5083 Al/1060 Al/AZ31 Composite Plates Fabricated by Explosive Welding

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Background

Magnesium + Aluminum = Composites

Low density(1.8g/cm3)
High specific strength
Good castability

Low elastic modulus
Limited corrosion resistance

Explosive Welding

Good capability to join dissimilar metals

Good applicability for combination of large-area plates

Low density(2.7g/cm3)

Excellent ductility

Good corrosion resistance

Low density

Well combined

Good corrosion resistence

5083 Al/1060 Al/AZ31 Composite plates

Purpose of fabricating composite plates by explosive welding：

- A high bond rate
- An acceptable strength
- An equivalent density to magnesium alloy

Solution

4mm 5083 Al + 2mm 1060 Al + 12mm AZ31

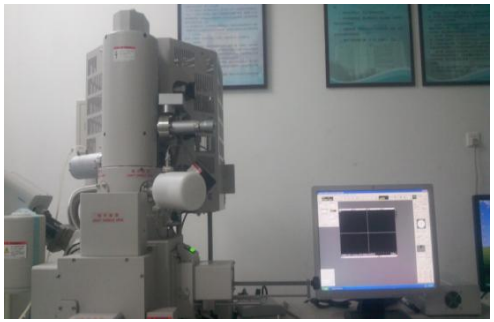
Mechanical properties of experiment materials

Samples	Yield strength $\sigma_{0.2}$(MPa)	Tensile strength（MPa）	Elongation（%）
5083 Al	115	303	21.1
1060 Al	80	115	5.8
AZ31	150	245	14.3

