APPLICATION OF MAGNETIC PULSE WELDING (MPW) FOR ALUMINIUM ALLOYS AND SPCC STEEL SHEET JOINTS

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OUTLINE

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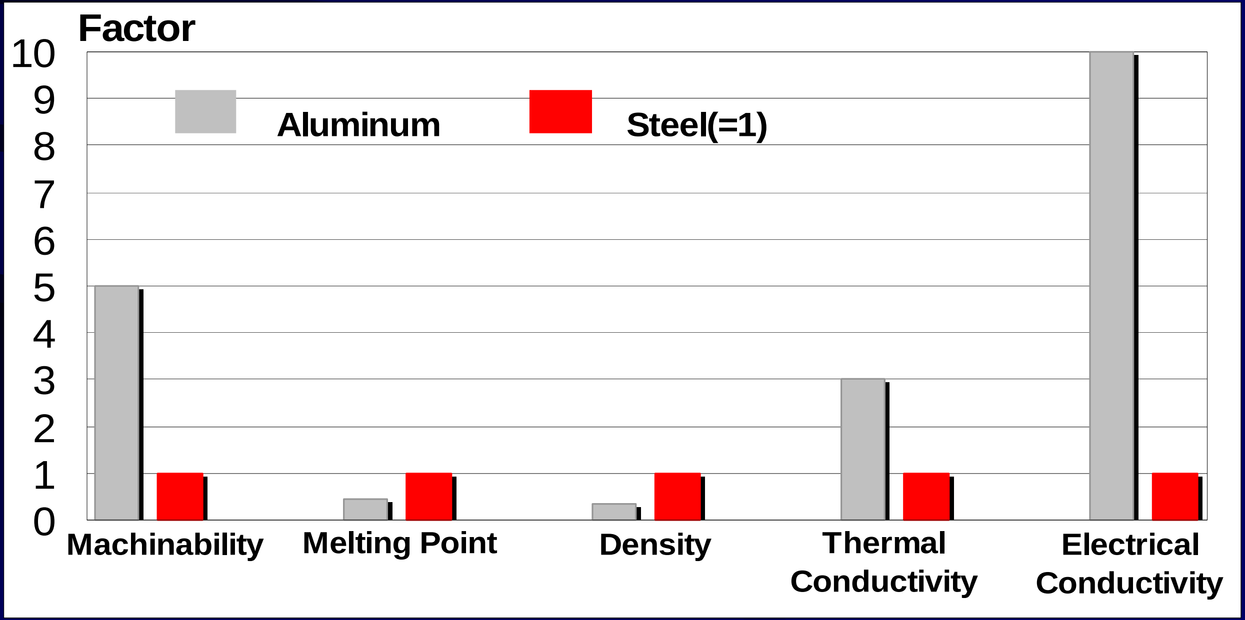
1) Introduction

Hybrid structures of aluminium alloy and steel are suggested for reducing the weight of automobiles to improve fuel efficiency and control air pollution. Therefore, joining steel and aluminium alloy in different shapes is receiving attention.



Comparison of Aluminium and Steel

1) Introduction

History:

Magnetic Pulse Welding process was developed in the late 1960s and early 1970s for nuclear energy applications. Russian scientists at the Kurchatov Institute of Nuclear Physics invented a technique for pulsed magnetic welding of end closures of nuclear fuel rods.

1) Introduction

The magnetic pulse welding (MPW) is a cold weld process of conductive metals to the similar or dissimilar material such as Aluminium alloys to SPCC-Steel sheet. The MPW process is a heat-free which can eliminate localized annealing.

1) Introduction

Magnetic Pulse Welding Benefits and Advantages

- ✓ Use for several dissimilar metals joints combination
- ✓ Eliminates localized annealing
- ✓ Heat-free solid state welding process
- ✓ Less Joint weight
- ✓ Joint interface is stronger than the weakest material
- ✓ No filler material

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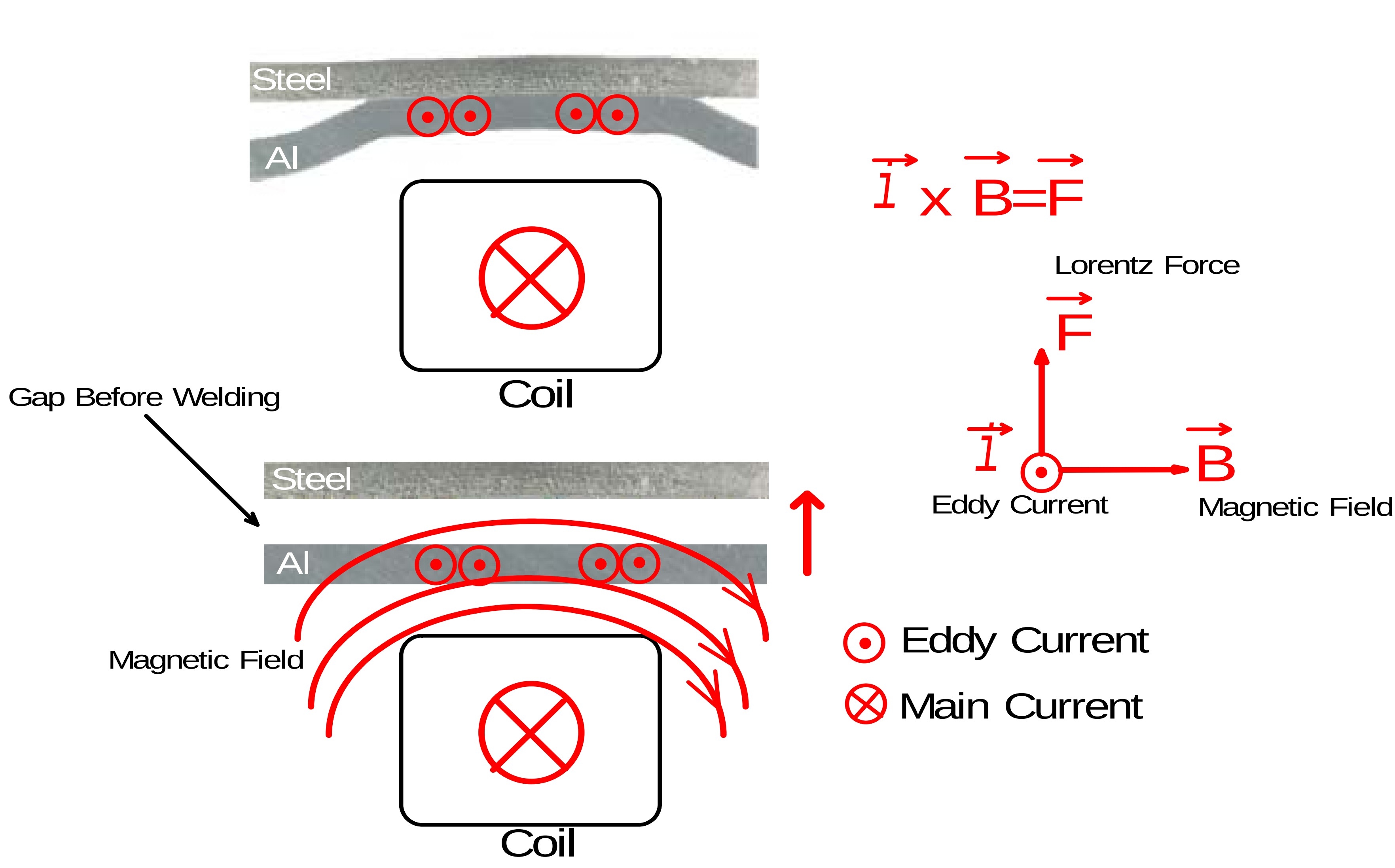
2) MPW Principle



