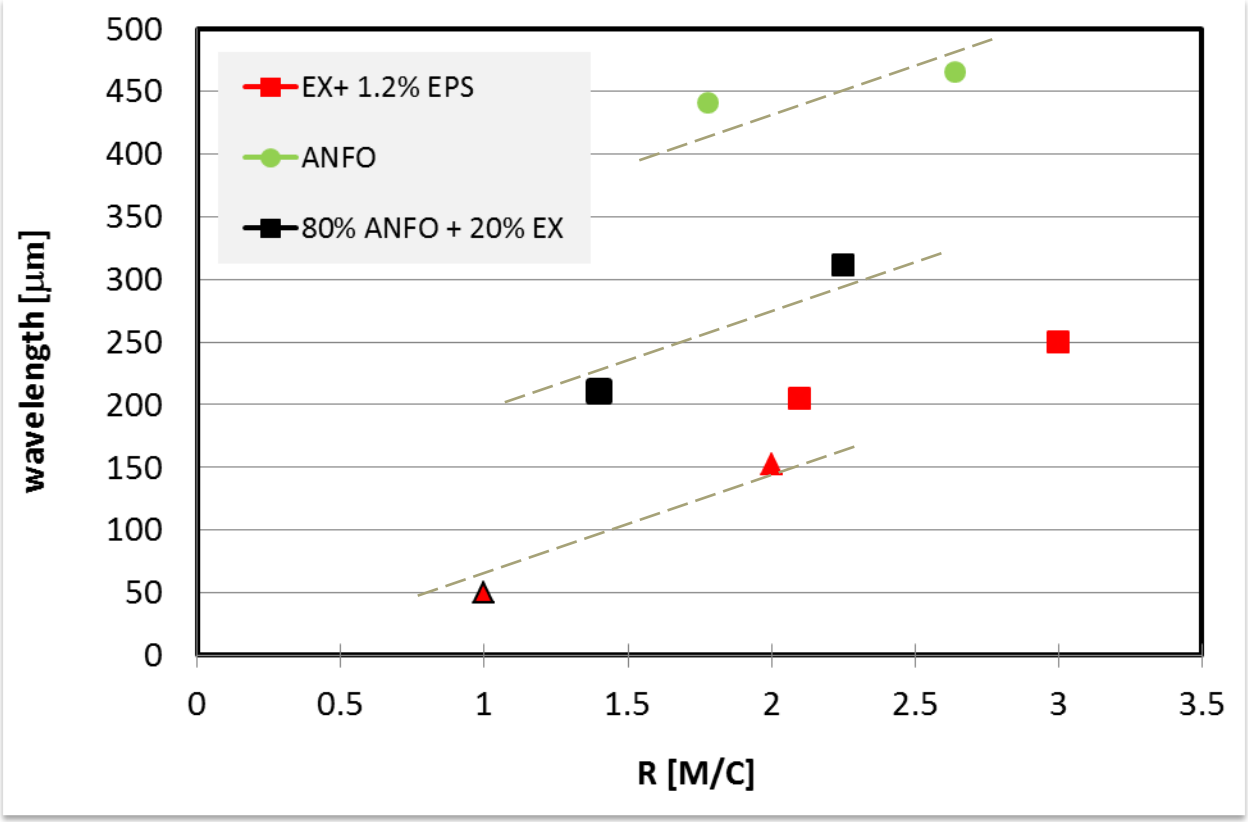




Wave amplitude vs R



Wavelength vs R

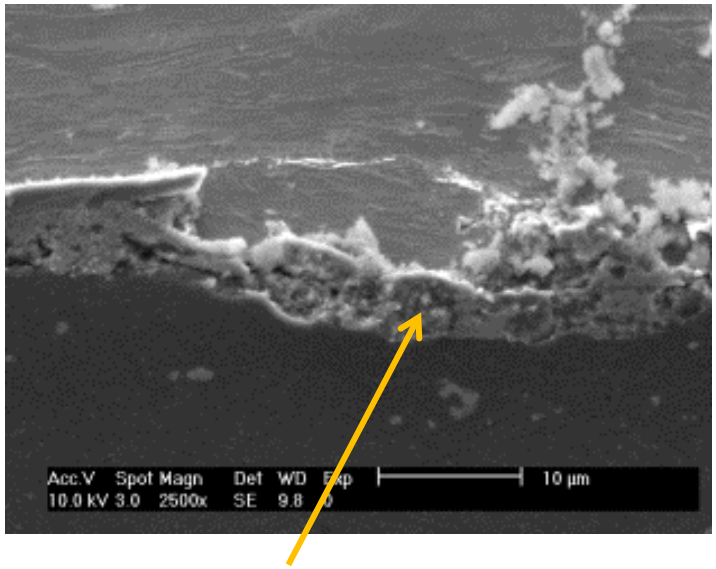


Results: Intermetallics compounds

SEM and ***EDS*** analysis to interface zone have shown the formation of intermetallics compounds.

