Contents

1. Thermal management overview

2. Henkel products and application examples
   - Greases
   - Phase change materials
   - Paste adhesives
   - Film adhesives
   - Heat spreaders/absorbers
Thermal Management Overview

Introduction

• Semiconductor and Electronic assemblies generate heat as the by-product of normal operation

• Management of heat is essential to optimizing performance and reliability; therefore it is considered during design

• Thermal interface materials optimize heat transfer between components
Thermal Management Overview

Removal of unwanted heat

Heat generated from an electronic/electrical component affects:
- System reliability
- Product performance
- Thermal Platform Costs
- Limits design advances
  - size requirements
  - power density
Thermal Management Overview

TIM Functions

- Inefficient heat transfer
  - Air trapped in the thermal conduction path.
  - Thermal conductivity of air is poor

Replace Air with Thermal Interface Material
Thermal Management Overview

TIM Levels

- **TIM1**
  - Power die-attach – conductive paste, solder

- **TIM2**
  - Package to heat-sink – all TIM’s adhesive and non-adhesive

- **TIM3**
  - Board/module to heat-sink – LMP alloys, grease, adhesive paste and film
Thermal Management Overview
TIM Selection

- Every application has multiple options

- Best solution driven by many factors
  - Thermal
  - Electrical
  - Mechanical
  - Process
  - Re-work
  - Reliability
Henkel offers a wide variety of thermal management materials
Thermally Conductive Grease
Product Recommendation

<table>
<thead>
<tr>
<th>Silicone Free</th>
<th>High Performance</th>
<th>High Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCTITE® NSWC100</td>
<td>LOCTITE® TG100</td>
<td>LOCTITE® TC8M</td>
</tr>
</tbody>
</table>

“All Customers Use Thermal Grease”

• The “original” TIM and still widely used
• Requires spring loaded clamp to hold device in place
  • Higher pressure improve performance
• May “pump-out” of the interface in applications that cycle frequently between hot and cold
## TIM2 – thermal grease

### Standard products

<table>
<thead>
<tr>
<th>Description</th>
<th>TC W/mK</th>
<th>Temp. Stability</th>
<th>Volume Resistivity Ω cm</th>
<th>Dielectric Strength V/mil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TG100</strong> Non insulating high thermal conductivity silicone-based</td>
<td>3.4</td>
<td>-40 / +150°C</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>NWSC100</strong> Silicone-free water cleanable</td>
<td>1.4</td>
<td>-40 / +150°C</td>
<td>1.9x10&lt;sup&gt;15&lt;/sup&gt;</td>
<td>250</td>
</tr>
<tr>
<td><strong>TC8-M</strong> Electrically insulating silicone-based hi temp stability</td>
<td>2.3</td>
<td>-40 / +200°C</td>
<td>1x10&lt;sup&gt;13&lt;/sup&gt;</td>
<td>500</td>
</tr>
<tr>
<td><strong>TCP8175-M1</strong> Electrically insulating silicone-based hi temp stability w/175µ spacers</td>
<td>2.3</td>
<td>-40 / +200°C</td>
<td>1x10&lt;sup&gt;13&lt;/sup&gt;</td>
<td>500</td>
</tr>
</tbody>
</table>
**TIM2 Applications – Henkel Products**

**Automotive**

Thermally conductive and electrically insulating compound with 175µ spacers beads

**Product benefits**
- Lower device temperature
- High electrical insulation
- High thermal conductivity, low thermal resistance
- Stable after 2000 TC @ -40+125°
- 175µ spacers for uniform bondline thickness

**Used in**
- Gearbox, Control Units

**Product**
- TCP 8175M1
Phase change materials

- Phase change materials are low temperature thermoplastics that combine the wetting properties of a grease with the convenience of a solid at room temperature
- PCTIM melts to high viscosity liquid at specified temperature
- Requires spring loaded clamp to hold device in place
  - higher pressure improves performance
- Does not “pump-out” of the interface during thermal cycling
- Henkel PCTIMs are available as application specific preforms or standard sheets and as pre-applied systems
Phase change materials