2) MPW Principle

The eddy current ***i*** and the magnetic pressure ***p*** are given as following:

i = Eddy current

P = Magnetic Pressure

μ = Magnetic permeability

ω = Angular frequency

B = Magnetic Field

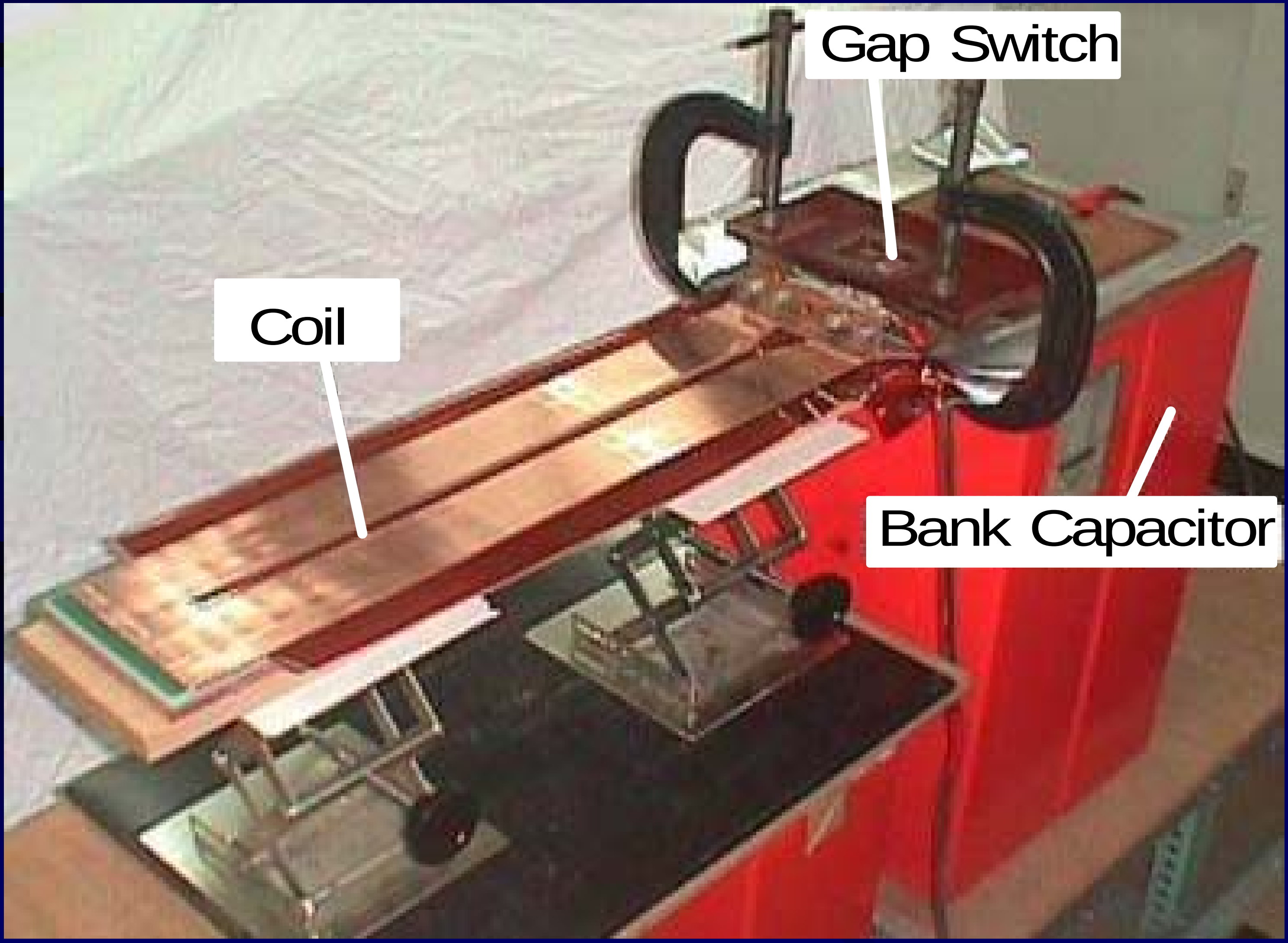
κ = Electrical conductivity

τ = Thickness

$$\nabla \times i = -\kappa \left(\frac{\partial B}{\partial t} \right)$$

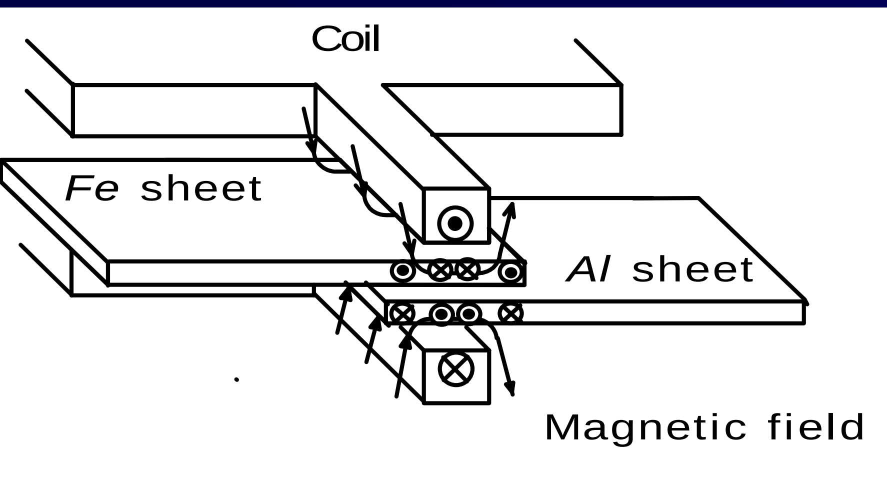
$$\begin{cases} P(pressure) = \left(\dfrac{B^2}{2\mu} \right) \left[1 - \exp\left(\dfrac{-2\tau}{\delta} \right) \right] \\ \delta(skin-depth) = \sqrt{2/\omega\kappa\mu} \end{cases}$$

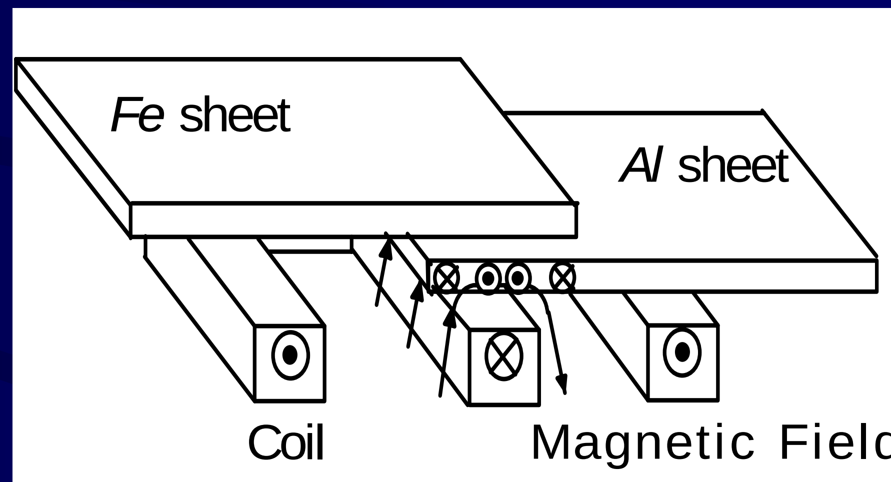
3) Experimental Setup



3) Experimental Setup

MPW Coil



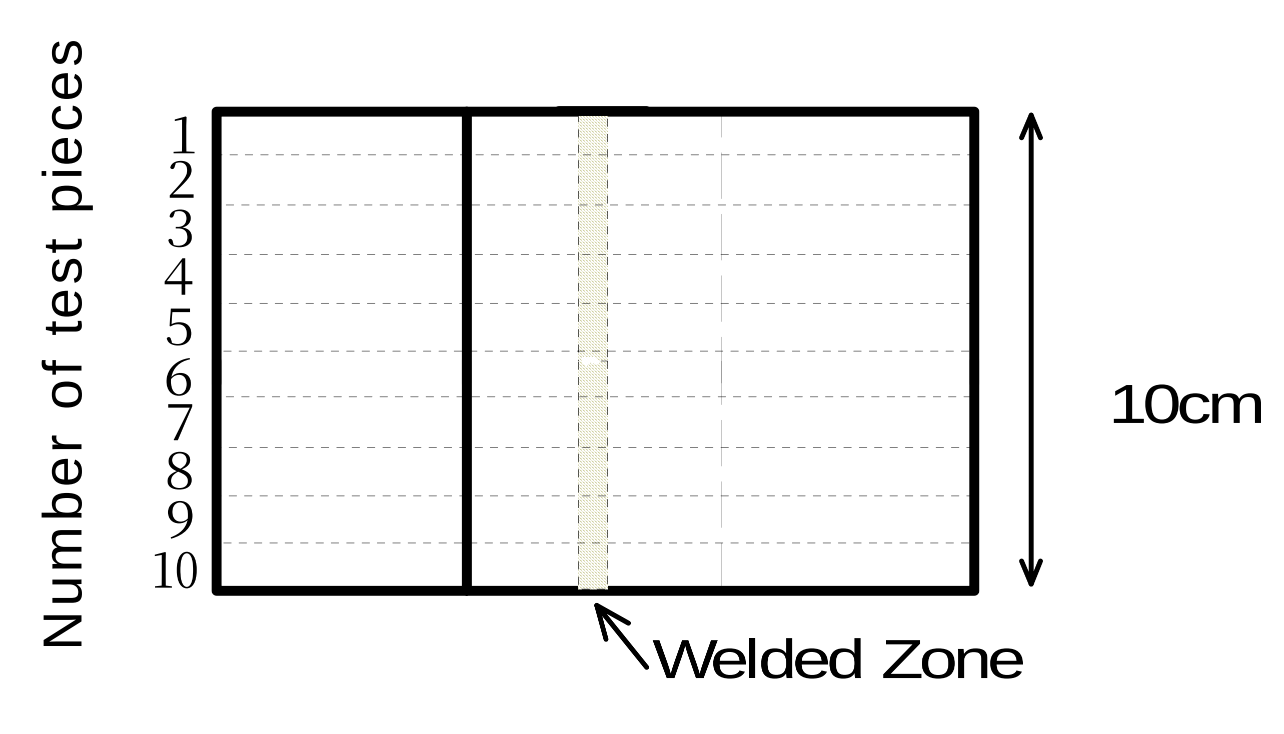


Double H-shaped Layer Coil

One E-shaped layer Coil

3) Experimental Setup

The aluminium alloys (A1050, A2017, A3004, A5182, A5052, A6016, and A7075) and Steel (SPCC) sheets with size of 10x10cm were prepared to carry out the weld testing



