Power Supplies
Advanced Materials for Higher Performance

Tech Taipei 2017
Sep 21, 2017
Agenda

1. **Henkel Company Introduction**
2. Power Technology Trend
3. Application & Solution Overview
   - Transistors to Heatsink
   - Coil to Heatsink / Case
   - PCB to Heatsink / Case
   - High Power Module
4. Product Roadmap & Key Products List
5. Conclusion
Who we are
140 Years of History

- Founded 1876, Headquarters: Düsseldorf, Germany
- Employees from **125 nations**
- **170 manufacturing** and **21 major R&D sites** around the world
Adhesive Technologies
Over 90 years of adhesive innovation
Serving Our Customers Worldwide
Global End-to-End Business

Electronics Headquarters:
Irvine, CA USA

Estimated Adhesive Electronics Employees: 3,086
- R&D, Technical Service, Sales
- R&D, Technical Service, Sales, Manufacturing
- Technical Service, Sales, Manufacturing
- Manufacturing

Globally aligned infrastructure to serve our customers locally
Adhesive Electronics Steering Units

Semiconduct or Packaging
- Wirebond Packaging
- Flip Chip Packaging
- 3D & TSV Packaging
- Wafer Level Packaging
- MEMS Devices
- Sensors
- Camera Modules
- Passive Devices
- LED Device Packaging

Display Assembly
- OLED Assembly
- LCD Assembly
- Touch Modules
- Display Cleaners

Consumer Electronics
- Mobile, Tablets, Accessories & Peripherals
- Computing
- Storage (HDD)
- Digital Printing
- Connectivity
- Entertainment

Automotive Electronics
- Automotive Lighting
- ADAS & Safety
- Chassis & Interior
- Powertrain
- New Energy Vehicle (NEV)

Industrial & Infrastructure
- Power & Automation
- Telecom/Datacom
- Defense/Aero
- Medical
- Batteries
- Safety & Security
- Appliances
- Solar
- Printed Electronics
Adhesive Electronics: Technologies

Semiconductor Materials
- Die Attach Materials
- Optical Clear Adhesives (LOCA, OCA)
- Wafer Processing Materials
- Display Sealant
- Conductive Display Inks/Pastes
- Adhesives for Display Module Assembly

Display Materials
- 1st Level Underfills
- Circuit Board Protections
- Low Pressure Molding
- Adhesives for Printer Heads

Encapsulation
- 2nd Level Underfills
- Metal Sintering Adhesives
- Potting Materials
- General Adhesives

Component Assembly
- Electrically Conductive Assembly Adhesives
- Chipbonder
- Assembly Films

Printed Electronics
- Conductive Printable Inks
- Dielectric Coating

Soldering
- Solder Paste
- Liquid Flux
- Solder Wire

Thermal Management
- Thermal Interface Materials
- Thermally Conductive Adhesives
- Insulated Metal Substrate (IMS)

Device Assembly
- Structural adhesives
- Debondable Adhesives
- Surface Treatment
- Instant Bonding Adhesives
- Elastic Bonding Adhesives
- 3D Printing

Equipment
- Motion Control
- Volumetric Dispensing
- Valves
- Controllers

Adhesives for Speciality Module Packages (Fingerprint, Communication Camera, Opto)
Solutions Across the Board

- Potting Materials
- Thermal Management Materials
- Encapsulants
- Electrically Conductive Adhesives
- Printed Inks and Coatings
- TECHNOMELT Low Pressure Molding Materials
- Underfills
- Solder Materials
- Surface Mount Adhesives (Chipbonders)
- Conformal Coatings
Agenda

1. Henkel Company Introduction
2. **Power Technology Trend**
3. Application & Solution Overview
   - Transistors to Heatsink
   - Coil to Heatsink / Case
   - PCB to Heatsink / Case
   - High Power Module
4. Product Roadmap & Key Products List
5. Conclusion
Global Power Supply Trends
4 Market Drivers

**Power Densities**
- Increasing Watts/In3
- Driving Higher Reliability Requirements
- Si → SiC/GaN

**Cost**
- Low Cost Chinese Entrants
- Process Improvement

**Automation**
- Manual to Semi or Fully Automatic
- Reduced Manufacturing Footprint

**Legislation**
- Improved Efficiencies
- Sustainable
- Environmental
Power Conversion Performance Trends

1. Power Density [kW/dm³]
2. Power per Unit Weight [kW/kg]
3. Relative Costs [kW/$]
4. Relative Losses [%]
5. Failure Rate [h⁻¹]
6. Time to Market [mo]
Impact of Trends & Drivers on Materials Selection