Properties of Loctite phase-change TIMs:

- **100% wetting** at the interface*
- **No interfacial thermal resistance***
  - Phase-change compound to the mating surface
  - Phase-change compound to the aluminum substrate
- Change phase at 45-60°C from solid to liquid
- Compound **expands** in volume*
  - Expansion actively forces out trapped air pockets*
  - Expansion **eliminates** interstitial voids that penalize performance.

*Properties not found in all thermal greases*
Phase change technology 1
Phase change technology 2
Phase change technology 3
Phase change technology 4
## Thermally Conductive Phase Change

Product Recommendation

<table>
<thead>
<tr>
<th>High Performance &amp; Silicone Free</th>
<th>High Temperature (\text{NEW})</th>
<th>Electrical insulation</th>
<th>Foil-based Pads</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCTITE® PSX -D = dispense -P = printable</td>
<td>LOCTITE® 7000 Series</td>
<td>LOCTITE® EIF1000 (Isostrate)</td>
<td>LOCTITE® TCF1000 (Powerstrate)</td>
</tr>
</tbody>
</table>

“Henkel is among best products in this segment”
# TIM2 – phase change film

## Standard products

<table>
<thead>
<tr>
<th>Description</th>
<th>TC  W/mK</th>
<th>Thickness</th>
<th>Th.imp. °C-cm²/W</th>
<th>Phase Change T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EIF1000 (Isostrate)</strong></td>
<td>0.45</td>
<td>50, 63, 75, 100, 150µ</td>
<td>0.78</td>
<td>60</td>
</tr>
<tr>
<td>Electrically insulating w/kapton MT layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thermstrate</strong></td>
<td>1</td>
<td>75, 100µ</td>
<td>0.143</td>
<td>60</td>
</tr>
<tr>
<td>Non insulating w/aluminium layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TCF1000 Powerstrate Xtreme</strong></td>
<td>3.4</td>
<td>200, 400µ</td>
<td>0.022</td>
<td>45</td>
</tr>
<tr>
<td>Non insulating unsupported high thermal conductivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ECF1000 Silverstrate</strong></td>
<td>1.5</td>
<td>80, 100µ</td>
<td>0.022</td>
<td>51</td>
</tr>
<tr>
<td>Electrically conductive compound w/al layer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TCF1000 – “Formerly Powerstrate”
Highest Thermal Performance – non-insulating

- Lowest thermal resistance
- Thermal conductivity is 3.4 W/mK
- No substrate = minimum bondline thickness
- 45°C phase change temperature
- Silicone free
- Available in 8 or 16mils thickness
Product: LOCTITE® EIF
Description: Phase change material on Kapton MT for electrical insulation.
Phase change temp.: 60°C
Thermal Conductivity: 0.45 W/mK
Typical applications: Heat dissipation and electrical isolation for high voltage devices
Key Benefits:
  - High cut-through resistance
  - High dielectric strength
## TIM2 – phase change paste
### Standard & new products

