LIQUID THERMAL INTERFACE MATERIALS

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Efficient Thermal Management

Replace Air with a high efficient thermal conductive Material

- In-efficient Heat Transfer
- Air pockets within the path
- TC from air = in-efficient?
## Filler in polymer

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity (W/m-K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>0.025</td>
</tr>
<tr>
<td>Polymers</td>
<td>0.2</td>
</tr>
<tr>
<td>Aluminum oxide</td>
<td>30</td>
</tr>
<tr>
<td>Alumina hydrate</td>
<td>25</td>
</tr>
<tr>
<td>Aluminum nitride</td>
<td>175</td>
</tr>
<tr>
<td>Aluminum</td>
<td>200</td>
</tr>
<tr>
<td>Boron nitride</td>
<td>30-600</td>
</tr>
<tr>
<td>Silicon dioxide</td>
<td>10</td>
</tr>
<tr>
<td>Silicon carbide</td>
<td>100-200</td>
</tr>
<tr>
<td>Graphite</td>
<td>120-165</td>
</tr>
<tr>
<td>Diamond</td>
<td>2000</td>
</tr>
</tbody>
</table>

![Diagram showing filler in polymer](image_url)
Liquid Dispense Thermal Interface Materials
Benifits of Cure in Place Liquids

• Low Assembly Stress

• Conformability
• Optimized Material Usage
• Logistics Simplification
• Thermal Performance and Cost
Thermal Conductivity
Defined

The time-rate of heat-flow through a unit area, which produces a temperature difference across the unit thickness. An inherent or absolute property of the material.

Typically measured in W/m-K
Thermal Conductivity (W/m-K) vs Thermal Resistance (°C/W)

<table>
<thead>
<tr>
<th></th>
<th>Gap Pad</th>
<th>Liquid TIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>W/m-K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>3.03</td>
<td>2.05</td>
</tr>
<tr>
<td>°C/W</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thermal Conductivity = Material
Thermal Resistance = Application
Thermal Resistance
Mapping TO-220 Testing

The thermal performance of an assembly measure by the ratio of the temperature difference between two surfaces to that of steady state heat flow through them.

Typically units (°C/ Watt) include interfacial Resistances
• **Void Formation**
  Air inclusion in the TIM during application to heat sinks. Lack of flow during assembly due to high viscosity or not enough material applied can limit the coverage of the TIM.

• **Pump Out**
  Occurs during power on and off where there is CTE mismatch.

• **Dry Out**
  Loss of polymer content from the TIM. Leads to increased viscosity and increased contact resistance.

• **Flow Out**
  Loss of TIM from the interface due to gravity or other accelerations.
Reliability

Thermal Performance (°C/W) / Time Aged (Hours)

- GF1500 -50°C to 150°C
- GF1500 150°C
- GF1500 85°/85%

Dielectric Breakdown (V/mil) / Time Aged (Hours)

- SP900S -50°C to 150°C
- SP900S 150°C
- SP900S 85°/85%
Viscosity
Self Leveling to Slump Resistant
Rheology & Measure of Viscosity
Three Distinct Rheology Zones

Low Shear
- At rest in packaging
- On dispensed surface

Intermediate Shear
- Flow in tubes
- Flow in fittings

High Shear
- Flow through nozzle

Viscosity (Pa.s)

Shear Rate (1/s)
Liquid Dispense Alliances
Equipment Manufacturers
Liquid Dispense Thermal Interface Materials

Quality

- Manually placed pads risk failures – human factor
  - Risk enhanced with multiple pads in one module
- Liquid dispense utilizes automated equipment
  - Slump resistant materials = repeatable bead
  - Cameras to quality check the dispense pattern
Liquid Dispense Thermal Interface Materials

Air Entrapment
Value Analysis Chart

- Liquid Option
- Pad Solution
- One Year

Dispensing Capital Investment

Capital Payback

Total Program Savings

- Total Cost of Application vs. # of Applications
- Y-axis: $0 to $3,000,000
- X-axis: 0 to 80,000 Applications

- $1,238,918
- $578,438

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THermal Live 2015

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