Reliability Assessment of Advanced Flip-Chip Interconnect Electronic Package Assemblies under Extreme Cold Temperatures (-190°C and -120°C)

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OUTLINE

• Objective
• Introduction
• Test articles
• Experimental data
• Results and discussion
• Conclusions
• Acknowledgements
Venus
0.72 AU
Sun: 5504 °C
Earth
AU: Astronomical Unit
1 AU = ~150 million km
Mercury
0.39 AU
Earth's Moon: -233/123 °C
Jupiter
39.5 AU
Mars
1.52 AU
Saturn
Neptune
Pluto
Temperature, °C
39.5 AU
Schematic of the Flip-chip attachment and the chip

(Courtesy of Practical Components)
Flip-chip bond structure

Courtesy of Quality Conformance ... Edited by M. Pecht, et al.,
Test article details

- FB250 and FB500 test boards
- Test board material: FR4
- Tg: 176°C, 0.031” thick, copper conductor, Taiyo PSR-400 solder mask
- **FB250 board**: 10 chips of 250 x 250 mil^2, 18 mil pitch.
- **FB500 board**: 10 chips of 500 x 500 mil^2, 18 mil pitch.
(Courtesy of practical components)
Optical photographs of the assembled advanced flip-chip Interconnect test boards of FB250 and FB500
<table>
<thead>
<tr>
<th>Underfill</th>
<th>Stage temp. C</th>
<th>Air Pressure (psi)</th>
<th>Needle gauge</th>
<th>RPM</th>
<th>Line speed (in/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDP-960</td>
<td>80</td>
<td>6</td>
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<td>250</td>
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Parameters for underfill component FB500

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Parameters for underfill component FB250
X-Ray image of solder wetting after reflow
Cross section images of top right corner viewing from chip side
CSAM images of underfill with voids
Resistance of daisy chains such as A,B,C,D,E,F,G,H,J,K of flip-chip FB250 test board. A. Measured resistance at room temperature, b. resistance measured after 481 thermal cycles −120°C to 115°C and −120°C to 85°C (TC1), c. Resistance measured after 200 thermal cycles −55°C to 100°C (TC2), and d. Resistance measured after 311 thermal cycles −125°C to 85°C (TC3).
Resistance of the daisy chains such as J,K,G,H,E,F,C,D,A,B of flip-chip FB500 test board.  
A. Resistance of the pair at room temperature, b. resistance of the pairs measured after 481 thermal cycles –120°C to 115°C and –120°C to 85°C (TC1), and c. Resistance of the pairs measured after 200 thermal cycles –55°C to 100°C (TC2) and d. Resistance of the pairs measured after 311 thermal cycles –125°C to 85°C (TC3).
Resistance of the daisy chains such as A,B,C,D,E,F,G,H,J,K of flip-chip FB250 test board. a. Resistance of the daisy chains at room temperature, b. resistance of the daisy chains measured after 70 thermal cycles (−190°C to 25°C) and c. Resistance of the daisy chains measured after 88 thermal cycles (-190°C to 25°C).
Resistance of daisy chains such as J,K,G,H,E,F,C,D,A,B of flip-chip FB500 test board.  A. Resistance of the daisy chains at room temperature, b. resistance of the daisy chains measured after 70 thermal cycles (−190°C to 25°C) and c. Resistance of the daisy chains measured after 88 thermal cycles (-190°C to 25°C).
Flip-chip boards with electrical leads in the thermal chamber to monitor daisy chain resistance
Experimental extreme temperature test data obtained during the first cycle.
Resistance of daisy chain associated with FB250 chip obtained during thermal cycling
Resistance of daisy chain associated with FB500 chip obtained during thermal cycling
FB 500: First Failure at 322\textsuperscript{nd} cycle (Chip 5)

Temp is decreasing \(-190^\circ\text{C}\)
Conclusions

• Flip-chip interconnect test boards were assembled with underfills and subjected to extreme temperature ranges that cover military specifications, extreme Mars and an asteroid environments.
• Very interesting results have been observed when tested over –190°C to 85°C.
• Several failures were observed during the cold cycle and recovers in the hot cycle. More detailed analysis will be performed in the future.
• Diagnostic studies and failure analysis is yet to be done.
Acknowledgements

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