<table>
<thead>
<tr>
<th>Description</th>
<th>TC W/mK</th>
<th>Drying Time 100µ</th>
<th>Th.imp. °C-cm²/W</th>
<th>Phase Change T</th>
<th>Application Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PSX-D</strong> Non insulating fast dry compound</td>
<td>3.4</td>
<td>5’@60° 3’@125°</td>
<td>0.022</td>
<td>45°C</td>
<td>Dispensing</td>
</tr>
<tr>
<td><strong>PSX-Pm</strong> Non insulating medium dry compound</td>
<td>3.4</td>
<td>30’@60° 5’@125°</td>
<td>0.022</td>
<td>45°C</td>
<td>Printing</td>
</tr>
<tr>
<td><strong>PSX-Pe</strong> Non insulating extended dry compound</td>
<td>3.4</td>
<td>4h@60° 10’@125°</td>
<td>0.022</td>
<td>45°C</td>
<td>Printing</td>
</tr>
<tr>
<td><strong>TCP7000</strong> High temp. stable non insulating medium dry compound</td>
<td>3.0</td>
<td>30’@60° 5’@125°</td>
<td></td>
<td>45°C</td>
<td>Printing</td>
</tr>
<tr>
<td><strong>TCP7800-NC</strong> High temp. stable electrically insulating medium dry compound</td>
<td>3.0</td>
<td>30’@60° 5’@125°</td>
<td></td>
<td>45°C</td>
<td>Printing</td>
</tr>
</tbody>
</table>
Non-insulating – PSX-D and P

- Dispensable and printable phase change thermal interface material
- Dries to a solid phase change coating at room temperature and can be accelerated with heat
- Available in fast, medium, extended dry formulation
- Phase change temperature at 45°C
- High Th. Conductivity (3.4W/m°C)
- Low Th. Resistance (small particle size can yield thin bondline)
- Silicone free
- Easy rework
- Excellent long term reliability (no pump-out)
PSX-D and PSX-P

- Offers **flexibility** with thickness
-Offers **flexibility** with application
- Eliminates part number complexity
- Eliminates cost associated with filming, liners, die-cutting, etc.

*printable phase change in honeycomb pattern*
## Dry Times

<table>
<thead>
<tr>
<th>Product</th>
<th>Thickness</th>
<th>Dry Time at 22°C</th>
<th>Dry Time at 60°C</th>
<th>Dry Time at 125°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PSX-D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast Dry Formulation</td>
<td>2 mil</td>
<td>30 minutes</td>
<td>3½ minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>6 mil</td>
<td>2½ hours</td>
<td>8 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>10 mil</td>
<td>5 hours</td>
<td>21 minutes</td>
<td>4 minutes</td>
</tr>
<tr>
<td><strong>PSX-Pm</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Dry Formulation</td>
<td>2 mil</td>
<td>30 hours</td>
<td>22 minutes</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>6 mil</td>
<td>50 hours</td>
<td>50 minutes</td>
<td>4½ minutes</td>
</tr>
<tr>
<td></td>
<td>10 mil</td>
<td>65 hours</td>
<td>65 minutes</td>
<td>8 minutes</td>
</tr>
<tr>
<td><strong>PSX-Pe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extended Dry Formulation</td>
<td>2 mil</td>
<td>Not Recommended</td>
<td>4 hours</td>
<td>7 minutes</td>
</tr>
<tr>
<td></td>
<td>6 mil</td>
<td>&gt; 500 hours</td>
<td>11½ hours</td>
<td>12 minutes</td>
</tr>
<tr>
<td></td>
<td>10 mil</td>
<td></td>
<td>18½ hours</td>
<td>18 minutes</td>
</tr>
</tbody>
</table>
Dispensable/printable phase change

Why a fast, medium and extended dry? Why not just one version?

• Some customers don’t want to dry the material in an oven but want it to dry at room temperature. They should consider the fast or medium dry formulations.

• Other customers don’t want it to dry too fast because that would cause machine downtime (drying on the printer). These customers should consider medium and extended dry formulations.

• So depending on the customers process, application and desired work life, one version may be more suitable than the other.

Once dried, all 3 versions are the same formulation
LOCTITE® 7000 Series Phase Change
High Temperature (150°C) for power electronics.