1. Power Density
   - Better thermal performance materials
   - Move to WBG semiconductors – higher temperature materials with better thermal cycling reliability

2. Cost
   - Lower processing cost, reduction of fixturing / hardware, reduction in SKU’s, lower BOM cost, better yields

3. Efficiency
   - Better thermal performance

4. Reliability
   - Softer materials, Moisture resistance, ionic cleanliness, environmental stability

5. Time to Market
   - EMI Absorption, thermal materials, design partnerships
1. Henkel Company Introduction
2. Power Technology Trend
3. Application & Solution Overview
   - Transistors to Heatsink
   - Coil to Heatsink / Case
   - PCB to Heatsink / Case
   - High Power Module
4. Product Roadmap & Key Products List
5. Conclusion
Transistors to Heatsink
Conventional solution

Application:
• Thermal interface material between Transistors (TO-220, 247,3P, etc.) and Heatsink for heat dissipation

Traditional Thermal Solutions:
• Mica and Grease
• Thin Gap pad (eg. Henkel Sil-Pad)
• Electrical Insulative PCM (eg. Henkel PCM Film)

Mounting Method:
• Screw, Clip, Spring, bar, etc.
Transistors to Heatsink
Henkel Solution for Lowest Total Cost

• The Power Supply industry is advancing innovation through investment in *lean manufacturing* and *total cost solutions*....

• Henkel’s Innovative Thermal Interface Materials (TIMs):
  + *Eliminate* Mechanical Fasteners
  + *Save* Space (2D & 3D)
  + *Ensure* Highest Dielectric Strength
  + *Ensure* Highest Thermal Performance
  + *Improve* L/T Reliability & Durability
  + *Increase* Production Through-put / Yields

= Lowest Total Solution Cost
Coil to Heatsink / Case

Application:
- Coil needs TIM for transferring heat to heatsink or case, or need Potting material for protection

Design Feature:
- Working temperature normally at 0~150°C.
- High thermal conductivity is required.
- High mechanical strength is essential.
- Not complicated processing procedure is preferred.
- Soft, so low stress in large potting applications

Recommended Solutions
- Curable liquid Gap Filler (Two-part), high thermal potting material for automatic processing
PCB to Heatsink / Case

**Application:**
- Require TIM to be added between PCB and heatsink or case for heat dissipation

**Traditional Solutions:**
- Gap pad (Thermal Pad)

**Recommended TIM:**
- Curable liquid Gap Filler (Two-part)

**Benefits:**
- Highly automatable and repeatable
- Conformability
- Optimized material usage
- Low assembly stress
Liquid Gap Filler Dispense

**Key Performance:**
- Minimal stress during assembly
- Excellent wet-out ability
- Single solution for Multiple applications
- Multiple rheology and cure schedule
Dispenser for Gap Filler

Volume measuring type digital control dispenser (2Head type)

Automate of weighing, mixing and dispensing specific amounts. High precision dispensing has been achieved!!

GAP FILLER 1500 dispense data (N=20)

<table>
<thead>
<tr>
<th></th>
<th>吐出量</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVE [mg]</td>
<td>3191.2</td>
</tr>
<tr>
<td>MAX [mg]</td>
<td>3204.9</td>
</tr>
<tr>
<td>MIN [mg]</td>
<td>3169.8</td>
</tr>
<tr>
<td>3σ</td>
<td>38.0</td>
</tr>
<tr>
<td>精度［±%］</td>
<td>0.6</td>
</tr>
</tbody>
</table>
High Power Module Application

1. High temp resistance and reliability > High Tg potting material
2. Low thermal resistance > Insulative Metal substrate (T-Clad)
3. High die attach bonding strength > Silver sintering material
4. High performance and reliability > Pre-applied PCM

Next Generation Materials Developed for high power application
1. High Tg Potting

Develop high temperature resistance potting products for *Power Electronic Applications.

*Power Electronics: >175°C operating Temperature.

Application temperature

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>~ 150 degC</td>
</tr>
<tr>
<td>Si-IGBT and SiC, GaN</td>
<td>175 degC ~</td>
</tr>
</tbody>
</table>

→ Heat generation from inside of packages.

