# New Developments in Laser Welding of 21st Century Automotive Materials

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CII Welding Conference 2016

Materials Joining and Engineering Technologies

# TWI – An Extension of your Resources

- The World Centre for Materials Joining Technology
  Research & Technology Organisation, Established in 1946
- Industrial Membership based
- Five UK locations and 13 international offices

# Automotive Sector Drivers

- The automotive industry is moving towards lighter, stronger vehicles to achieve future efficiency and crash performance targets
  - 100kg of weight saved cuts $CO_2$ by 9g/km
- UK Automotive Council predict a C/D class car must reduce in weight 150kg by 2020 and a further 150kg by 2030

- Major OEMs strategy
  - 2020 High strength steel body integrating aluminium and plastics
  - 2030 High strength aluminium, carbon fibre composites

# Auto Body Sector Technology Needs

## Distortion

Paint curing cycles, welding heat

## Paint systems

No fade, less coats, low T cure, Green, faster painting cycles

## Weight reduction

EC $CO_2$ emissions → 95g/km by 2021

## Crash safety

Euro NCAP ratings since 2009, crash repair, design & modelling

## Production economics / environment

Future vehicles bodies will be more complex, they must remain affordable and green
Manufacturing technology must develop

## Corrosion prevention

12 year anti corrosion guarantees are standard

## Recyclability

End of Life Vehicle Directive 2000
EU 8-9MT car scrap
Design for dissassembly

## New materials

Weight reduction is critical
Corrosion performance
Structural strength
Drivability, recyclability

## Dissimilar joining

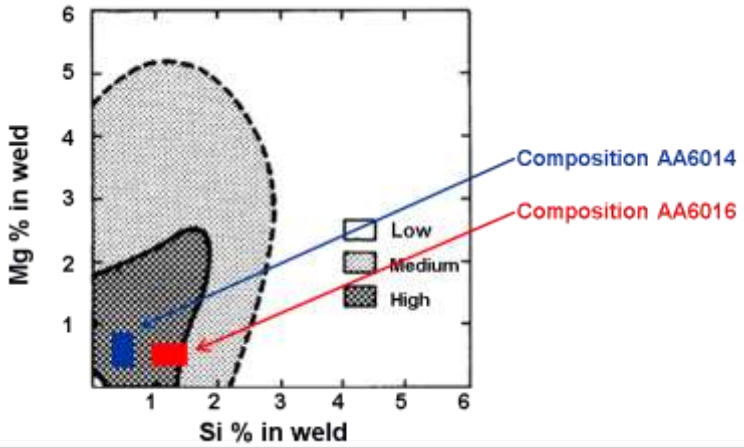
All major OEMs have a multi material vehicle strategy

# Remote Laser Welding

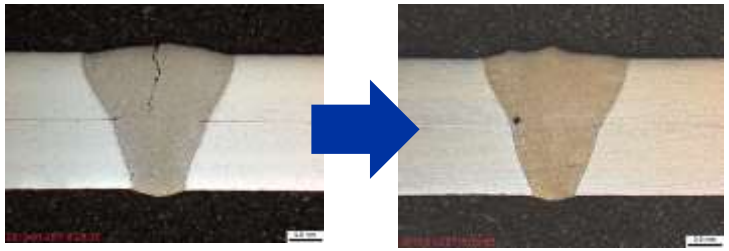
- Audi Q5 door
  - Welding flange <6mm, increased visibility, decreased weight
- 45 laser stitches (25-40mm length each) in <30s
  - ~120s with RSW

# Remote Laser Welding of AA6xxx

- AA6xxx alloys are used for outer panels because of:
  - Formability and strength, rapid bake hardening response, excellent surface finish post forming
- The balance of Mg and Si in AA6xxx - crack sensitive
- Usually an Al-Si filler wire would be used to prevent cracking
- But use of a filler wire is not possible with high speed remote laser welding