- LOCTITE® 7000 and 7800NC (NC = Non-conductive version)

<table>
<thead>
<tr>
<th></th>
<th>LOCTITE® 7000</th>
<th>LOCTITE® 7800NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial thermal performance</td>
<td>best</td>
<td>better</td>
</tr>
<tr>
<td>reliability</td>
<td>better</td>
<td>best</td>
</tr>
<tr>
<td>stencil pattern</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Phase Change Temp</td>
<td>45°C</td>
<td>45°C</td>
</tr>
</tbody>
</table>
Application examples

Power IC
(as a pre-applied solution)

Heatsinks
(as a pre-applied solution)

HB LED Applications
TIM2 Applications – Henkel Products
Industrial – Emerging – Automotive

Printable Phase Change thermal interface materials – non insulating

- **Product benefits**
  - High TC – very low TR better than grease
  - Pre-applied
  - Silicone-free
  - Thermally stable @ 125°C and 150°C
  - 100% surface wetting
  - No “pump-out” effect

- **Used in**
  - Power modules, IGBT, electric and Hybrid vehicles, wind turbine inverters

- **Product**
  - PSX-Pm, TCP7000 and TCP7800-NC
Thermally Conductive Adhesives (TCA)

- Thermally conductive materials that cure from a liquid to a solid when exposed to heat, UV, moisture, activator, etc.

Function
- Provide thermal path
- Provide mechanical bond

Features
- Good thermal cycling resistance
- Multiple chemistries
- Multiple cure mechanisms
- Repairable
- Different application process
- Fast fixture/fast cure
- Bondline control
  - Self-shimming

Insert Video: showing air escaping under glass
Insert animation: illustrating HS pressing onto PC on lid, PC flow, but not past bondline, etc.
Paste adhesives

- Thermal Resistance achieved with adhesives as good or better than traditional Thermal Interface Materials
- Smaller, lighter designs achievable through elimination of clamping hardware
- Bonded assemblies are long lived and very reliable
- Electrical properties from highly conductive ground plane quality to highly insulating are available
- Bonding solution for dispense or print applications
- Do not require pressure during cure
- Both electrically insulating and conducting available
## TIM2 – adhesive paste

### Standard products

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>TC W/mK</th>
<th>Viscosity mPa-s</th>
<th>Curing</th>
<th>Spacers</th>
<th>Temp. Stability</th>
<th>Applic. Method</th>
<th>Shelf Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE 3530</td>
<td>1K Epoxy Rigid</td>
<td>2.3</td>
<td>60000</td>
<td>10'@150°C 30'@100°C</td>
<td>No</td>
<td>-40/+150°</td>
<td>Dispensing screen printing</td>
</tr>
<tr>
<td>TCP 3003</td>
<td>1K Epoxy semiflex</td>
<td>1.9</td>
<td>60000</td>
<td>30'@150°C 60'@120°C</td>
<td>No</td>
<td>-40/+150°</td>
<td>Dispensing screen printing</td>
</tr>
<tr>
<td>3875 A&amp;B</td>
<td>Acrylate 2parts</td>
<td>1.75</td>
<td>A: 32000 B: 90000</td>
<td>3-5' @RT</td>
<td>No</td>
<td>175µ</td>
<td>Dispensing</td>
</tr>
<tr>
<td>3876 A&amp;B</td>
<td>Acrylate 2parts</td>
<td>1.75</td>
<td>A: 32000 B: 90000</td>
<td>3-5' @RT</td>
<td>No</td>
<td>175µ</td>
<td>Dispensing</td>
</tr>
<tr>
<td>5404</td>
<td>1K Silicone</td>
<td>1</td>
<td>55000</td>
<td>10' @150°C 15' @130°C</td>
<td>130µ</td>
<td>-40/+200°</td>
<td>Dispensing</td>
</tr>
<tr>
<td>5406M</td>
<td>1K Silicone</td>
<td>1.5</td>
<td>50000</td>
<td>48hrs@ RT</td>
<td>No</td>
<td>-40/+200°</td>
<td>Dispensing</td>
</tr>
</tbody>
</table>
## TIM2 – adhesive paste

