Exploring the Potential of Silver Wires for Power Device Integration

Presented by

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Source: IMAPS

Introduction

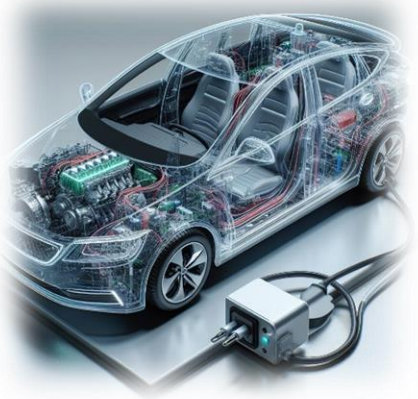
Power devices are critical components in decarbonization through a variety of products ranging from power generation to electric vehicles.

Consumer electronics

Factory Automation

Power supply
(server power supply, UPS)

EV

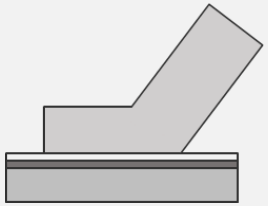
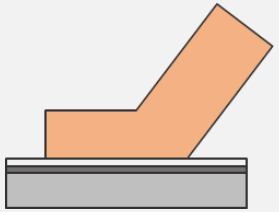
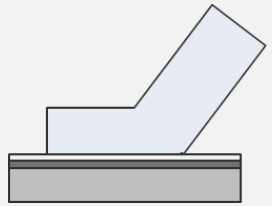


- **There is an increasing demand for power devices that need to withstand high temperatures operating in either high current or high voltage requirements**

Source: IMAPS

Introduction

Wire Material

Relative Comparison Among Al, Cu and Ag		
Al	Cu	Ag
 • Relatively high electrical resistance • Low melting point, 660°C • Very good processability • Easy surface oxidation which turns into insulator	 • Low electrical resistance • High melting point, 1085°C • Very Hard processability • Easy and bulk oxidation	 • Lowest electrical resistance • High melting point. 962°C • Very good processability • No oxidation; only tarnishing by sulfides
• Due to its relatively high electrical resistance and low melting point, it cannot withstand high-temperature operating environments in high currents and voltages.	• It is expected to withstand high temperature, high current, and high voltage operating environments, but its hardness requires buffer layers and/or thick copper plating on devices.	• It is the best electrical conductor known and can high temperatures

- Ag has combined characteristics of both Al and Cu is relatively better for power device interconnection

Source: IMAPS

Scope

1. Heavy Ag Wire Characteristics
2. Heavy Ag Wire Bonding

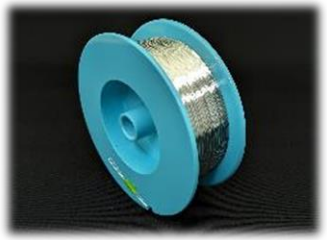
Source: IMAPS

Heavy Ag Wire Characteristics

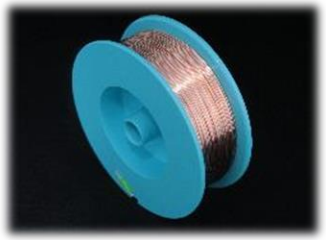
Strength and Elongation

- Wire diameter : 400um
- Purity: >4N (>99.99%)