Characterization and test methods

Microstructural characterization

Optical microscope

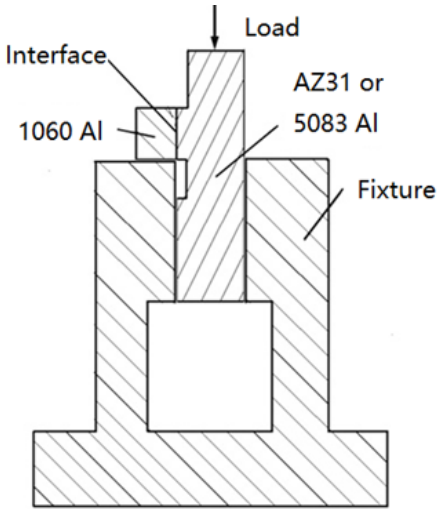


Scanning electron microscope

Transmission electron microscope

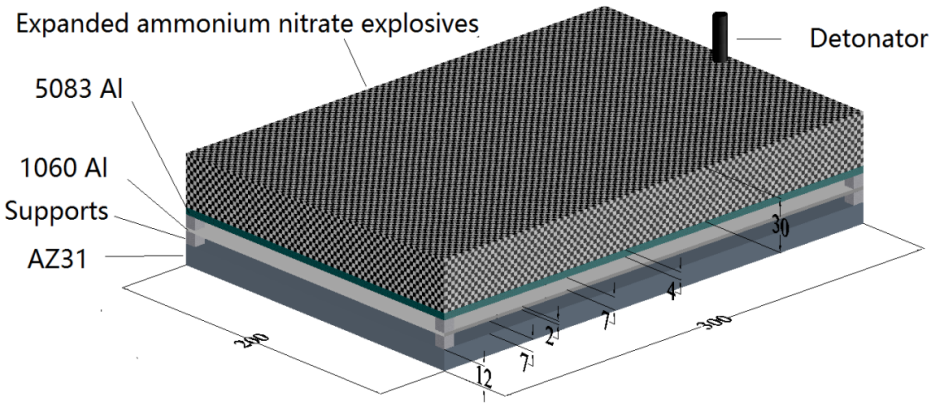
Mechanical test

Tensile test

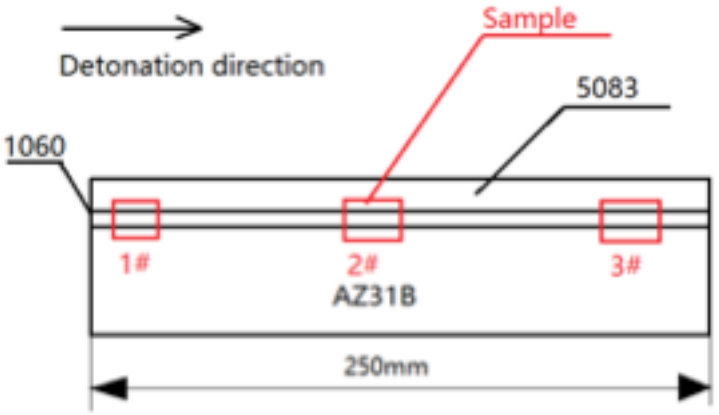


Shear test

5083 Al/1060 Al/AZ31 Composite plates



Experimental conditions of explosive welding

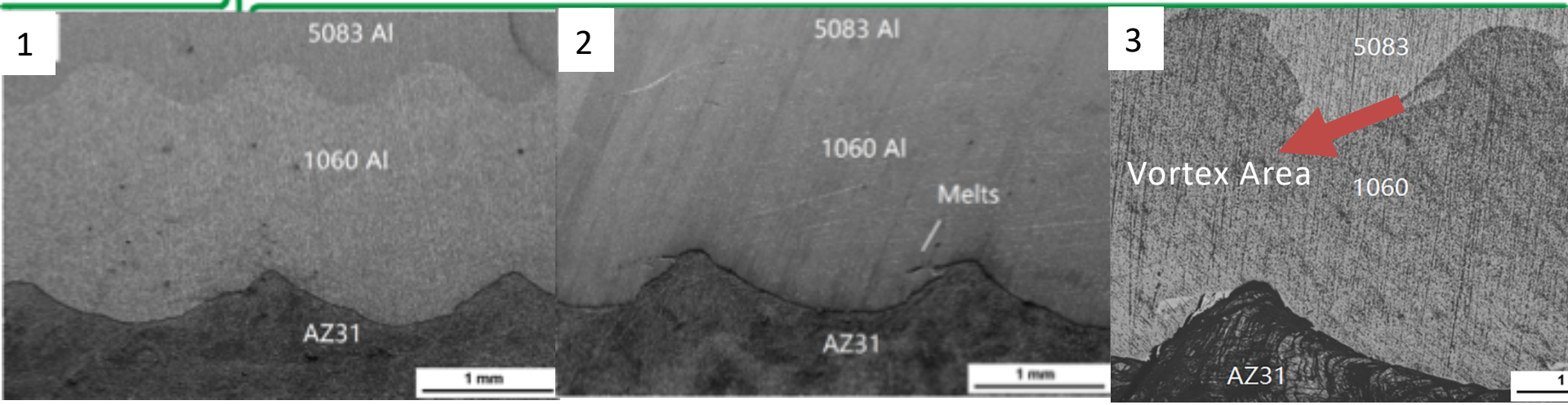


Schematic diagram of sampling

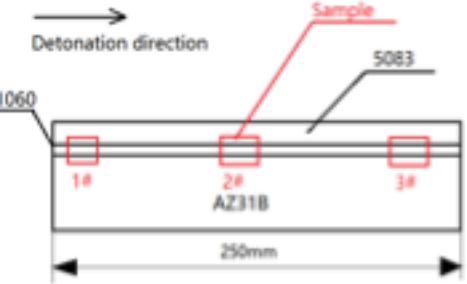
Materials	Stand-off distance (mm)	Explosives	Thickness of Explosives	Bonding rate%
4mm 5083 Al 2mm 1060 Al 12mm AZ31	7	Expanded ammonium nitrate	30	85