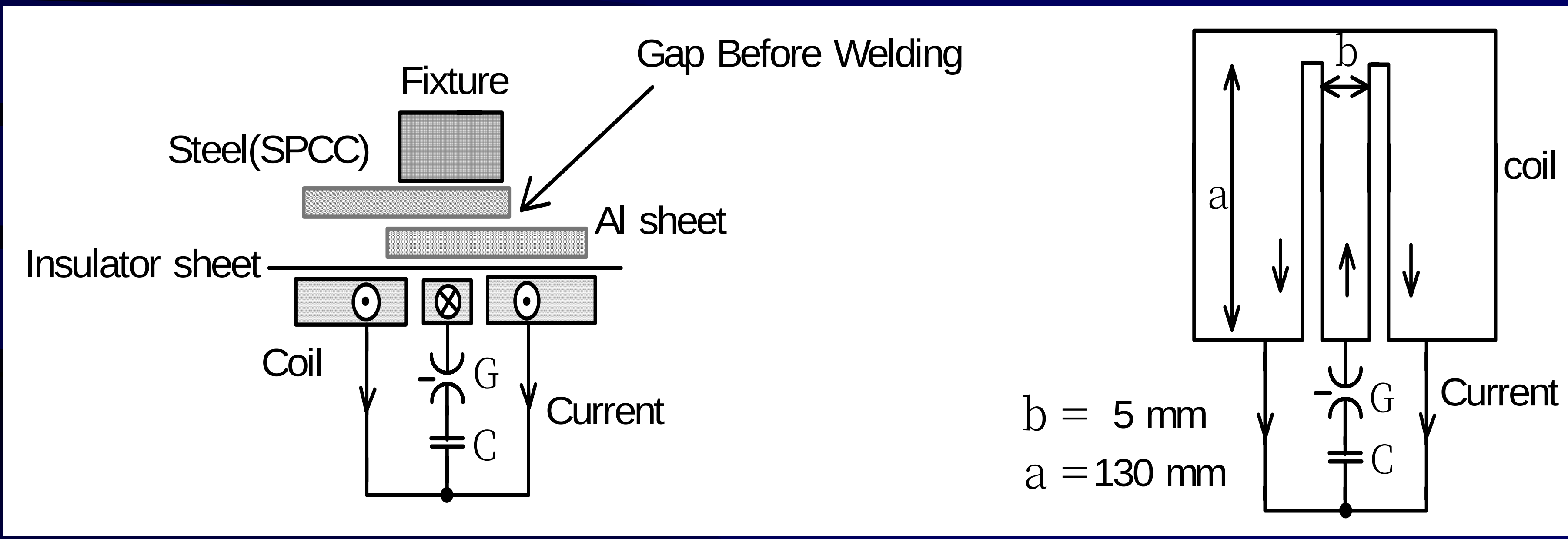
3) Experimental Setup

The Aluminium Alloy and SPCC Steel Characteristics

Sample Specification	A1050	A2017	A3004	A5182	A5052	A6016	A7075	SPCC
Conductivity [IACS%]	61	49	41	33	35	53	45	13
Tensile Strength [MPa]	165	187	255	360	290	212	292	350