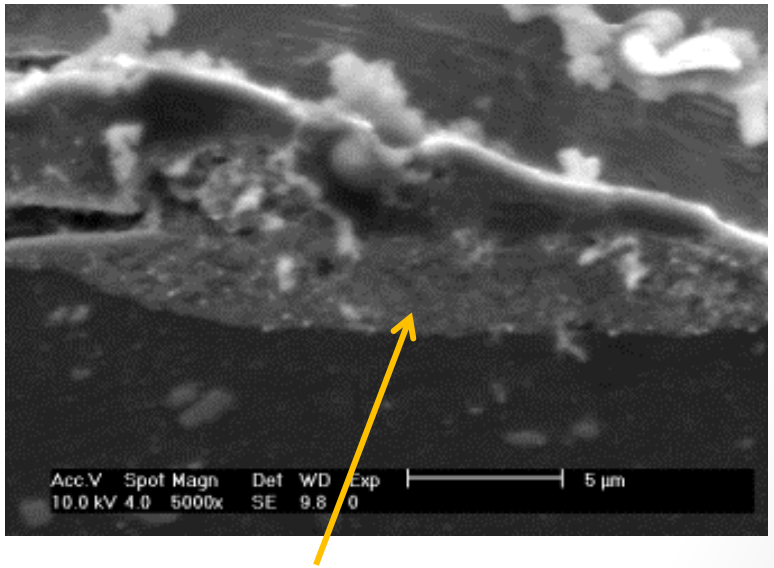
Thickness of intermetallic compounds band increases with increase of R

EX+15% HGMB (zone 1)



- Any known phase.

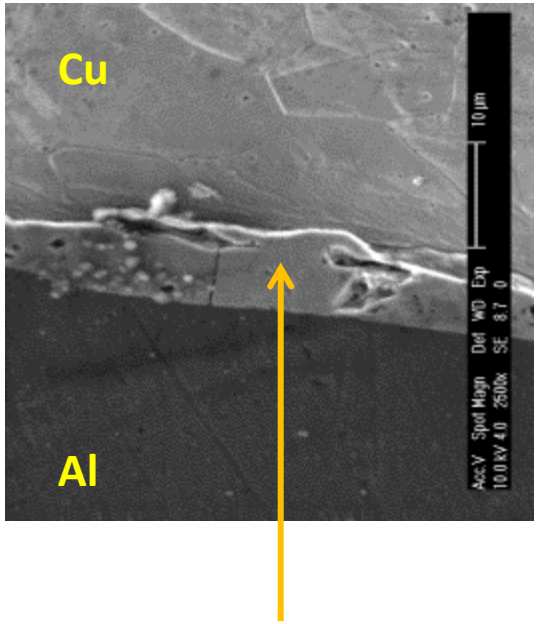
EX+15% HGMB (zone 2) EW2



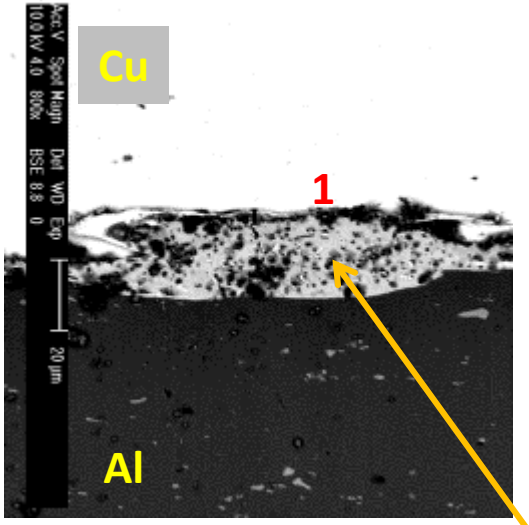
- Atomic composition close to CuAl2, (Hang et. al., 2008)