# Solution

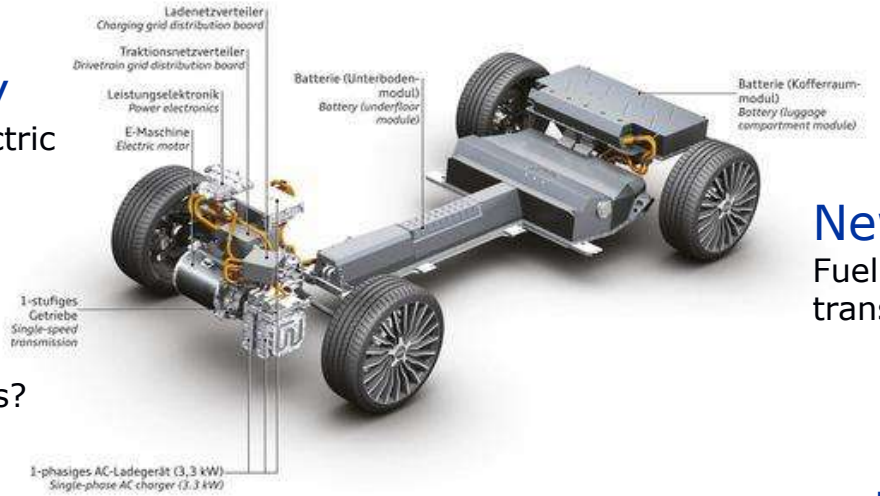


- Crack free welds can be made at speeds of up to 10m/minute
- No shielding gas is required

# Power Train Sector Technology Needs

## Reliability
Break down? Motor life, repairability

## Power technology
Fossil fuel, hydrogen, electric Hybrid, other?




## New infrastructure
Fuelling, home charge, power transfer, safety

## Environmental
$CO_2$, other waste products?

## Sustainable production
Environmental cost of production, rare earth metals, mining, political sensitivity

## Battery technology
Green batteries, charging time

## Cost
Transport for the people

## New vehicle architecture
New power train = new layout.
Present cars are designed around the internal combustion engine