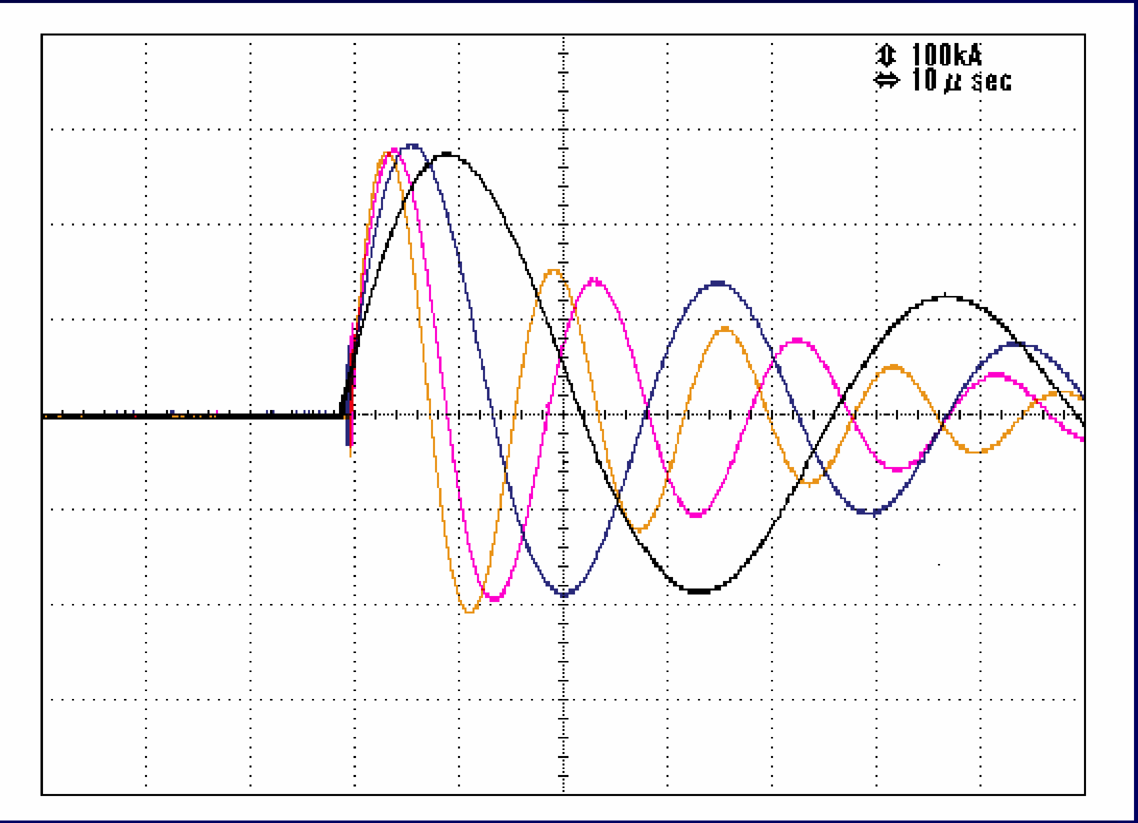
3) Experimental Setup

System Setup



4) Experimental Results

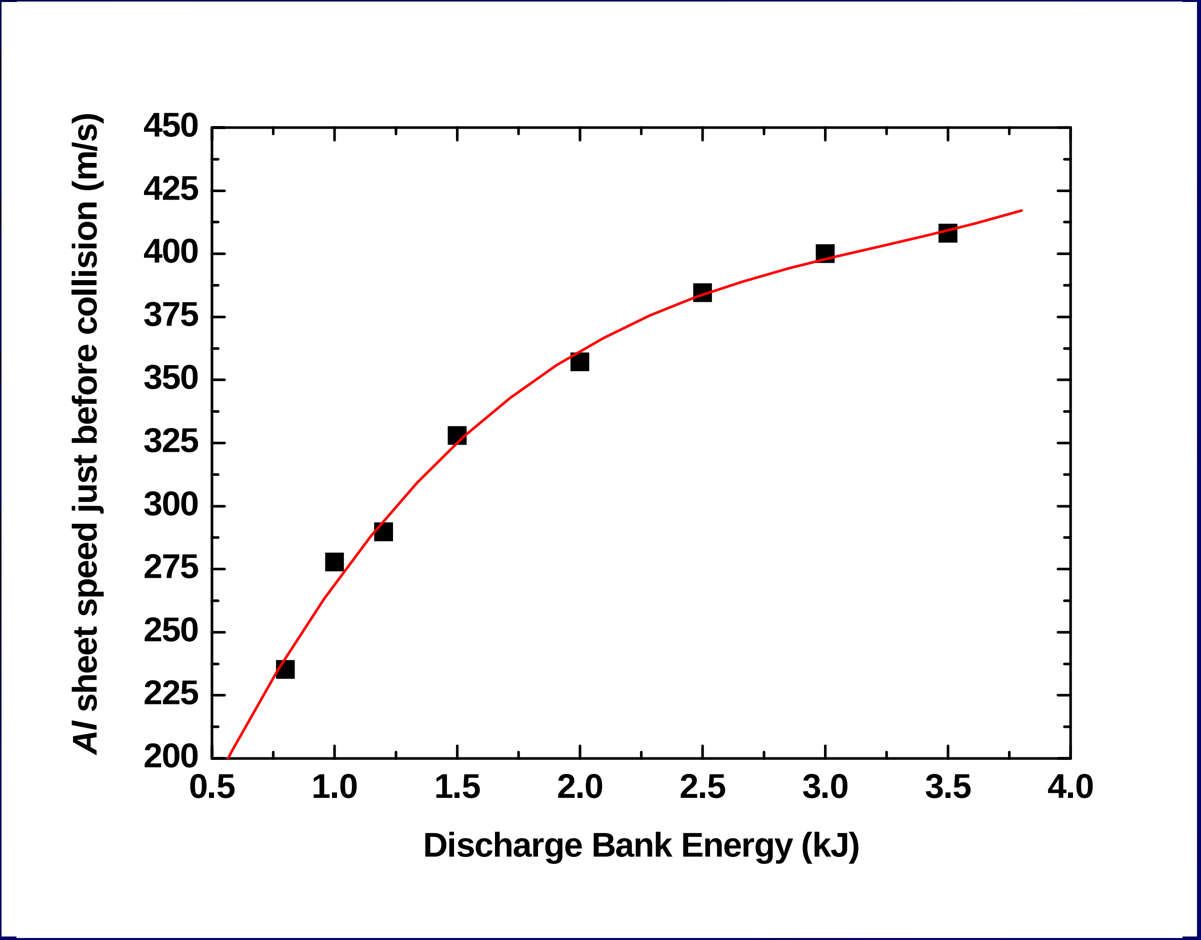
4-1) Discharge Current



Skin-Depth	Capacito
δ =0.58mm	490 μ F
δ =0.45mm	210 μ F
δ =0.36mm	90 μ F
δ =0.33mm	60 μ F