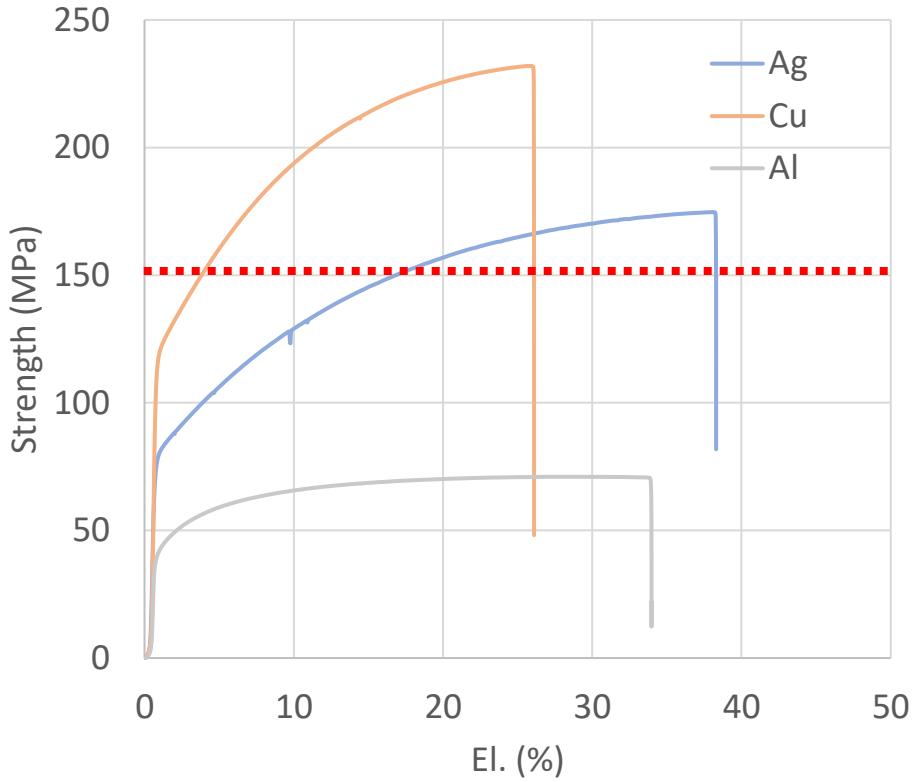
Ag wire



Cu wire



Al wire



- **Ag wires provide intermediate strength between Cu and Al**

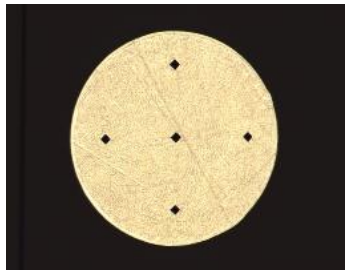
Source: IMAPS

Heavy Ag Wire Characteristics

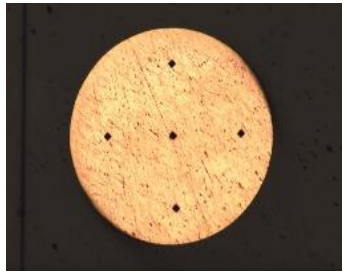
Vickers Hardness

- Wire diameter : 400um
- Purity: >4N (>99.99%)
- Test equipment : Mitutoyo HM-220D
- Test Force : 0.03kgf
- Time : 10sec