**Development products**

<table>
<thead>
<tr>
<th></th>
<th>Chemistry</th>
<th>TC W/mK</th>
<th>Viscosity mPa-s</th>
<th>Curing</th>
<th>Spacers</th>
<th>Temp. Stability</th>
<th>Applic. Method</th>
<th>Shelf Life</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>20323-12A</strong></td>
<td>1K Epoxy Semiflex</td>
<td>2.0</td>
<td>70000</td>
<td>30’@150°C</td>
<td>No</td>
<td>-40/+150°</td>
<td>Dispensing screen printing</td>
<td>6mths @-25°</td>
</tr>
<tr>
<td><strong>XTY 80288-1</strong></td>
<td>1K Epoxy spot cure</td>
<td>2.2</td>
<td>35000</td>
<td>30”@150°C 1’@120°C 5’ @ 70°C</td>
<td>No</td>
<td>-40/+120°</td>
<td>Dispensing</td>
<td>1year @-40</td>
</tr>
</tbody>
</table>
Thermally Conductive Adhesives
Bead-on-Bead

- Bead-on-Bead thermally conductive adhesives are unique products based on proven, proprietary structural adhesive technology.
- They represent a new concept in bonding a wide variety of heat dissipating electrical and electronic devices to heat sinks and heat spreaders.

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3875</td>
<td>1.75 W/m°C two-part thermally conductive adhesive</td>
</tr>
<tr>
<td>3876</td>
<td>1.75 W/m°C two-part thermally conductive adhesive with 7 mil glass spacer beads</td>
</tr>
</tbody>
</table>
Bead-on-Bead

The Process – Basic Concept

- The term “Bead-on-Bead” describes a unique chemistry for a two-part acrylic adhesive
- Rather than premixing parts A&B, each part is applied to the component and the mixing occurs when the two items to be bonded are joined.
- There are two methods for applying this product type:

Option 1

Apply Part A

Apply Part B

Mixing & curing occurs upon assembly

Option 2

Apply Part A

Apply Part B

Mixing & curing occurs upon assembly
# Bead-on-Bead
## Features & Benefits

<table>
<thead>
<tr>
<th>Product attribute</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>High thermal conductivity – 1.75 W/m°C</td>
<td>Improved cooling performance – allows for use of smaller, lighter and more cost effective heat sinks</td>
</tr>
<tr>
<td>No mix, no measure, two-part system</td>
<td>Avoids the need for meter-mix dispense systems, solves problems associated with primer-based adhesives, huge process window for assembly</td>
</tr>
<tr>
<td>High bond strength</td>
<td>High reliability – no field failures due to heat sinks debonding</td>
</tr>
<tr>
<td>Fast fixture</td>
<td>High production throughput</td>
</tr>
<tr>
<td>Unique Color Coding</td>
<td>Parts A &amp; B have different colors to avoid confusion and merge into a new color to indicate product has mixed</td>
</tr>
<tr>
<td>Lower viscosity</td>
<td>Easy dispensing</td>
</tr>
<tr>
<td>Excellent environmental resistance</td>
<td>High reliability in even the most demanding applications</td>
</tr>
<tr>
<td>Glass spacer beads</td>
<td>Available 7 mil glass beads provide controlled gap and electrically isolate components from heat-sink</td>
</tr>
</tbody>
</table>
Operating Parameters

Dispensing – Needle Dispense

Dispense Part A

Dispense Part B on top

“X” pattern provides most uniform coverage. One large dot in the center is also acceptable.
Operating Parameters
Dispensing – Stencil Printing

Needle dispense Part A onto component, stencil print Part B onto heat sink.
Operating Parameters
Curing – Fixture Time

• Fixture Time 3-5 mins
  • Fixture time is defined as the amount of cure time required for a 320mm² Bondline to support a 3kg weight
  • Fast fixturing allows parts to quickly gain enough strength to avoid displacement during subsequent processing.
  • This product has high tack (or green strength) and average heat sinks will not shift position even before fixture strength is achieved.
TIM2 Applications – Henkel Products