Results: Intermetallics compounds

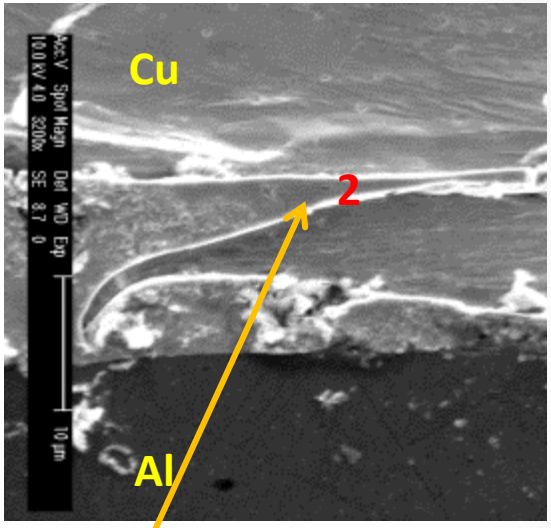
EW5- **EX+15% HGMB**



EW6- **EX+1.2% EPS** - 1



EW6- **EX+1.2% EPS** - 2



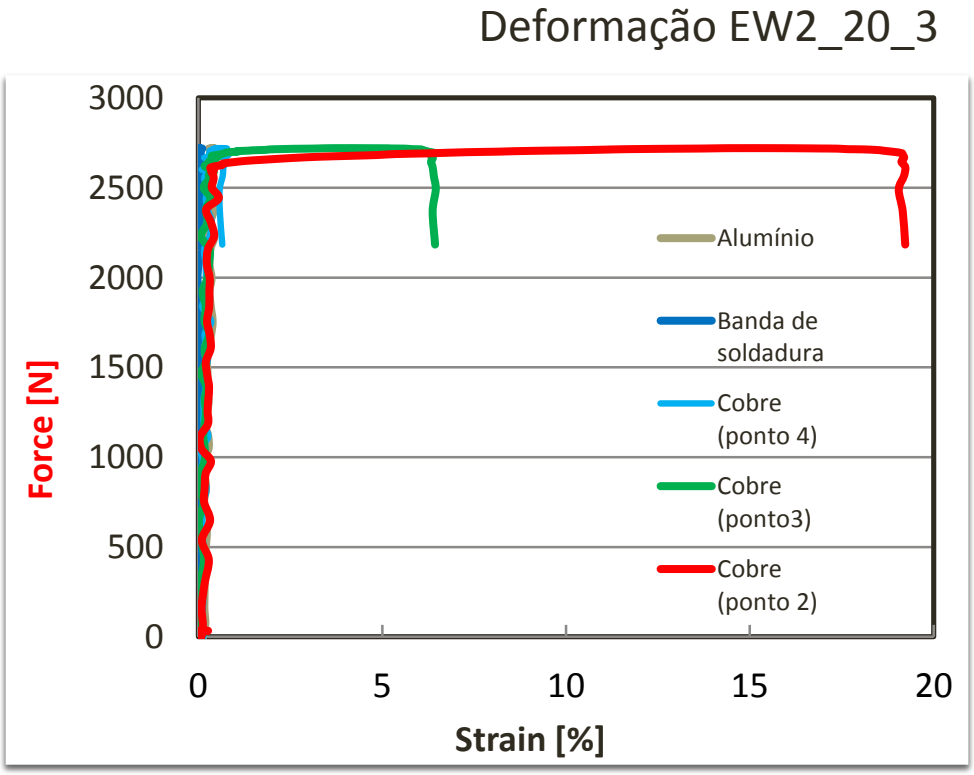
Intermetallic compound in EW5:

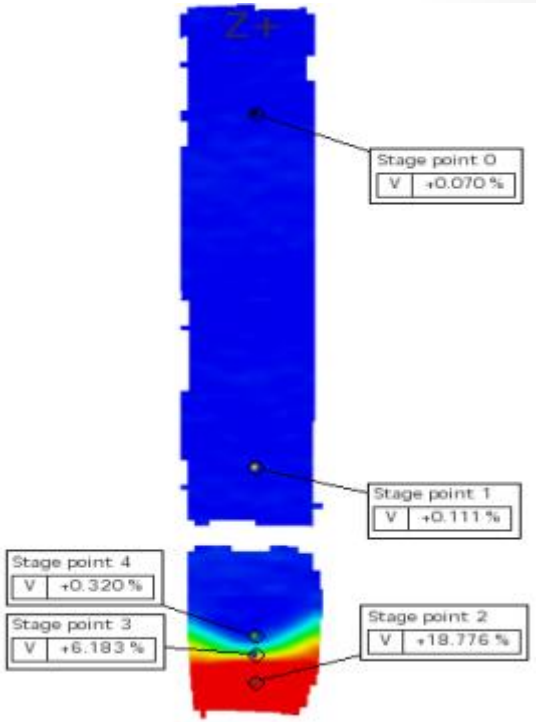
CuAl2

Intermetallic compound in EW6:

Zone 1 : ≈ CuAl2.
Zone 2 : ≈ CuAl

Results: Tensile tests





Tensile Tests of the welds revealed that plastic deformation ocurrs in the Copper material for specimem prepared with EX+15%HGMB and with Ex+1.2% EPS.

The joint was able to tranfer load, similar to an overlap weld.

Conclusions

- The increase of R leads to the formation of bigger intermetallic zones with the formation of $CuAl_2$ and CuAl.
- Tensile Strength of Al-Cu joint laps is higher than tensile strength of Cu.
- Fluctuations in detonation flow are a function of the explosive nature. Local fluctuations in detonation flow are transmitted to the metal surface, in contact with explosive, inducing on it a crater pattern that is function of the explosive nature.
- Beyond the parameters (Vp, sod, R) that influence the wavy pattern, the local fluctuations in detonation flow play an important role on the characteristics of the interfacial waves.

Thank you for your attention

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