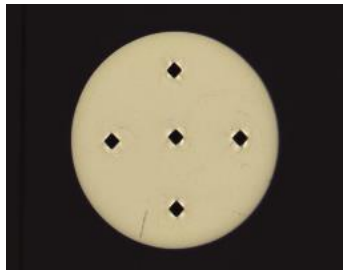
Ag

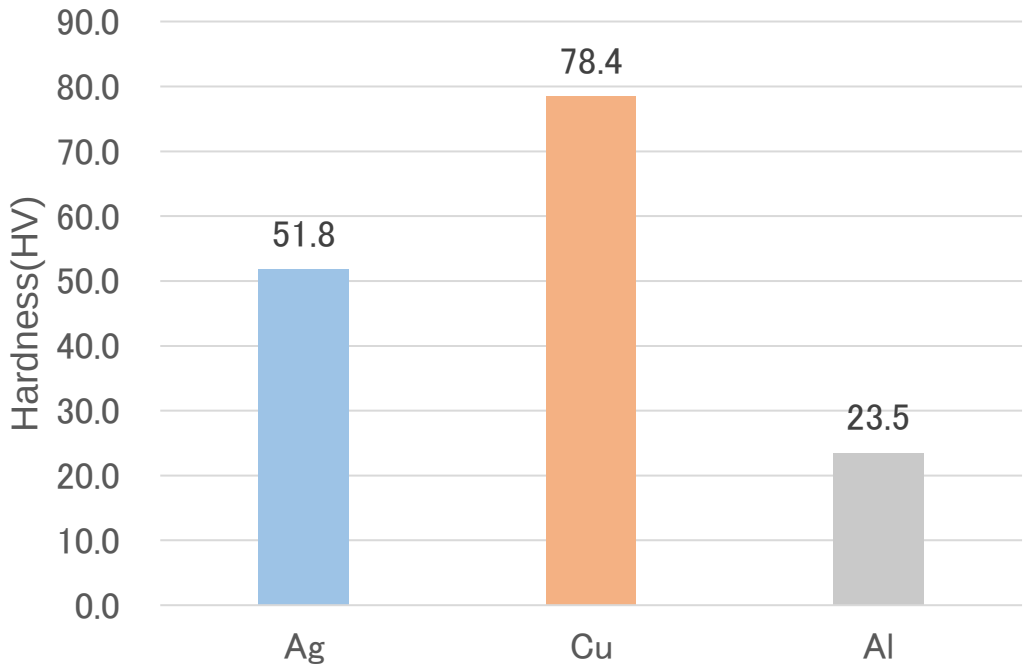


Cu



Al





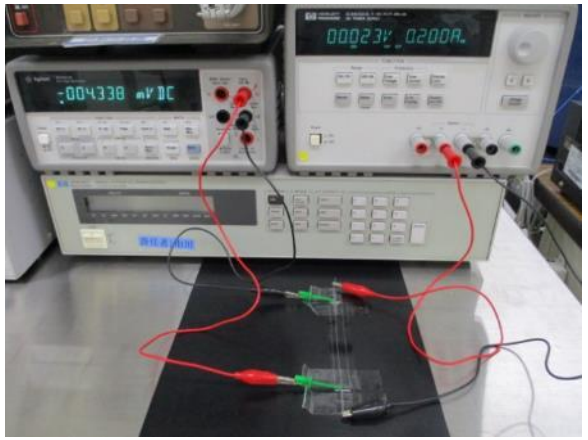
- **Ag wire provide intermediate hardness between Cu and Al**

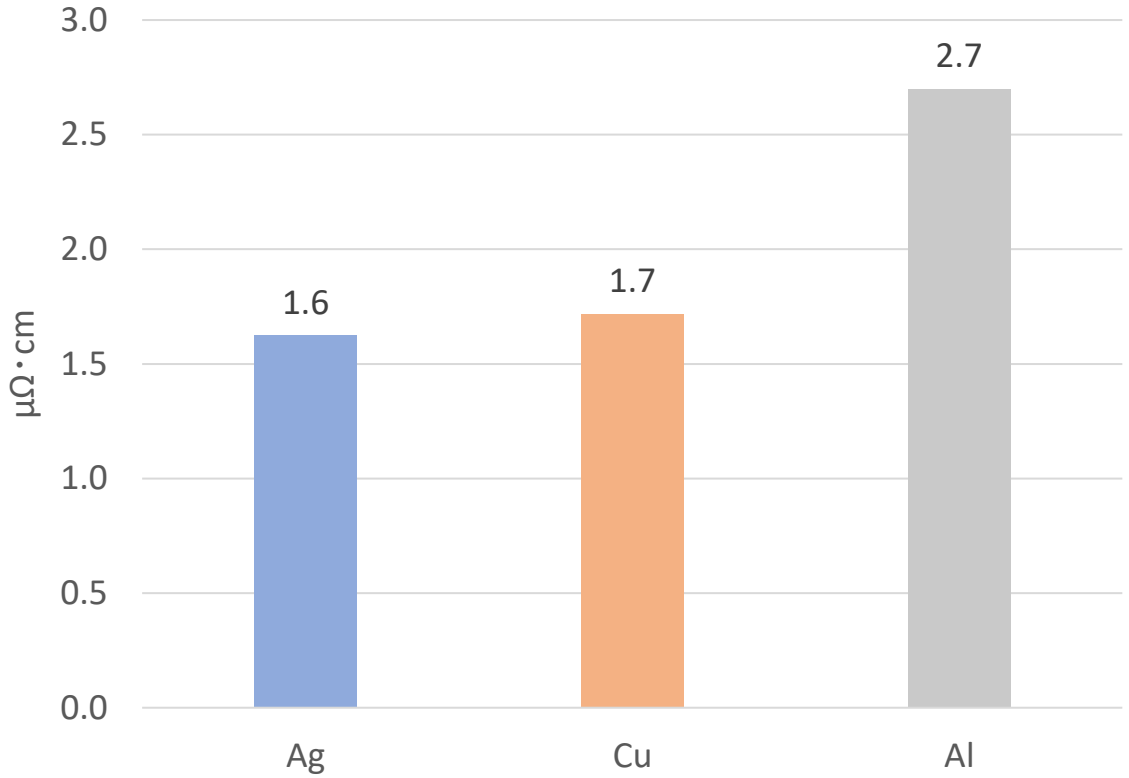
Source: IMAPS

Heavy Ag Wire Characteristics

Electrical Resistance

- Wire diameter : 400um
- Purity: >4N (>99.99%)
- 4-terminal
- Length: 10mm
- Current: 200mA





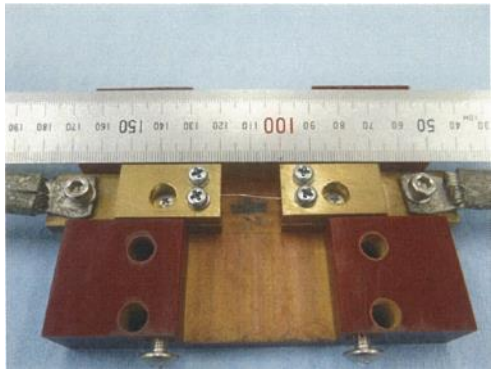
- **Ag wire provides lowest resistance vs Cu and Al**