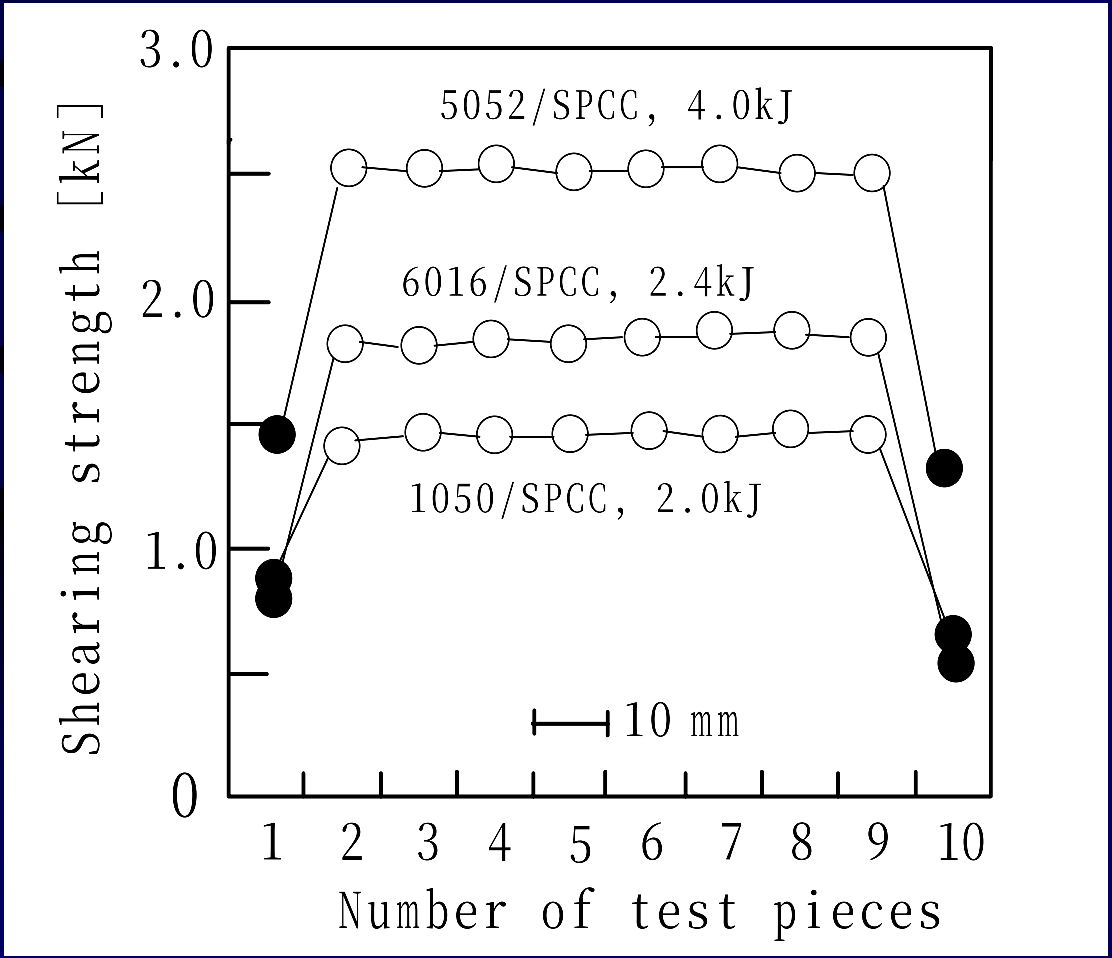
4) Experimental Results

4-2) Al sheet Speed before Collision



4) Experimental Results

4-5) Tensile Shear Test



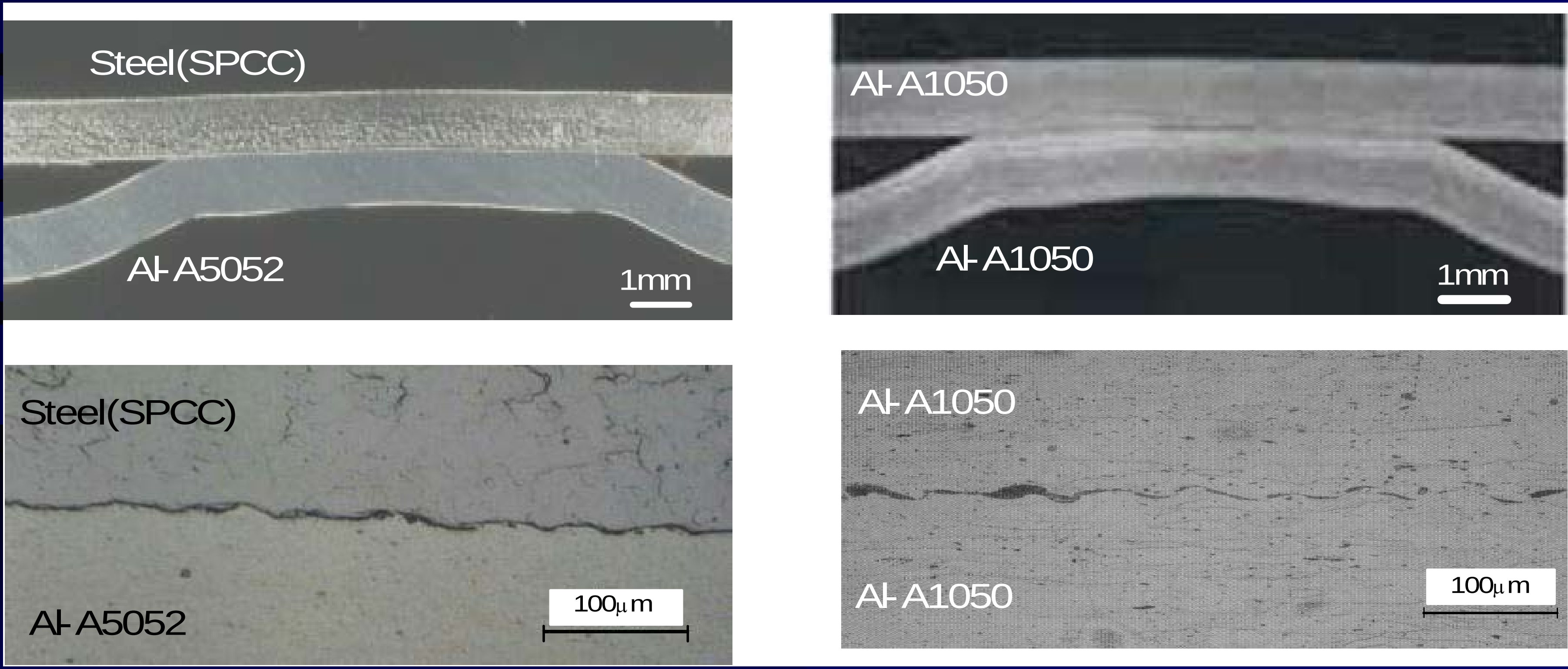
Distribution of tensile shearing strength for 10 divided pieces of welded sample:
A1050/SPCC
A5052/SPCC
A6016/SPCC