Microstructural observation

Waveform



SEM images of the 5083 Al/1060 Al/AZ31 composite interface



Interface parameters

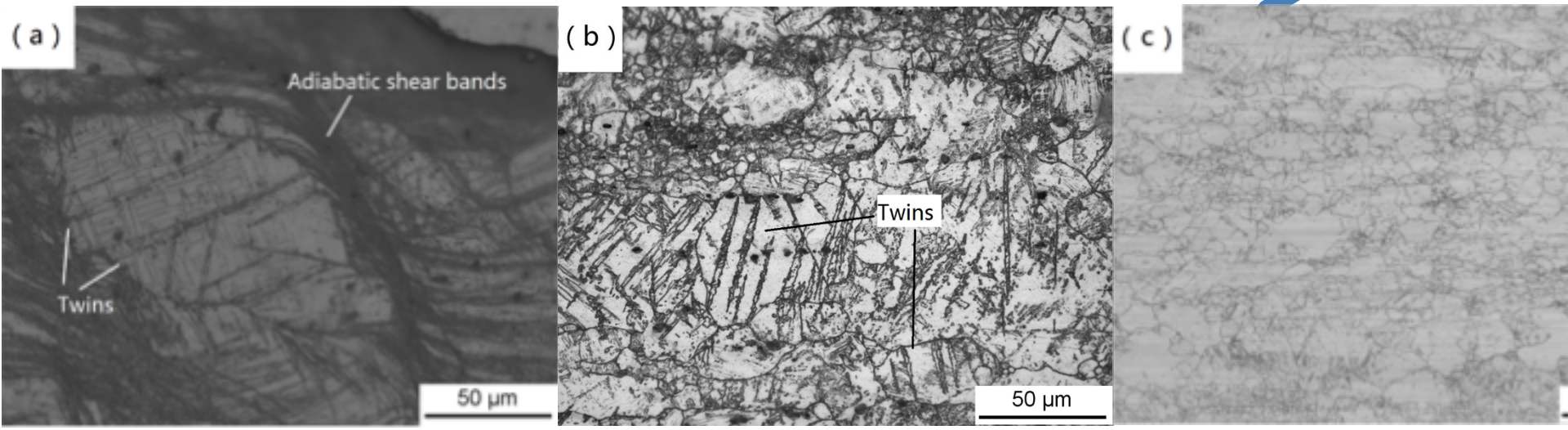
Samples	Wavelength of 5083 Al/1060 Al mm	Amplitude of 5083 Al/1060 Al mm	Wavelength of 1060 Al/AZ31 mm	Amplitude of 106(Al/AZ31 mm
1#	1.39	0.33	1.89	0.34
2#	1.95	0.44	2.07	0.40
3#	2.05	0.50	2.35	0.44

With an increasing distance from the initiation point, the wavelength and amplitude also increase.

Microstructural observation

Microstructural evolution in AZ31

Increasing distance from the interface 1060 Al/ AZ31



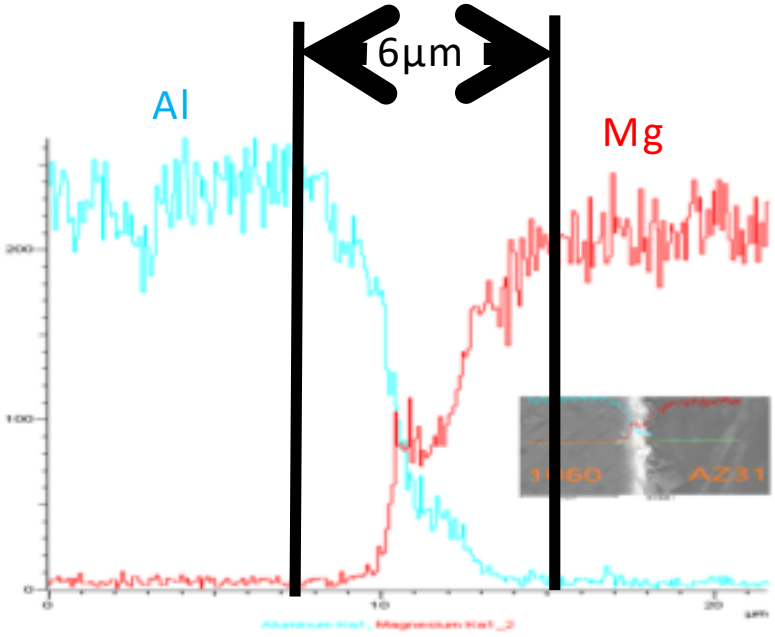
- With an increasing distance from the interface, the deformation of the materials decreased.