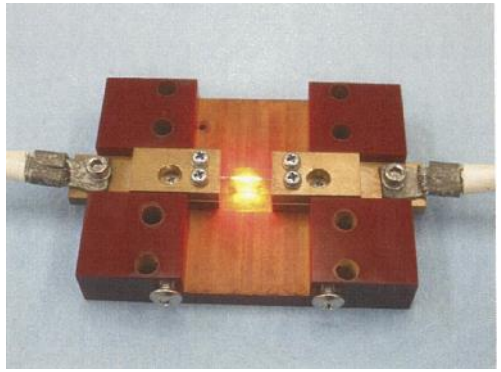
Source: IMAPS

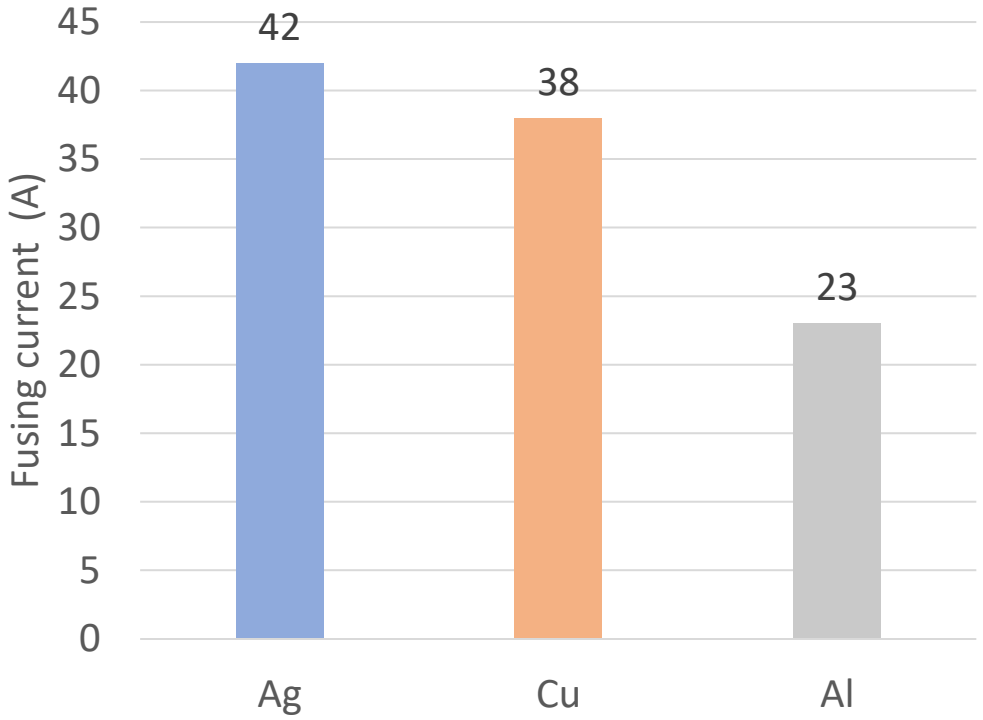
Heavy Ag Wire Characteristics

Fusing Current

- Wire diameter : 400um
- Purity: >4N (>99.99%)
- DC
- Length: 20mm
- Melting Time: 10s







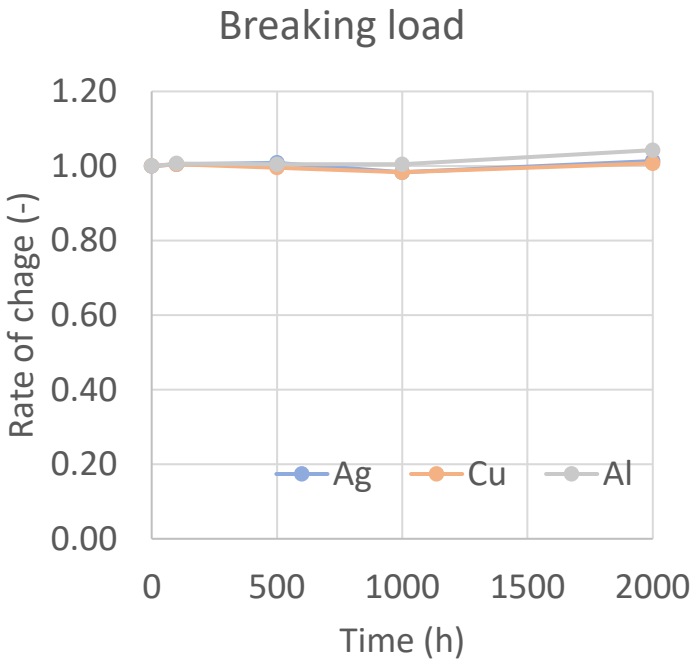
- **Ag wire provides highest fusing current vs Cu and Al**

