Reliability of Double Side Argomax® Silver Sintered Devices with various Substrate Metallization

Francois Le Henaff1, Gustavo Greca2, Paul Salerno2, Olivier Mathieu3, Martin Reger3, Oscar Khaselev2, Monnir Boureghda2, Jeffrey Durham2, Anna Lifton2, Jean Claude Harel4, Satyavrat Laud4, Weikun He5, Zoltan Sarkany5, Joe Proulx5, John Parry5

1 Alpha Assembly Solutions, Elisabeth-Selbert-Strasse 4, 40764 Langenfeld, Germany
2 Alpha Assembly Solutions, 109 Corporate Boulevard South Plainfield NJ 07080, USA
3 Rogers Germany GmbH, Am Stadtwald 2, 92676 Eschenbach, Germany
4 Renesas Electronics America (REA), 2801 Scott Blvd, Santa Clara, CA 95050 USA
5 Mentor Graphics, 81 Bridge Road, East Molesey, KT8 9HH UK

INTRODUCTION
- ALPHA Argomax® high performance silver sintering technology
- Double side ALPHA Argomax® sintered modules
- Thermo-mechanical and electrical performance evaluation

MATERIALS
- 8.80 x 8.80 x 0.090 mm IGBT from Renesas Electronics America
- Cu clip - Design courtesy of Renesas Electronics America
- Raw Cu, spot Ag and full Ag Si-N AMB substrates from Rogers
- ALPHA Argomax® 8020 and 8050 films
- Sintered @ 250°C, 10 MPa, 2 min
- No special cleaning was used prior to sintering
- No formic gas was used during the process

THERMAL CONDUCTIVITY
Tj (°C - Y Axis) for a 2kW power applied to 90 µm Si chip, using ALPHA Argomax® sinter material and solder at different bond line thicknesses (BLT). Thermal conductivity (W/(m*K) - X Axis)

RELIABILITY TESTS

THERMAL CYCLING
- Liquid to liquid
- -55°C / +165°C
- 3 min dwell time
- Transition time < 5s
- 1K cycles

<table>
<thead>
<tr>
<th>Module type</th>
<th>Zth (°C/W) @ t = 0 cycle</th>
<th>Zth (°C/W) @ t = 1k cycles</th>
<th>Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag AMB</td>
<td>0.350</td>
<td>0.355</td>
<td>+1.40%</td>
</tr>
<tr>
<td>Spot Ag AMB</td>
<td>0.338</td>
<td>0.343</td>
<td>+1.46%</td>
</tr>
<tr>
<td>Raw Cu AMB</td>
<td>0.326</td>
<td>0.322</td>
<td>-1.22%</td>
</tr>
</tbody>
</table>

➤ @ 1k cycles, Zth of sintered modules << failure criteria of 15% increase
➤ Soldered modules failed after 200 cycles

POWER CYCLING
- 200A, 5s ON and 10s OFF
- Tjmax = 130°C, ΔT = 100°C
- 65K cycles

<table>
<thead>
<tr>
<th>Module type</th>
<th>Zth (°C/W) @ t = 0 cycle</th>
<th>Zth (°C/W) @ t = 65k cycles</th>
<th>Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag AMB</td>
<td>0.345</td>
<td>0.320</td>
<td>-7.25</td>
</tr>
<tr>
<td>Spot Ag AMB</td>
<td>0.338</td>
<td>0.330</td>
<td>-2.37</td>
</tr>
<tr>
<td>Raw Cu AMB</td>
<td>0.326</td>
<td>0.295</td>
<td>-9.51</td>
</tr>
</tbody>
</table>

➤ @ 65k cycles, Zth of sintered modules << failure criteria of 15% increase
➤ Soldered modules failed after 45k cycles
Reliability of Double Side Argomax® Silver Sintered Devices with various Substrate Metallization

**ANALYSIS**

**THERMAL CYCLING**
on Raw Cu AMB
@ t = 0 cycle  @ t = 1k cycles

**RAW COPPER AMB ASSEMBLY**
@ t = 65k power cycles

**POWER CYCLING**
on Raw Cu AMB
@ t = 0 cycle  @ t = 65k cycles

---

**ARGOMAX® SILVER SINTERED MODULES**
- Excellent adhesion on all three AMB metallizations
- ALPHA Argomax® layer porosity < 10%
- No delamination
- Pass reliability tests w/o degradation on all three finishes
- No structural modification of ALPHA Argomax® sintered layer and interfaces with die, clip and substrates
- Tjmax reduced @ 200A
  - Solder Tjmax = 173°C
  - ALPHA Argomax® sinter Tjmax = 130°C

**SOLDERED MODULES**
- Same material was used
- Innolot SnAgCu+Sb+Bi alloy
- @ 200 TC, Zth increased > 15%
- Important delamination
- Internal study

---

**SUMMARY**
- Superior thermomechanical performance of ALPHA Argomax® sintered modules compared to soldered modules
- No change in electrical performance after thermal and power cycling tests on all three AMB substrate finishes
  - ALPHA Argomax Sintered modules did not meet any of the failure criteria; whereas, soldered samples failed rapidly
  - ALPHA Argomax® capability on raw copper will lower the cost of sintered devices
- Lower Zth and Tjmax enable:
  - Operation of high current Si devices at temperature below 200°C
  - Capability to shrink the package
- Reliability increased by a factor of 10 to 15 with Argomax® silver sintering technology
  - Tests stopped @ 65k PC, Argomax® sintered modules were without any defect

**FUTURE WORK**
- Variation of the clip thickness based on simulation results
- Full copper module without cleaning for the materials throughout the process