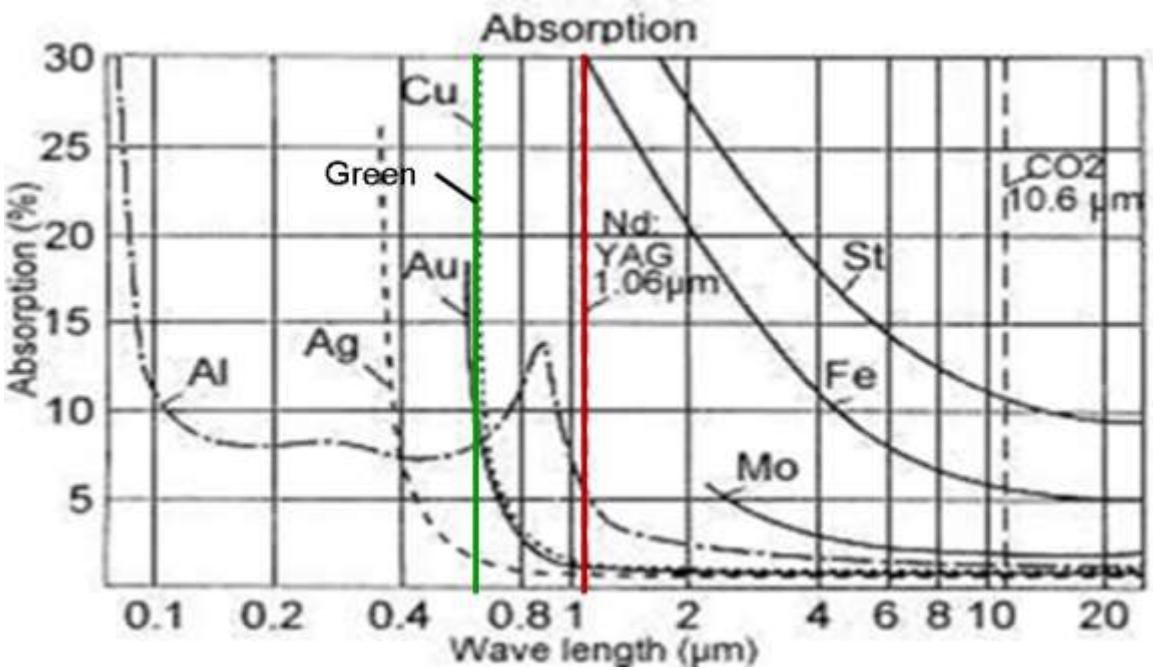
## Performance
Range, speed efficiency

# Industrial Drivers - Battery Interconnects

- Increasing adoption of hybrid and electric vehicles
- Mass production non-carbon fuels
  - Batteries (Li-based)
  - Hydrogen fuel cells etc
- Materials: Copper (CU-ETP), Aluminium (1xxx, 3xxx, 6xxx)
- Joints
  - Lap weld
  - Al-Al, Al-Cu, Cu-Al, Cu-Cu
  - Penetration depth and weld width requirements

