Dissimilar joining of thin/ultrathin metallic alloys

EPSRC Centre for Innovative Manufacturing in LASER-BASED PRODUCTION PROCESSES

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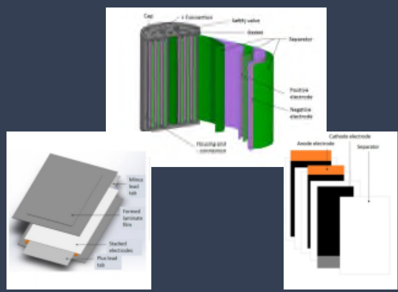
Background

- Industrial **demand** for **high-power lithium ion batteries** which are durable, reliable and inexpensive.
- Batteries are made up of **complex joining of thin multilayers** of several metals of which **aluminium** and **copper** are typical examples.
- **Pulsed fibre laser** is capable of producing high repetition rate and very short duration lasers which can be effectively used to **join dissimilar metals** and **prevent** the formation of **intermetallic compounds**.

Applications

Electronics, automotive and other industrial applications



Aim & Objectives

Joining of thin sheets of copper and aluminium in overlap configuration using a short pulse and high repetition rate pulsed fibre laser

- Understand **laser-material interaction** of thin **copper** and **aluminium** foils on bead-on-plate welds
- Investigate the **metal configuration** of the lap-joint: Al onto Cu or Cu onto Al
- Examine the **microstructure** of the weld
- Evaluate **mechanical strength** of the joints

Methodology

Tested parameters

- Waveform
- Pulse duration
- Peak power
- Frequency
- Travel speed

- Power density
- Interaction time
- Spot diameter

- Specific point energy

Stage 1 – Laser-material interaction (Al, Cu)

- Bead on plate
- 0.5 mm thick
- Pure aluminium
- Pure copper

Stage 2 – Bead on plate vs lap joint configuration (Al/Al, Cu/Cu)

- Lap joint
- 0.25 mm thick
- Pure aluminium
- Pure copper

Stage 3 – Material configuration (Al/Cu, Cu/Al)

- Lap joint
- 0.25 mm thick
- Pure aluminium
- Pure copper

Analysis of the welded joints

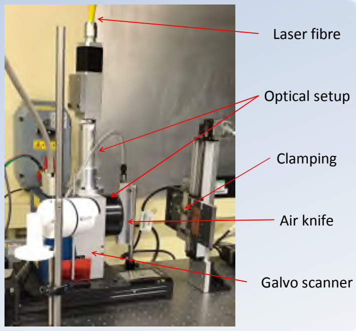
Metallographic analysis

Optical microscopy:
- Weld geometry
- Defects

SEM and EDS:
- Identification of intermetallic compounds

Mechanical testing

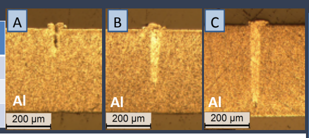
- Tensile-shear strength

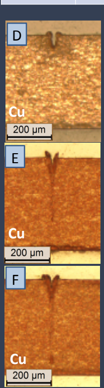


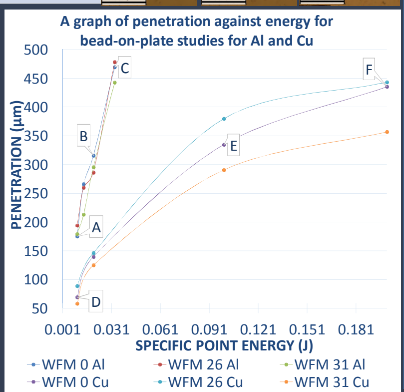
Results

Stage 1: Laser-material interaction

Waveform	Pulse duration (ns)
0	280
26	320
31	500

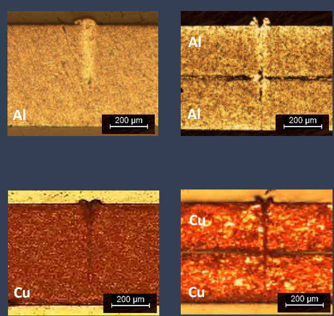






Stage 2: Bead on plate vs lap joint configuration

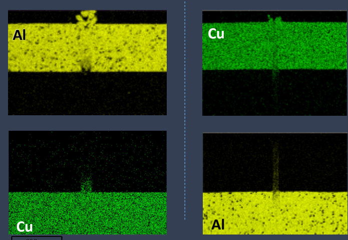
Bead on plate | Lap joint



Stage 3: Joining of Al to Cu

Optical microscopy:

EDS mapping:



Mechanical testing:

Configuration	Al - Al	Cu - Cu	Al - Cu	Cu - Al
Avg. max strength per unit length (N/mm)	4.2	6.3	4.6	4.7

Conclusions

- **Different energy levels** required to achieve the same **penetration depth** in **aluminium** and **copper** -> **Physical properties**
- For constant energy, a **balance** between **power density** and **interaction time** is required to **maximize** the **penetration depth** in copper-> **Thermal conductivity**
- **Deeper welds** in **lap joint configuration** when compared to **bead on plate** welds -> **Vapour pressure**, **plasma** and **thermal effects**
- **Better weld profile** with **copper** on **aluminium**.
- More **intermetallic compounds dispersed** in the **fusion zone** in **Cu-Al** configuration -> Welds produced with higher laser energy
- **Strength** of the **dissimilar metal joints** equivalent to that of the aluminium joints (the **weakest** of the **base metal**)

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