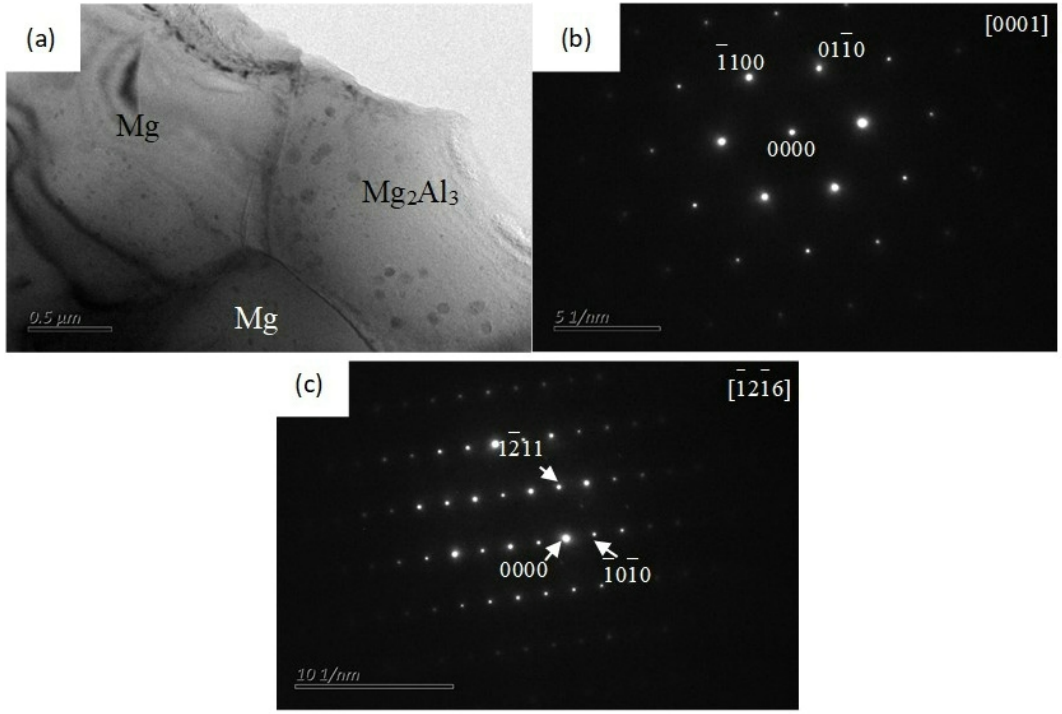
Severe deformation ▶ A certain degree of deformation ▶ No obvious deformation