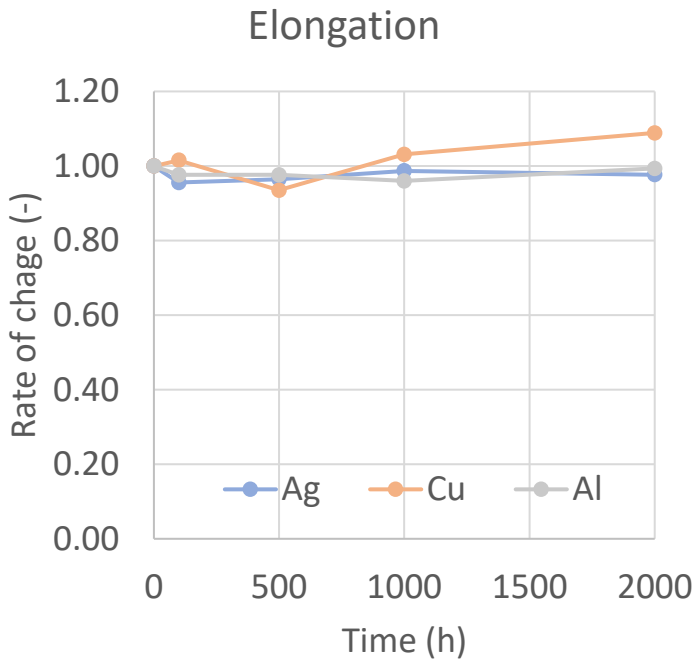
Source: IMAPS

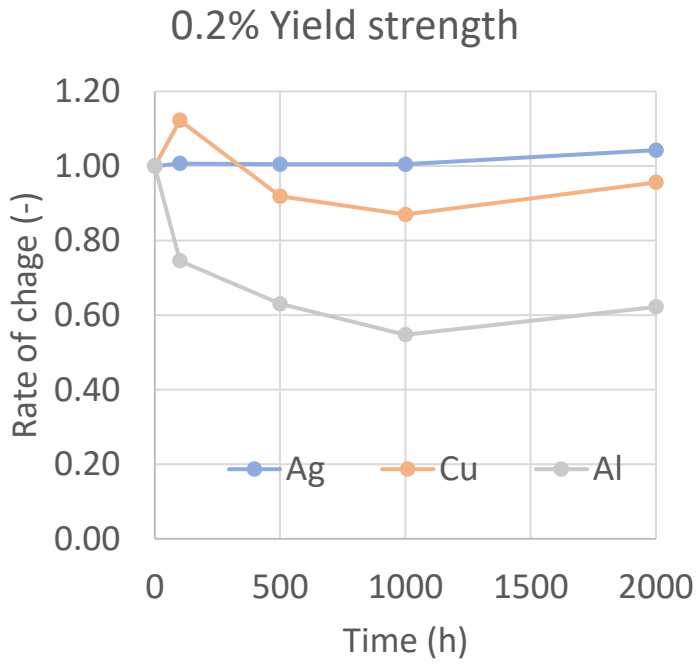
Heavy Ag Wire Characteristics

High Temperature Performance

High Temperature Storage Test, 175℃, 2,000 hours







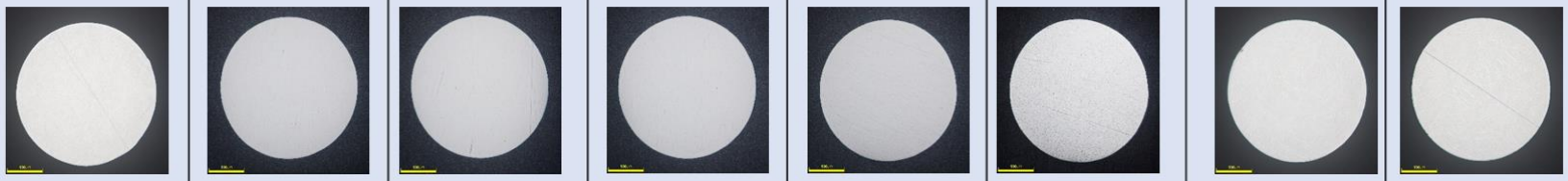
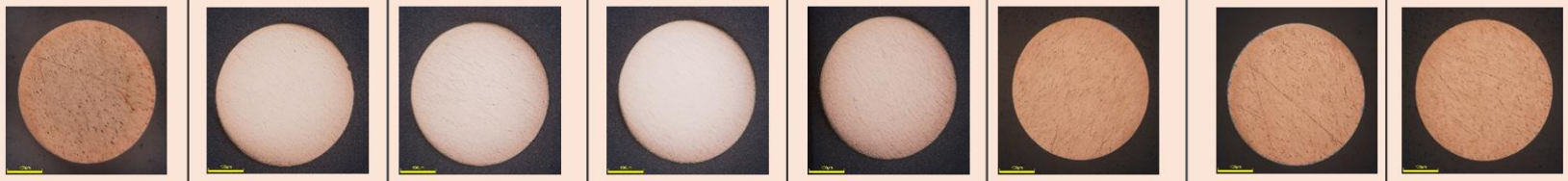
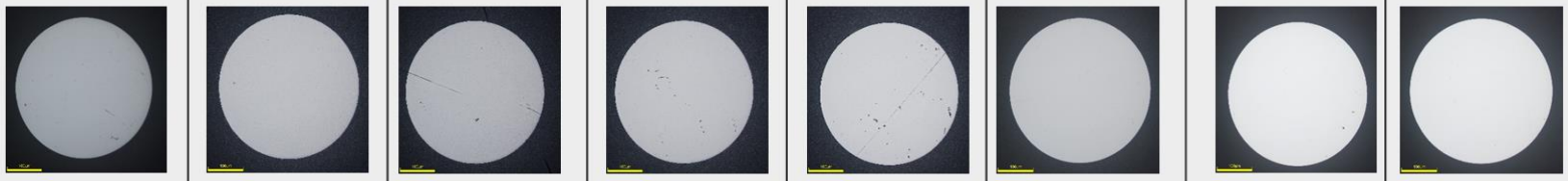
- Ag wire provides stable mechanical properties at high temperatures

