Improvement of Ag sintering Quality on Cu surface at Hydrogen atmosphere

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- Die attach materials for WBG devices
- Micron Ag sintering paste

✓ Experimental procedure

✓ Results
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- Two-Step sintering profile
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Wide-Band Gap (WBG) Power Devices

- Reduced power loss
- Higher voltages & frequency
- Higher operation temperature
- Reduced size and weight

Die Attach Materials for WBG Devices

- High-temperature solder
- Transient liquid phase (TLP) bonding
  - Cu (high melting temp)
  - Sn (low melting temp)
  - Cu$_5$Sn IMC (677 °C)

- Metal sintering structure
  - High-temperature operation
  - High thermal conductivity
  - High electrical conductivity
Micron Ag Sintering Paste

Advantage
• Pressure-less sintering is available

Disadvantage
• Shear strength to bare Cu surface is not high

Experimental Procedure

Die and substrate
Si die: Pt-Ag sputtered, 3 × 3 × 0.5 mm
Cu substrate: Bare and Ni-Ag plated, 50 × 50 × 0.5 mm

Ag paste apply
Stencil
Printing method Manual printing

<table>
<thead>
<tr>
<th>No.</th>
<th>Substrate</th>
<th>Sintering steps</th>
<th>Sintering atmosphere</th>
<th>Sintering temperature (°C)</th>
<th>Sintering time (min.)</th>
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<tbody>
<tr>
<td>1</td>
<td>Plated Ag</td>
<td>1 step</td>
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<td>30</td>
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<td>2nd H₂</td>
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<td>7</td>
<td>Bare Cu</td>
<td>2 steps</td>
<td>1st Air</td>
<td>180</td>
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<td>2nd H₂</td>
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Ag Sintering to Bare Cu Surface

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<th>Shear Strength (MPa)</th>
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<td>1 step</td>
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<td>30</td>
<td>&lt; 10</td>
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</table>

- Micron Ag can be sintered onto a Cu substrate
- Breakdown area is oxidized Cu layer
- Oxide is necessary for micron Ag sintering

Two-step Sintering Profile

1st step
To start micron Ag sintering in air.

2nd step
To reduce oxidized Cu in H₂.
Optimization of Two-step Sintering

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</table>

- Oxidized Cu was reduced by H<sub>2</sub>
- The shear strength was improved by two-step sintering

Share Strength of the Joint

Die shear tester: Dage 4000  
Shear head speed: 100 μm /s  
Shear head height: 100 μm

- Shear strength over 20 MPa has been achieved by the optimized Two-step sintering profile
Summary

- The heating in air is necessary to start Ag particles sintering
- Cu oxidation decreases bonding strength
- Two-step sintering profile combining sintering in air and reduction in hydrogen was proposed
- Shear strength over 20 MPa has been achieved by Two-step sintering profile with micron Ag paste