Shear bands and twins ▶ Twins ▶ Original microstructure

Microstructural observation

Interface



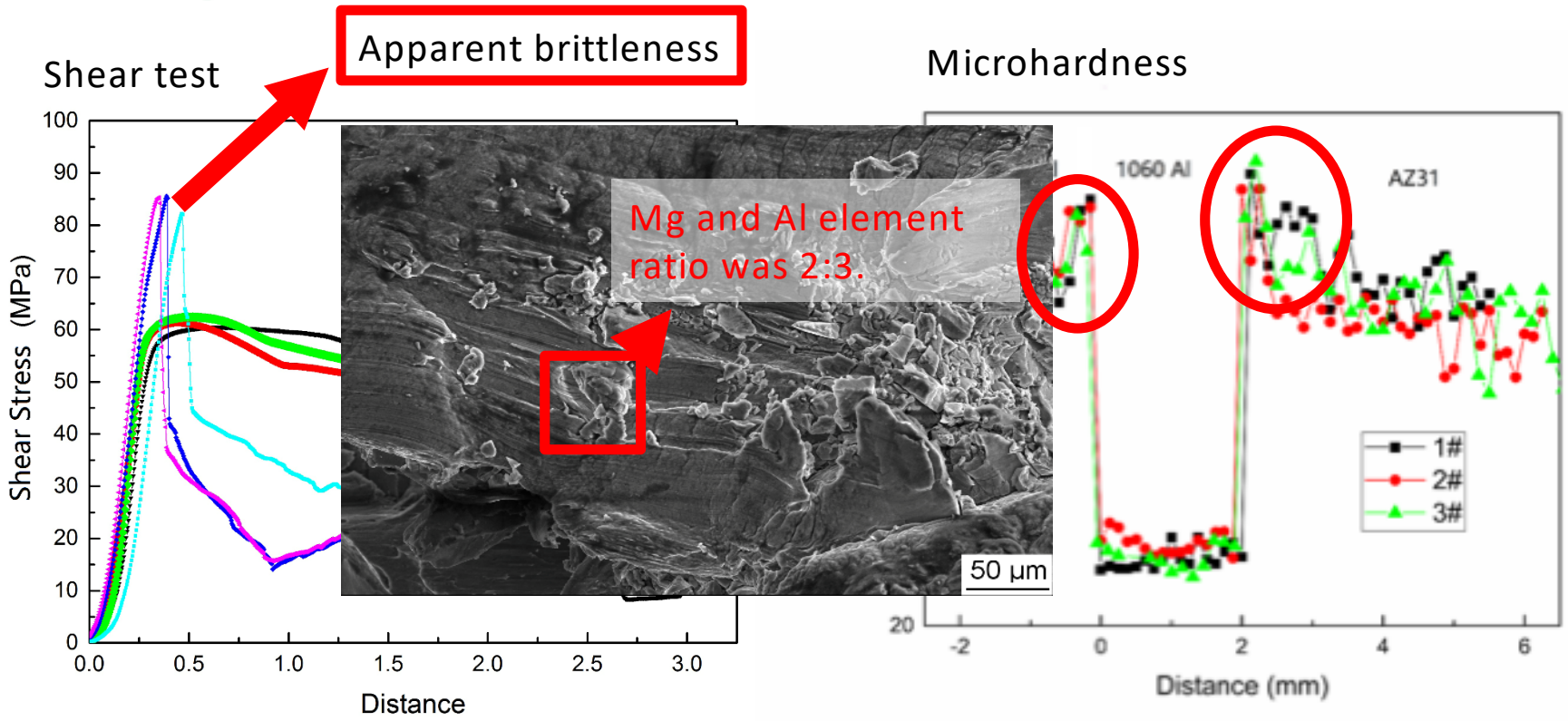


EDS(energy dispersive spectroscope) line scan between 1060Al /AZ31 interface

a:1060Al/AZ31 interface ; b: Mg diffraction pattern ; c:Mg2Al3 diffraction pattern

- Metallurgical bonding was formed between 1060Al and AZ31.
- Brittle phase Mg2Al3 existed at 1060Al/AZ31 interface.

Shear test and hardness measurement



Relationship between shear stress and displacement Microhardness profile across the interfaces

1. The bonding strength of 5083 Al/1060 Al interface and 1060 Al/AZ31 interface was 60MPa, 84MPa, respectively.
2. Hardening effect was obvious near 5083 Al/ 1060 Al interfaces and 1060Al/AZ31 interfaces.

Conclusion

1. Wavelength and amplitude of the waveform interfaces increased with an increasing distance from the detonation point.

2. During explosive welding, the AZ31 suffered severe plastic deformation, adiabatic shear bands, and twins occurred near the interfaces. Deformation decreased with an increasing distance from the interface.

3. The thickness of the diffusion layer in the 1060 Al/AZ31 layer was 6μm and Mg_2Al_3 was identified within this diffusion layer.

5. The shear bond strength of the 5083 Al/1060 Al interface was 60MPa, and the shear bond strength of the 1060 Al/AZ31 interface was 84MPa.

Thank you for your attention!