Source: IMAPS

Heavy Ag Wire Characteristics

Corrosion Performance

Pressure Cooker Test, 121℃, 100%RH, 2atm, 3,000hours

	0h	24h	48h	96h	300h	1000h	2000h	3000h
Ag								
Cu								
Al								

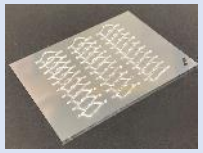
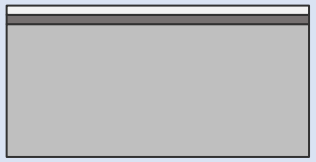
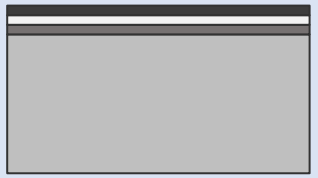
- Ag wire has no observed corrosion in high temperature high corrosion test conditions.

Source: IMAPS

Heavy Ag Wire Bonding

Wedge bonding on Al, Cu and Ni

- Temperature: Ambient
- Bond Time: 150ms

Pad material		
Al	Cu (DBC)	Ni
  Al-0.5%Cu >5um Ti 20nm Si 625um	  Cu 300um Al2O3 380um Cu 300um	 Ti 20nm Si 625um
Good	Good	Poor

- Ag wires bonds on Al and Cu pads but not easily on Ni

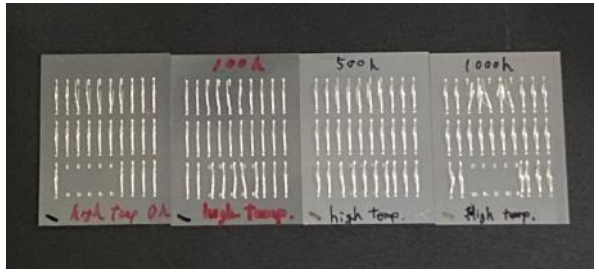
Source: IMAPS

Heavy Ag Wire Bonding

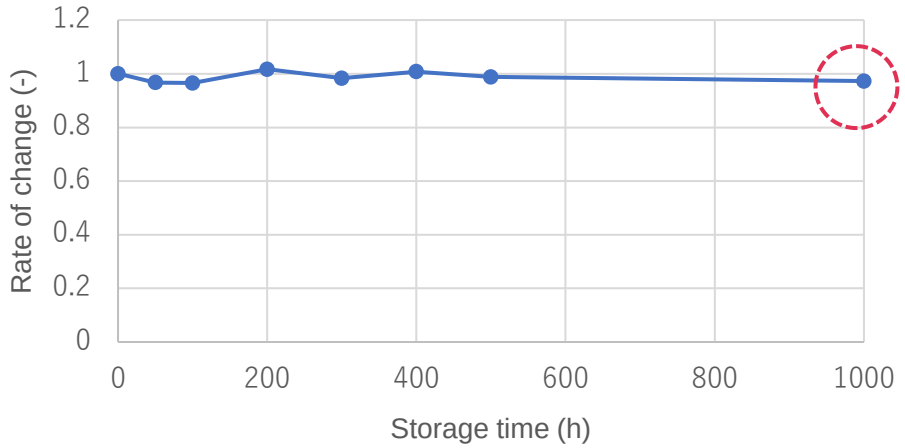
High Temperature Performance – Ag Wire on Al pad