# Welding Challenge: Reflectivity

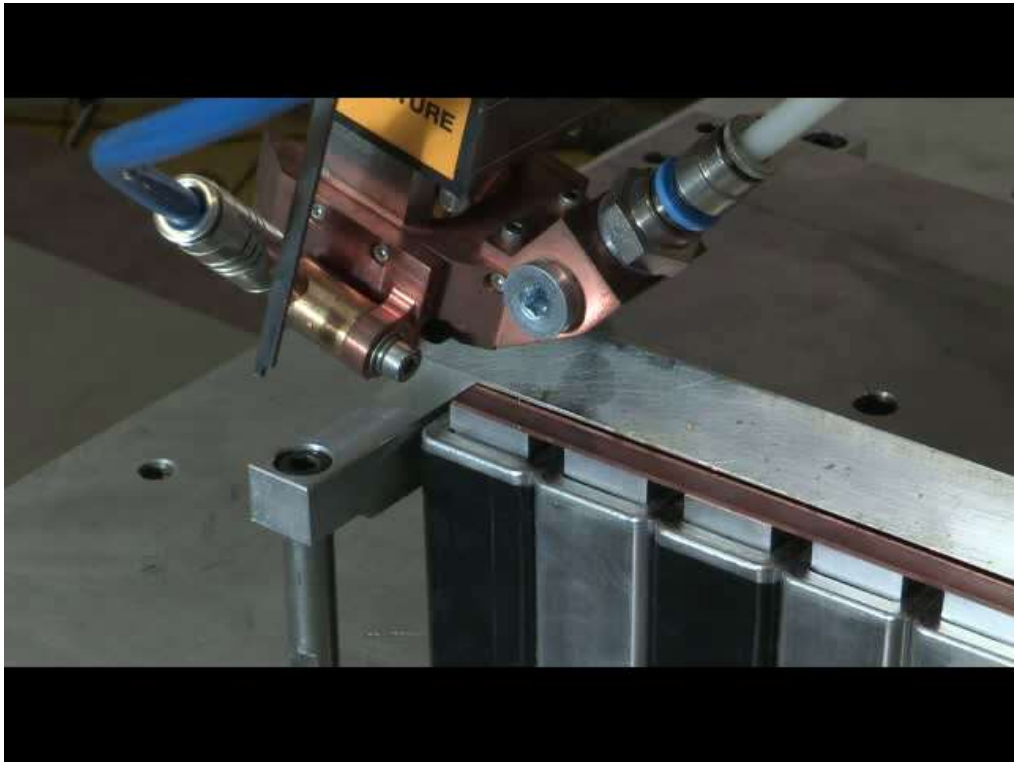
## Relevant when Copper on top

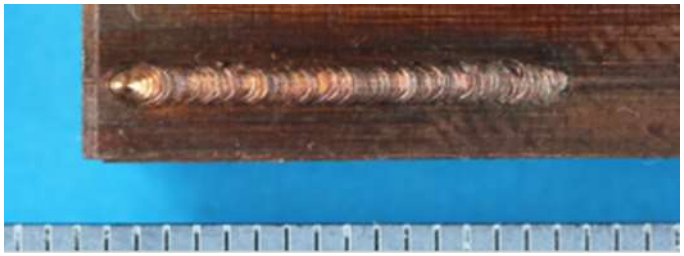


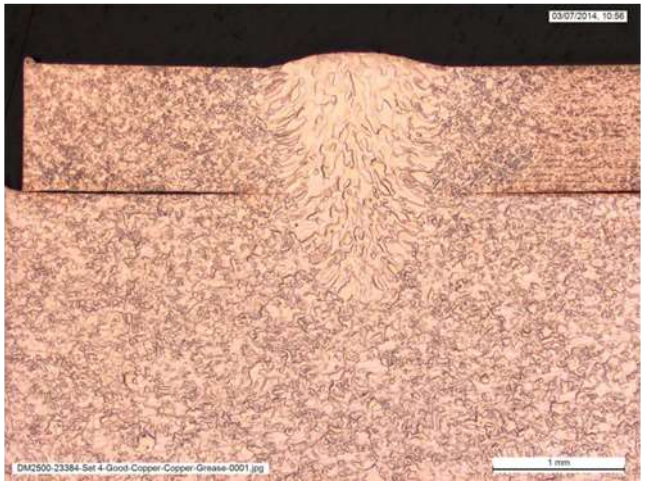


**Unstable process in Cu-Cu lap weld, leading to Presence of melt ejections and blow holes**

# Dual Wavelength Platform



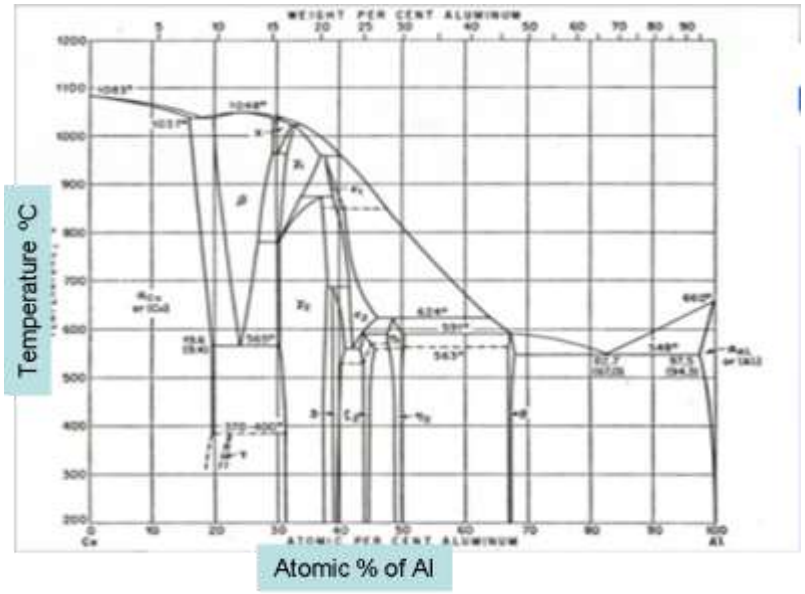


