Introduction

• Conformal coating is a protective polymer layer that is uniformly applied on the surfaces of PCB assemblies.
• Coatings are used to protect the electronics from hazardous environments.
• Some conformal coatings have been used for tin whisker mitigation.

Conformal Coated Interconnect Reliability (1/2)

• Parylene conformal coating was found to be beneficial for solder joint reliability under temperature shock between -196°C and room temperature [3].

• Pippola studied the thermoshock life of solder joint and found that polyurethane and epoxy coatings reduce the reliability of solder joints [4].


Dunn et al examined the effect that various conformal coatings have on the reliability of solder joints through 1000 cycles of -40°C to 100°C temperature cycling and found that conformal coatings have negative impact [5].
   - Polyurethane, epoxy, and silicone coatings had the worst impacts.

Lall also found that conformal coating had negative impact on solder joint reliability under temperature cycling, although the type of coating was not specified [6].

Hunt concluded in his study that conformal coating improves the thermomechanical reliability of solder joints under -55°C to 125°C temperature cycling [7].
   - Hunt hypothesized that pliable coatings are beneficial to solder joint reliability.

Motivation

• Limited studies on the effects of conformal coating on the interconnect reliability are presented in the literature.

• The studies in the literature present disagreements on the effects of conformal coating on the interconnect reliability under thermomechanical loadings.

• No study has been reported on the impact drop and vibrational reliability of conformal coated PCB assemblies.
Research Objective

To investigate the reliability of effect of conformal coating on surface mount interconnect reliability under temperature cycling, harmonic vibration, and drop tests
**Approach**

- Design of Test Vehicle
- Conformal Coating Application
  - Temperature Cycling -55 to 125°C, 15 mins dwell
  - Harmonic Vibration 3G and 4G
  - Drop Testing 3000G
- Failure Data Comparison
### Test Vehicle Specifications (1/2)

<table>
<thead>
<tr>
<th>Board Details</th>
<th>Coating</th>
<th>Components</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Layers</td>
<td>Acrylic (50µm)</td>
<td>BGA</td>
<td>4</td>
</tr>
<tr>
<td>9&quot;x4.5&quot;x0.063&quot;</td>
<td>Parylene like (50µm)</td>
<td>QFP</td>
<td>4</td>
</tr>
<tr>
<td>Surface Finish: ImAg</td>
<td>None</td>
<td>QFN</td>
<td>4</td>
</tr>
<tr>
<td>Solder: SAC305</td>
<td></td>
<td>Resistor (50% Pad Width)</td>
<td>4</td>
</tr>
<tr>
<td>$CTE_x : 13.8 \text{ ppm/°C}$</td>
<td></td>
<td>Resistor (50% Pad Length)</td>
<td>4</td>
</tr>
<tr>
<td>$CTE_y : 15.1 \text{ ppm/°C}$</td>
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<td></td>
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</tr>
</tbody>
</table>
Test Vehicle Specifications (2/2)

**BGA**
- 192 IO’s
- 14mm × 14mm
- CTE$_{xy}$ 7.6 (ppm/°C)
- Solder mask defined

**QFP**
- 44 IO’s
- 10mm × 10mm
- CTE$_{xy}$ 15.1 (ppm/°C)

**QFP**
- 52 IO’s
- 8mm × 8mm
- CTE$_{xy}$ 16.2 (ppm/°C)

**2512 Chip Resistor**
- 25mil × 12mil
- CTE$_{xy}$ 4.3 (ppm/°C)
Temperature Cycling Test
(-55 to 125°C, 15 min dwell)

<table>
<thead>
<tr>
<th>Components</th>
<th>Coating Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Number of Failures</td>
<td></td>
</tr>
<tr>
<td>BGA</td>
<td>8/8</td>
</tr>
<tr>
<td>QFP</td>
<td>0/8</td>
</tr>
<tr>
<td>QFN</td>
<td>8/8</td>
</tr>
<tr>
<td>2512 (50% Nominal Length)</td>
<td>8/8</td>
</tr>
<tr>
<td>2512 (50% Nominal Width)</td>
<td>8/8</td>
</tr>
</tbody>
</table>

- About 6000 cycles were conducted.
- Resistance monitoring is carried out for all components on the board to determine failure. Failure is defined based on the IPC-9701 standard, which defines failure as a **20% increase in initial resistance value for five consecutive scans**.
• Acrylic coated BGAs yield a characteristic life that is very close to the one of noncoated BGAs.
• Characteristic life of parylene coated BGAs are about twice the characteristic life of noncoated BGAs.
• Both coating improved the shape parameter of the BGA failure distribution.
Both coatings improved the characteristic life of QFNs under temperature cycling.

Acrylic coated QFNs have higher characteristic life than parylene coated QFNs.
• 3G and 4G base excitation vibration were exerted on the fixture.
• The resonant frequency of the boards is about 190Hz.
• At the resonant frequency, a transmissibility about 28 was observed.
Both acrylic coating and parylene coating improved the mean cycles to failure of BGAs under 3G vibration. However, acrylic coated BGAs have the lowest first time to failure. Parylene coated BGAs have larger improvements.
At 4G vibration, acrylic coating has little to no impact on the reliability of BGAs under harmonic vibration.

Parylene coated BGAs have higher characteristic life than both noncoated BGAs and acrylic coated BGAs.
Drop tests were performed on a Lansmont M23 drop tower.
Boards were constrained on aluminum plates with 3 inches of unconstrained span.
3000G impact acceleration with 0.35 millisecond pulse width on the fixture.
Shock Impact Testing (3000G at fixture)

- Noncoated BGAs have the highest characteristic life out of all the tested boards under drop test.
- The failure distributions are very close to each other.
The difference in the failure distribution between the BGAs seems insignificant when plotted with 90% confidence interval.
Summary

- Both acrylic and parylene like conformal coatings improved the reliability of all of the types of packages under -55°C to 125°C temperature cycling.
- Conformal coating also improved the reliability of surface mount components under 3G and 4G harmonic vibrational loadings.
- The impact of conformal coating on the surface mount packages seems to be insignificant under drop test.