High Temperature Storage Test, 175℃, 1,000 hours

As-bonded 100h 500h 1000h

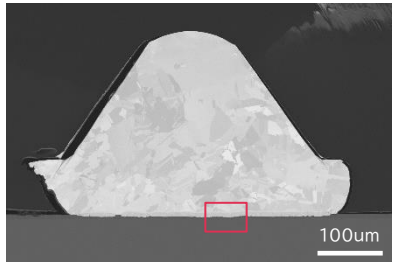


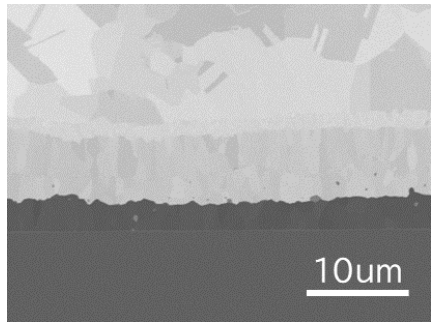
Rate of change in 1st shear strength

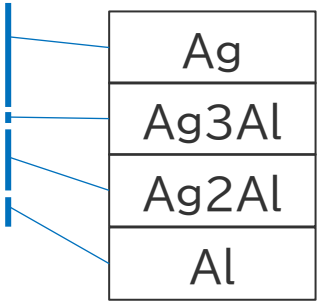


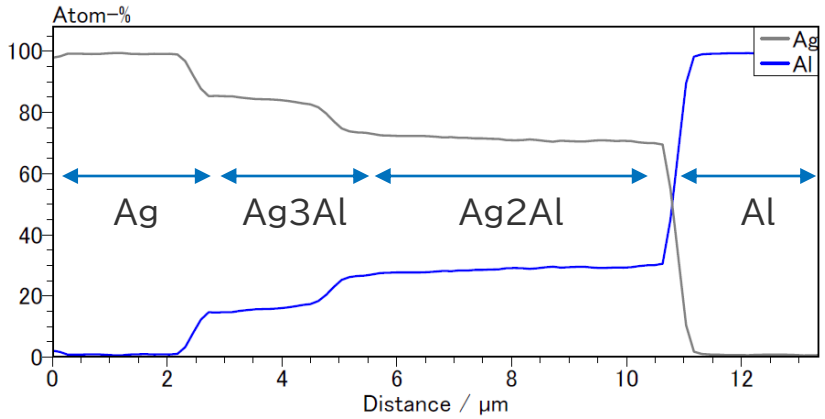
Cross –section image of SEM & EDX

Storage times: 1000h









※IMC was estimated not only by EDX but also by multiple analyses and literature.

- Ag wire bonds maintain stable strength on Al pads

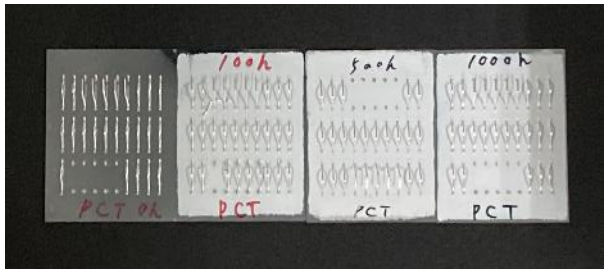
Source: IMAPS

Heavy Ag Wire Bonding

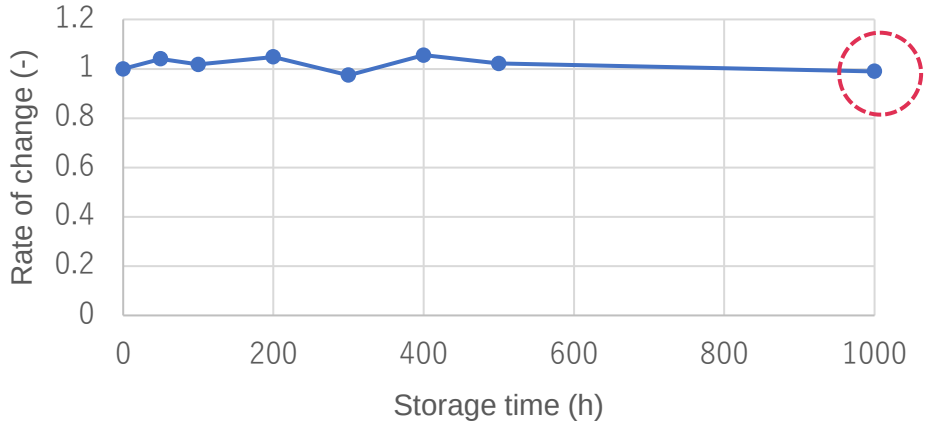
Corrosion Prevention – Ag Wire on Al pad