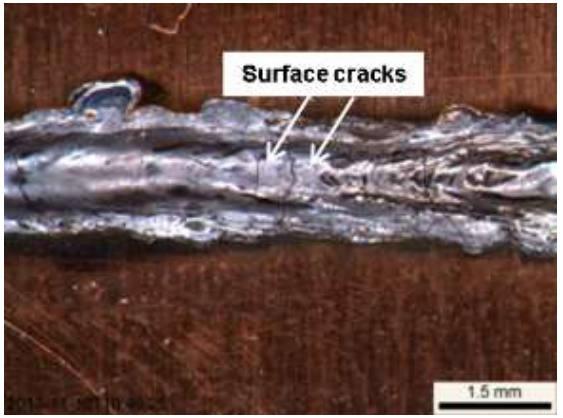


**Welds produced with optimised conditions: Processing speed of 6m/min**

# Welding Challenge: Dissimilar Materials

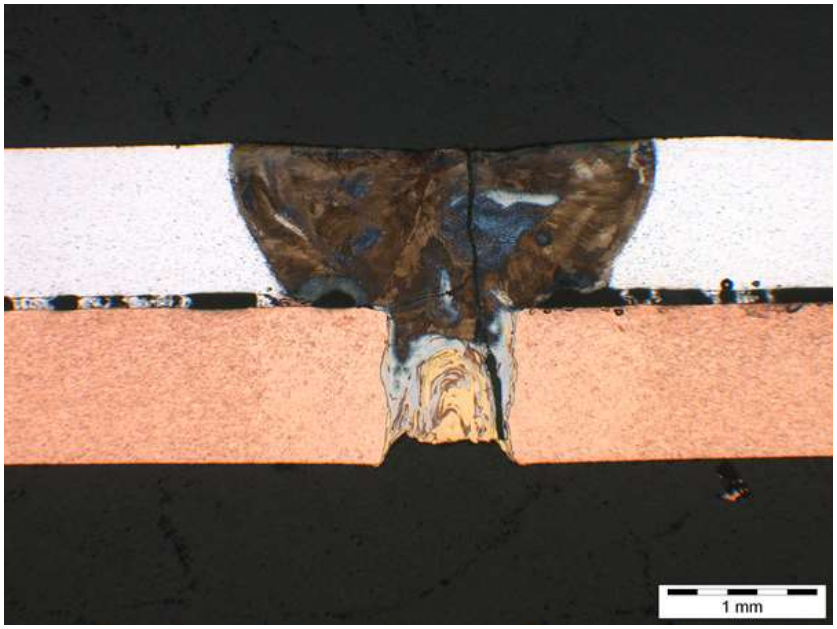
- CTEs
  - Distortion issues
- Thermo-physical
  - Melting points
  - Boiling points
  - Viscosity
  - etc
- Chemical compatibility
  - Brittle intermetallic phases, leading to fusion zone cracks