LED lighting

Thermally conductive silicone flexible adhesive for LED modules onto heat sink attachments

**Product benefits**
- One component
- Easy and fast dispensing
- Suitable for large bonding areas
- Compensate CTE mismatch
- RTV
- Stable after ThC @-50+200°C
- High TC – low TR

**Used in**
- Street lights, indoor lights and bulbs

**Product**
- 5406TA
TIM2 Applications – Henkel Products
Automotive – LED

Bead-on-Bead Thermally conductive adhesive

**Product benefits**
- Very fast fixing time
- Good adhesion
- 2 parts – no need to maintain exact mixing ratio
- Room temperature cure
- Can be either dispensed or screen printed
- High TC – Low TR

**Used in**
- Automotive LED head lamps

**Product**
- 3875 A&B
Film adhesives

• Epoxy film adhesives are blends of solid resins, catalysts, fillers in a dry sheet format
• They are made by coating a liquid suspension of the mix onto a support carrier (fiberglass fabric, polyester, polyimide) or a release liner (for making an unsupported film) and then evaporating the solvent
• Film adhesives are typically not b-staged resins because no polymerization has occurred prior to shipment
  • many are quite stable with 3 month work life at room temperature
Film adhesives offer design and manufacturing solutions

- Customized preforms made of film adhesive enable:
  - precise amount of adhesive exactly where needed
  - void-free bonds
  - controlled bondline thickness
  - pick and place assembly
  - no wasted adhesive
- TIM products have thermal conductivity up to 7 W/mK and thermal resistance down to 0.15 K-cm²/W
Film types by filler

- Electrically conductive
  - filled with metal powder (silver or gold)
  - allows for electrical and thermal conductivity
- Electrically insulating
  - thermally enhanced - filled with ceramic powder to enhance heat transfer
  - thermally insulating – unfilled. provides electrical isolation, and resists heat transfer, used for simple bonding of parts
Film – the process

align parts

cure with heat and pressure

epoxy flows along surfaces ("wets") and cures

microscopic surface features
Where are they used?

- Bonding large areas
  - best way to put an even distribution of adhesive over a large area
  - desired thickness easier to achieve than with screen printing
  - no solvent and uniform coverage means no voids
- Placing adhesive in complex patterns
  - better edge and flow control than with screen printed adhesives
- When high electrical or thermal conductivity is needed
  - higher fill densities can be achieved with films than pastes
- When “pick and place” is preferred
  - automated or manual assembly lines
  - no wasted adhesive
Void free bond line before and after reflow

- Scanning Acoustic Microscopy Images indicate that using film adhesives for PCB to heat sink assembly eliminates the risk for air inclusion.
- After reflow (260°C peak), the film bondline remains intact, void free.

Solder Paste After Reflow

Film Before Reflow

Film After Reflow

---

Temperature, °C

Sec

CONTROL Final final 2
### TIM2 – adhesive film

#### Standard products

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>TC W/mK</th>
<th>Thickness</th>
<th>Curing</th>
<th>Carrier</th>
<th>Temp. Stability</th>
<th>Shelf Life</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>550K – Electrically Insulating</strong></td>
<td>Epoxy</td>
<td>0.8</td>
<td>50-100µ</td>
<td>Glass fiber</td>
<td>-40/+150°C</td>
<td>1yr @ -40°C</td>
</tr>
<tr>
<td><strong>561K – Electrically Insulating</strong></td>
<td>Epoxy</td>
<td>0.9</td>
<td>100-125-200-250-305µ</td>
<td>Glass fiber</td>
<td>-40/+150°C</td>
<td>1yr @ -40°C</td>
</tr>
<tr>
<td><strong>563K – Electrically Insulating</strong></td>
<td>Epoxy</td>
<td>1.1</td>
<td>50-75µ</td>
<td>None</td>
<td>-40/+150°C</td>
<td>1yr @ -40°C</td>
</tr>
<tr>
<td><strong>566K – Electrically Insulating</strong></td>
<td>Epoxy</td>
<td>0.8</td>
<td>100-125-200-250µ</td>
<td>Glass fiber</td>
<td>-40/+150°C</td>
<td>1yr @ -40°C</td>
</tr>
<tr>
<td><strong>CF3350 – Electrically Conductive</strong></td>
<td>Epoxy</td>
<td>7.0</td>
<td>50-100µ</td>
<td>None</td>
<td>-40/+160°C</td>
<td>9mths@+5°C</td>
</tr>
</tbody>
</table>
Film adhesive applications