○ rupture of non-welded area

● rupture of welded area

4) Experimental Results

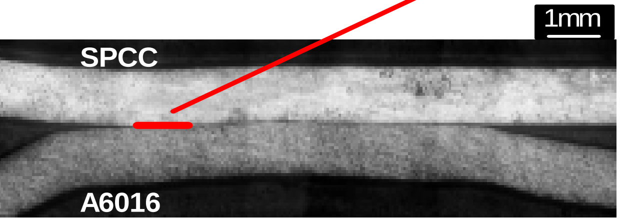
4-3) Weld Geometry

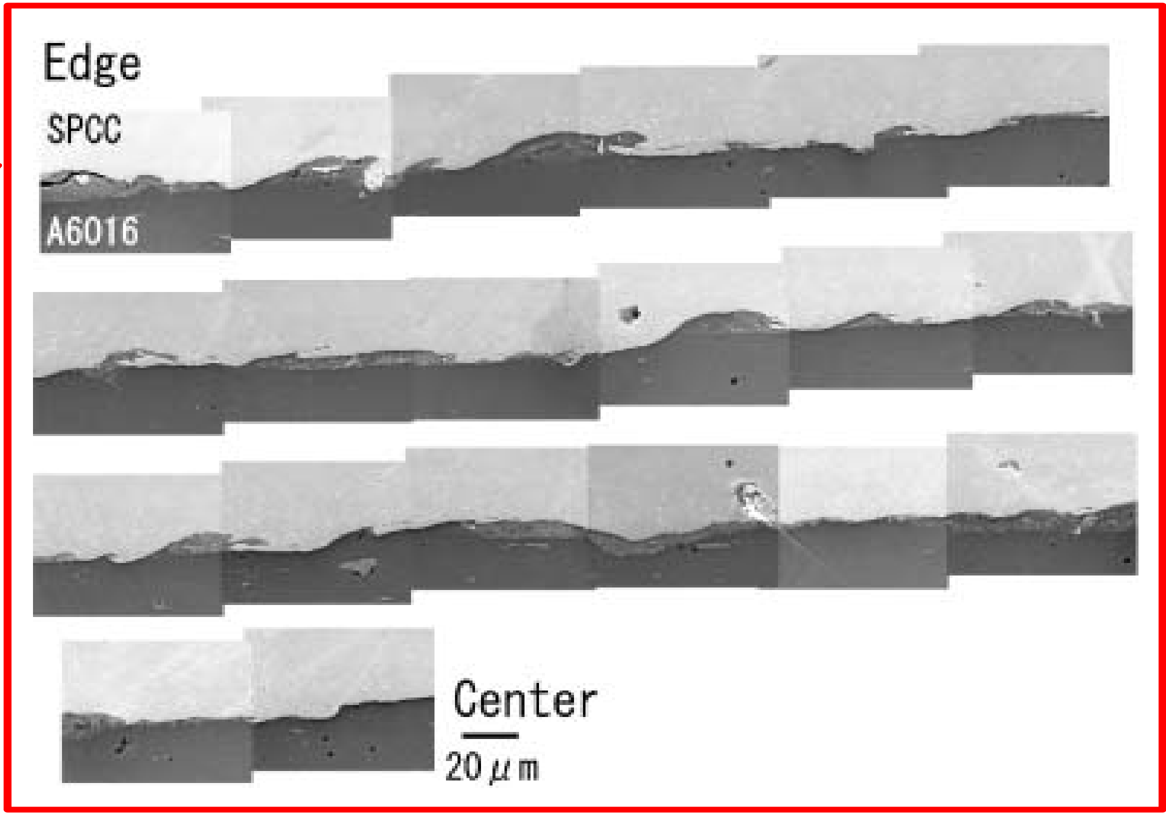


Typical macrostructure of joined interface zone
for A1050/A1050 and A5052/SPCC

4) Experimental Results

4-3) Weld Geometry

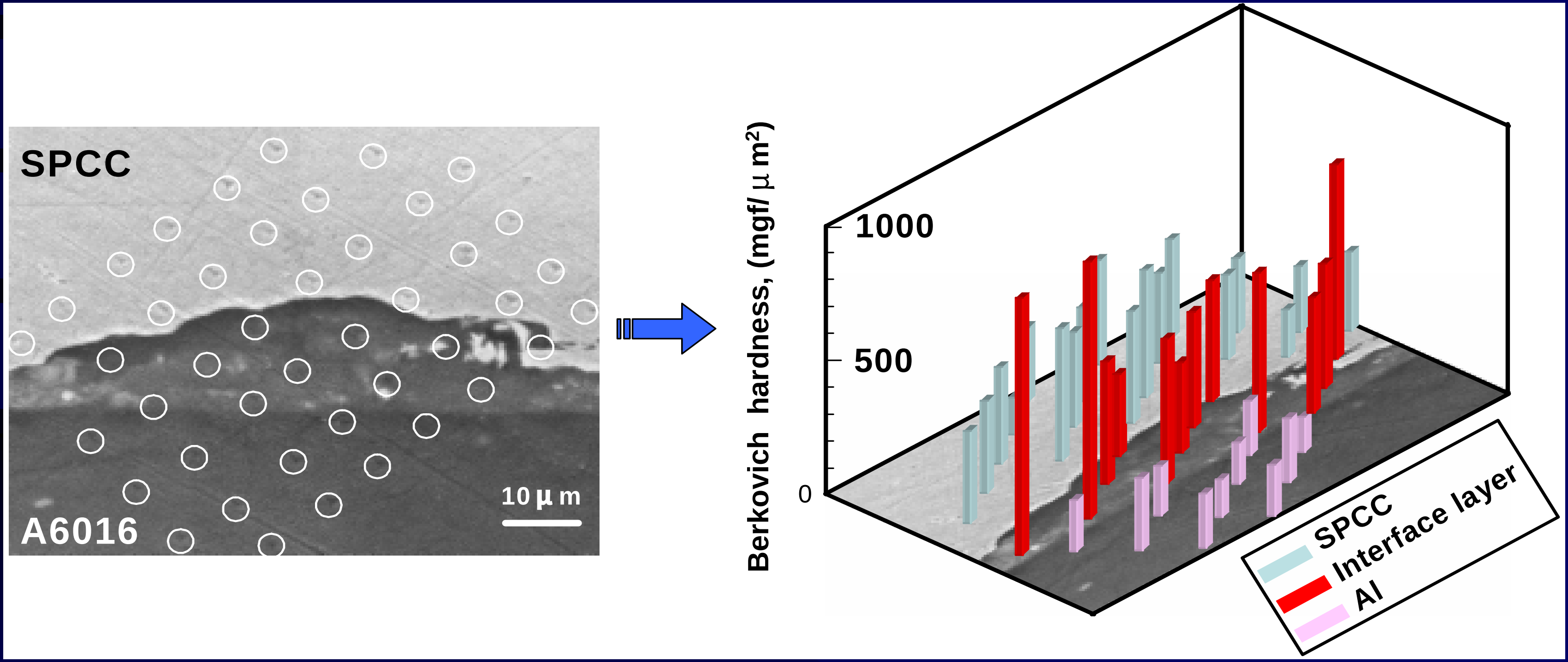




SEM image of joined interface for A6016/SPCC sample

4) Experimental Results

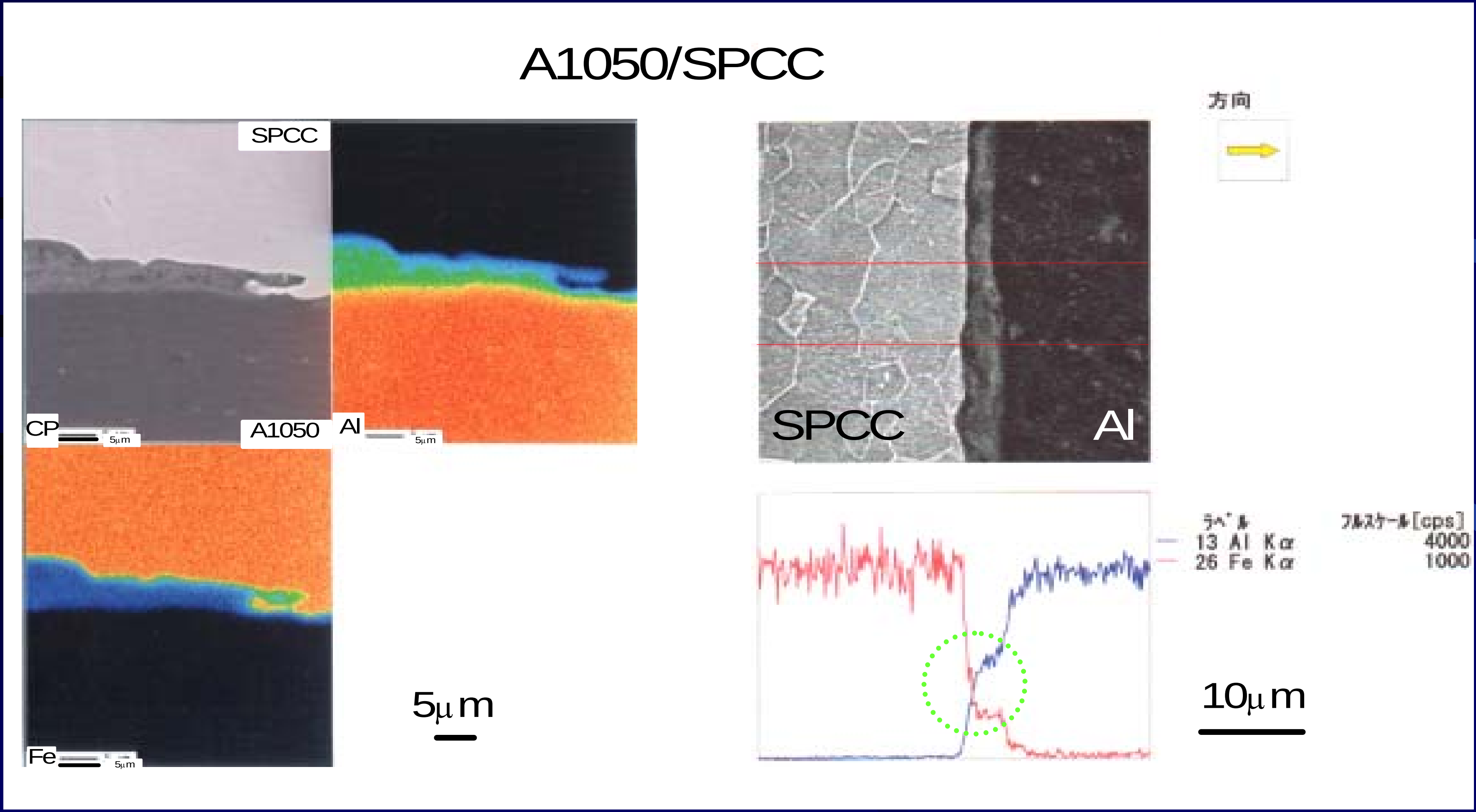
4-4) Micro-Hardness Profile



Micro-Hardness profile of interface layer for A6016/SPCC

4) Experimental Results

4-6) Electron Probe Micro-Analysis (EPMA)



5) Conclusions

We can conclude that the solid-state weld quality achievable for most aluminium alloys and SPCC steel combination by using MPW method.

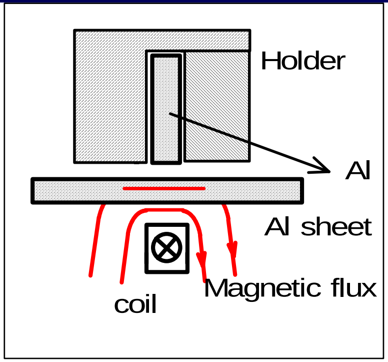