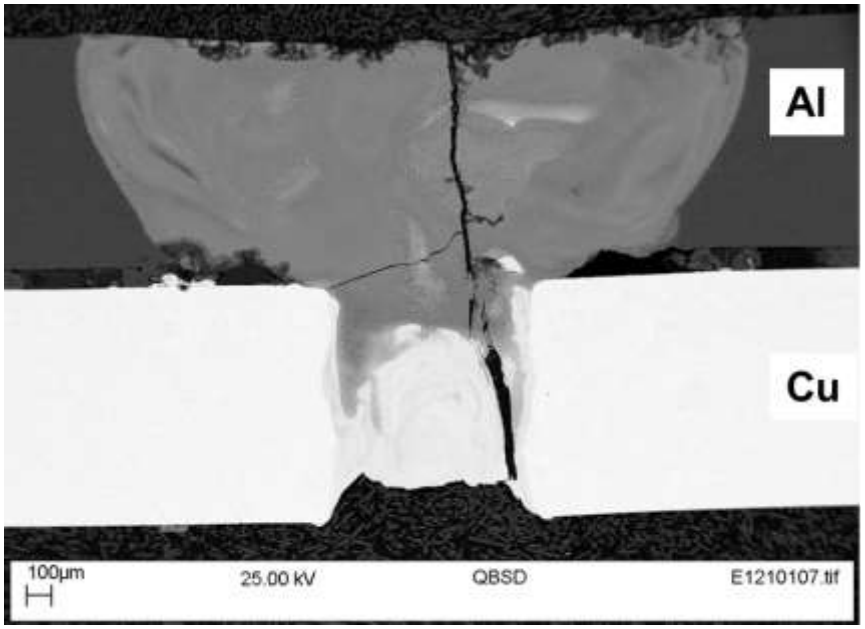


# Challenges – Brittle Intermetallic Phases

Typical problems when laser welding Al-Cu



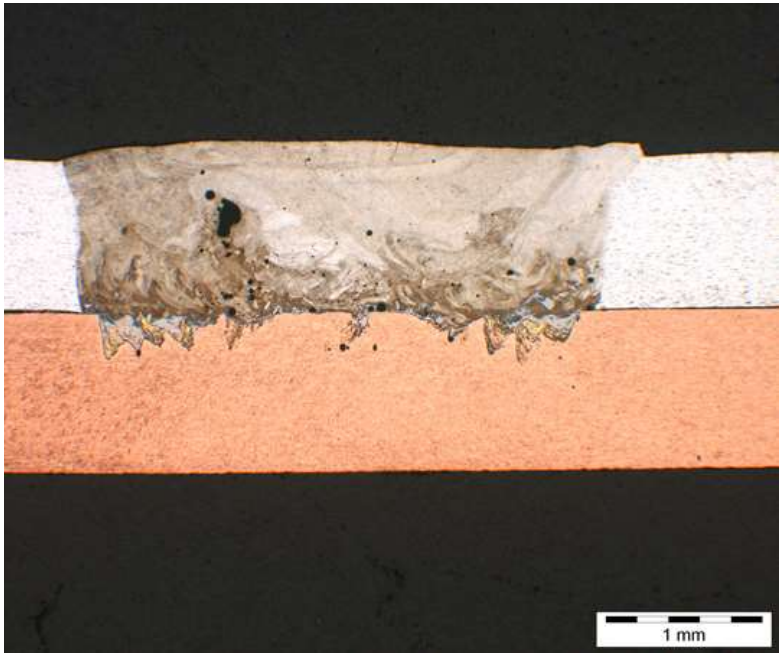

Al6061-CW004

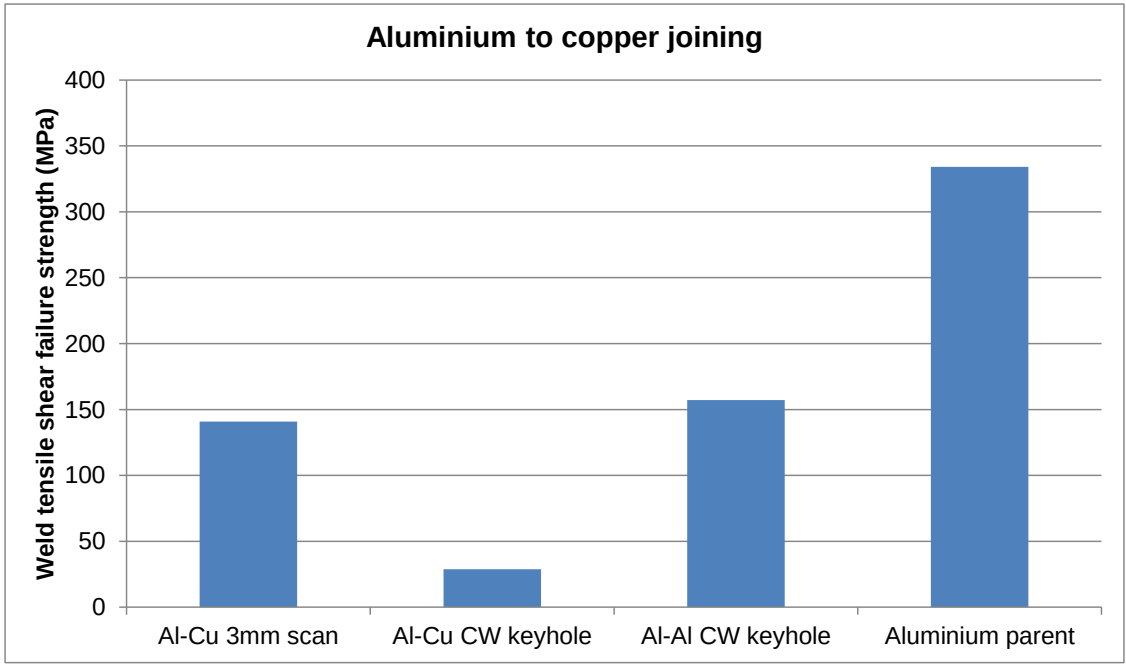
SEM analysis indicated crack initiated in the Cu rich phases in the weld root