- RF amplifiers and transceivers
  - wireless telecom base stations
    - boards to aluminum backplanes
    - heat sink coins to boards
    - size range from 25mm² to 250mm²
  - automotive radar
    - ceramic circuits to aluminum backplanes
    - typically 25mm² or less
- military radar (phased array)
  - ceramic and organic circuits to metal backplanes
  - typically 100mm² or less
Film Adhesive Applications

Ceramic Power Module To Metal Package

- Gold Leads and Groundplane
- Ceramic Board
- Chip
- Wirebond
- Die Attach
- Conductive Epoxy Film
- Housing
Market Need

- As device functionality increases and designs become more compact, devices become hotter.
- Design Engineers aim to keep HH devices under 45°C for consumer health and safety.
- Excess heat can also shorten component and battery life.

The new iPad gets up to 13 degrees hotter than the iPad 2 when playing a game.
Project Objective

- Enable Design Engineers to increase handheld device functionality while controlling skin temperatures with innovative material solutions
- Balanced Junction and Skin temperature

Project Deliverable

- Develop a material that can be applied in simple or complex pattern and reduce handheld device skin temperatures
  - Drop in skin temperature of >3°C
  - Film manual application
  - Maximum thickness of 0.2mm
  - Halogen free, RoHS compliant

Thermal Image of outside surface of tablet
LOCTITE TAF series - Thermal Absorber

- Advanced phase change composition coated between foil substrates
- First thermal absorbing & spreading hybrid material introduced to the market
- Combination of energy storage, heat spreading, thermal insulation, thermal conductivity
- Patent Pending
Thermal Absorber
LOCTITE TAF Construction example

• PET layer - Offers electrical isolation from Cu
• Cu layers - Offers heat spreading & EMI Shielding
• Absorber Coating - Offers thermal absorbing and insulation
• Conductive PSA - Fixed attachment and EMI shielding

Fully customizable X, Y & Z dimensions  ≥80µm Solutions
LOCTITE TAF
Performance on Galaxy Note 10.1

Reducing Handheld Device Temperatures

- Fast transient temperature rise for all materials
- 215 um TAF exhibits improved transient and steady state temperatures
- Older Gen1 TAF performs more like existing thermal solution

1. Run “Benchmark Stability Test” to generate heat
2. Measure skin temperature with FLIR SC655 Infrared Camera
3. Continuous recording for >2hrs to reach equilibrium
LOCTITE TAF
Current Technology Status

Benefits Over Competition

• Equivalent to higher performance over competitive materials by 1-3°C on skin and junction when ≥80µm
• Customizable dimensions & flexible absorption and insulation solution that can be oriented over/under components
• Lower price than graphite & composite alternatives
• Global Reach with world class supply chain and Technical Support capabilities

Industry Proven Technology

Google Nexus 7
Barnes & Noble Nook HD
HP Pavilion X2
ASUS MeMO Pad 8
Others: Dell Venue 11, Obelix Wacom
To enable Design Engineers to increase handheld device functionality by controlling skin and component temperatures with innovative material solutions.
Conclusion

- Henkel offers a **full range** of thermal interface materials
- Solutions for both non-bonding and bonding applications
- We can help you get the **heat** out
Thank you!

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