5) Conclusions

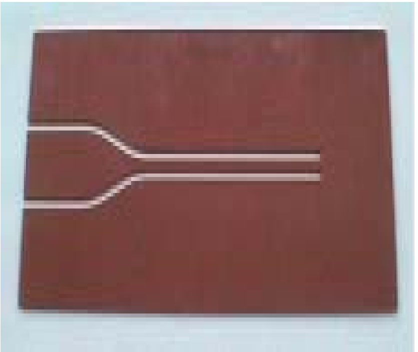
Our experimental results show that the weld joint is always stronger than the weaker metal and in all tested combination a discontinuous or continuous pocket-type, wavy transition layer was formed without any significant heat-affected zone (HAZ).

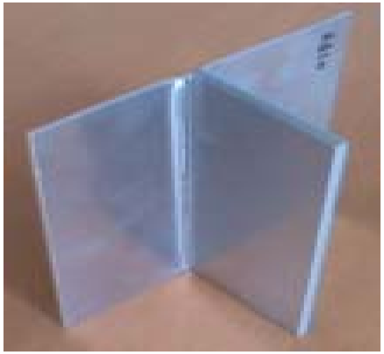
5) Conclusions

The capability of our MPW method has been also examined for several other types of metals joint, such as T-joint, circular joint, long sheet work-pieces (up to 500mm) successfully.








6) Future Plan

The first compact model

Now we are working on application of MPW for Super Alloy joints and also the design of the compact commercial MPW system for Industrial application.

Thank you for your attention

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