Pressure Cooker Test, 121℃, 100%RH 2atm

As-bonded 100h 500h 1000h

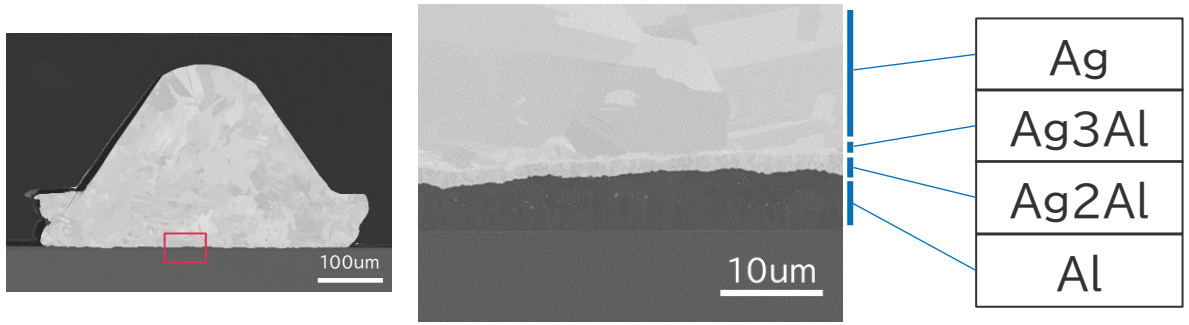


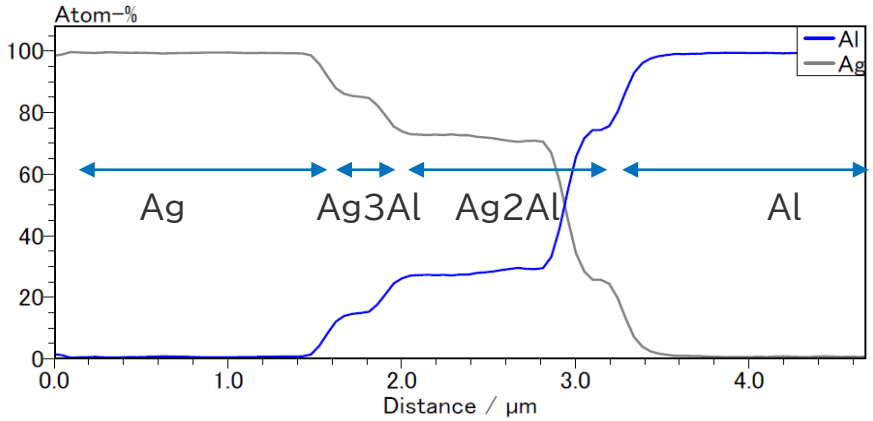
Rate of change in 1st shear strength



Cross –section image of SEM & EDX

Storage times: 1000h





※IMC was estimated not only by EDX but also by multiple analyses and literature.

- **Ag wire bonds maintain stable strength on Al pads**

Source: IMAPS

Heavy Ag Wire Summary

- Ag wire has excellent electrical properties compared to Cu wire and Al wire
- Ag wire has ideal intermediate mechanical properties between Cu and Al wires
- Ag is softer than Cu – good for sensitive pads
- Ag wire has stable mechanical and surface properties in high temperature high and high humidity environments
- Ag wire bonds very well on Al and Cu pads
- Ag wire on Al pads have acceptable reliability under high temperature and humidity conditions with stable intermetallics

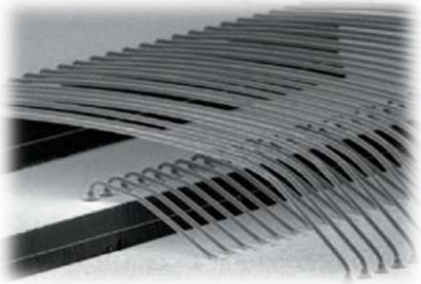
Source: IMAPS

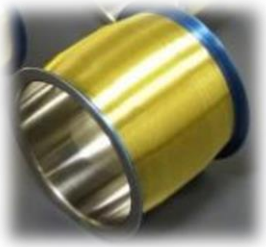
TANAKA Bonding wire

Au

【IC・Memory】

- ATV・High reliability
- Fine pitch device

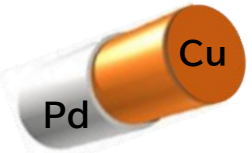




Cu

【IC】

- ATV・High reliability
- Fine pitch device



【Power】

- Low resistivity
- Bond-ability

Ag

【Memory・LED】

- Low resistivity
- High reliability

Al

【Power】

- High reliability
- Bond-ability

Please feel free to contact us if you want to try with any bonding materials, we can provide various materials.

Source: IMAPS