# Tailored Energy Distribution

- Present applications use simple energy distributions
  - Gaussian, top-hat
  - Annular
  - Twin-spot
  - Lines
- Laser beam scanners
  - Possibility to tailor temporal energy distribution to joint requirements
  - Limitless possibilities
- Similarities to electron beam
  - Electro-magnetic deflection

# Tailored Energy Distribution for Al-Cu



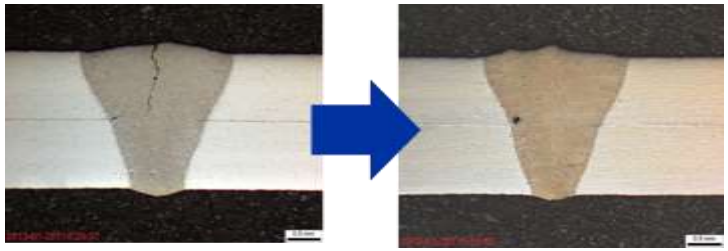




**Resulting weld (transverse) cross-section and tensile shear strength of quasi-optimised laser weld in Al6061-CW004**

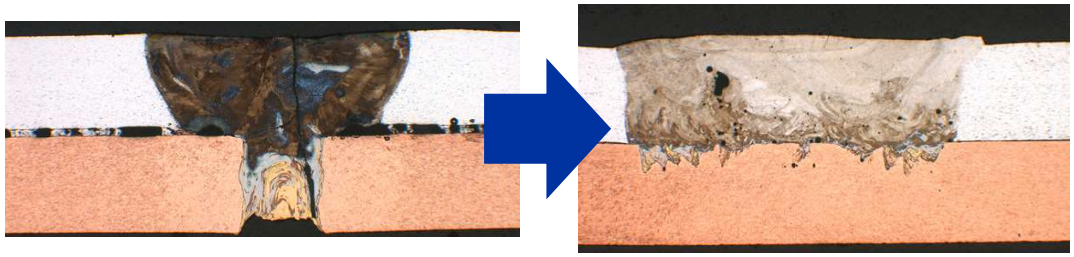
# Conclusions

- New materials and material combinations creating challenges for welding/joining in automotive sector
  - Laser welding has huge potential to address these

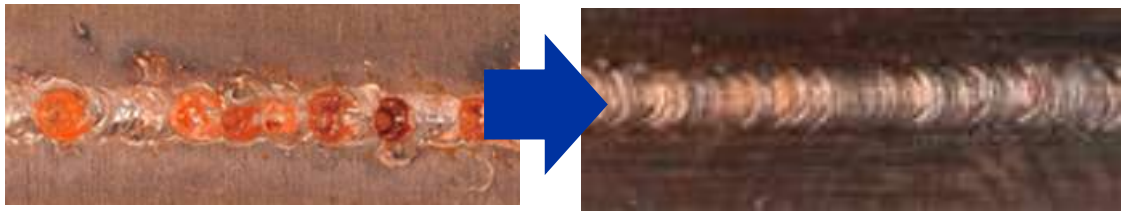
- Al 6xxx



- Al to Cu



- Cu to Cu



# Thank You For Your Kind Attention

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