Operation temp. < Encapsulant’s Tg
2. Insulative Metal Substrate

Single Layer constructions

- Circuit Copper $\rightarrow$ 17$\mu$m – 350$\mu$m
- Dielectrics: HRT, MP, HT, HPL $\rightarrow$ 38$\mu$m - 225$\mu$m thick
  - Thermal performance based on $\rightarrow$ 0.8 – 3 W/m-K
- Aluminum or copper base metals $\rightarrow$ 0.5 – 5 mm thick

Cross section view not to scale
3. Ag Sintering Die Attach

Copper base plate and DBC substrate with Ni/Au metallization
4. Pre-Applied Phase Change Material

- High Power Module technology trend is higher power and downsizing

- Developed PCM which is 150°C durable & high thermal conductivity (>3 W/mK)

- Stencil printing with Pre-Applied PCM

TIM has great impact to increase High Power Module module temp
Agenda

1. Henkel Company Introduction
2. Power Technology Trend
3. Application & Solution Overview
   - Transistors to Heatsink
   - Coil to Heatsink / Case
   - PCB to Heatsink / Case
   - High Power Module
4. Product Roadmap & Key Products List
5. Conclusion
# Adhesives (Pad form)
## Pressure Sensitive Adhesives & Laminates

### Tapes

<table>
<thead>
<tr>
<th>Pressure Sensitive Adhesive</th>
<th>BP100</th>
<th>BP400</th>
<th>BP660P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass reinforced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Un-reinforced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polymide film reinforced</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Laminates

<table>
<thead>
<tr>
<th>Heat-Cure</th>
<th>BP LMS-HD</th>
<th>BP LMS500P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass reinforced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polymide film reinforced</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SEALANTS (NEW)

<table>
<thead>
<tr>
<th>TLB 400 SLT</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thermal Performance (W/m-K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

**Note:** BP LMS-HD is marked with an asterisk (*) to indicate its unique characteristics.
## Liquid TIMs
### Market Leading Solutions

<table>
<thead>
<tr>
<th></th>
<th>Thermal Performance (W/m-K)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2K Cure-In-Place</strong></td>
<td></td>
</tr>
<tr>
<td>GAP FILLER 2K</td>
<td>GF1000/1000SR, 1500, 2000</td>
</tr>
<tr>
<td></td>
<td>GF3500S35</td>
</tr>
<tr>
<td></td>
<td>GF4000</td>
</tr>
<tr>
<td>LOW VOLATILE 2K</td>
<td>GF1500LV</td>
</tr>
<tr>
<td></td>
<td>GF3500LV</td>
</tr>
<tr>
<td>POTTING 2K</td>
<td>GF1400SL</td>
</tr>
<tr>
<td>LOW MODULUS 2K</td>
<td></td>
</tr>
<tr>
<td>SILICONE FREE 2K</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GF1100SF</td>
</tr>
</tbody>
</table>

| **1K Pre-Cured Gel** |                     |
| LIQUI-FORM          | LF2000               |
|                     | LF3500               |
Gap Pad® TIMs  
Expanding Pad-Form Innovation

<table>
<thead>
<tr>
<th>Thermal Performance (W/m-K)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULTRA LOW MOD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Putty-like GP3500 ULM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest Modulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP HC 3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP HC 5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP7000 ULM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silicone-Free</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLYURETHANE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP2202SF GP3004SF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP1000SF GP200SF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIGH DURABILITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP1000HD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VALUE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPV0-S/US, 1500S, 2000S40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPV0-US-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPV0, 1450, 1500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silicone-Free</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLYURETHANE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP2202SF GP3004SF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP1000SF GP200SF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIGH DURABILITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP1000HD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* EMI Absorbing  
  GP EMI 1.0   EXP 1a
# Key Product List

<table>
<thead>
<tr>
<th>Power Segment Driver</th>
<th>Implication</th>
<th>Henkel Response</th>
<th>Description</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Cost</td>
<td>Reduce TCO</td>
<td>Bond-Ply LMS HD</td>
<td>1.4 W/mK, Reinforced insulation, structural adhesive film</td>
<td>TIM</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>Reduce thermal resistance</td>
<td>Gap Filler 1400SL</td>
<td>1.4W/mK, self leveling, very soft</td>
<td>TIM</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>Reduce thermal resistance</td>
<td>Gap Filler 3500S35</td>
<td>3.6W/mK, easy to dispense, ultra conforming</td>
<td>TIM</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>High temp resistance</td>
<td>Potting</td>
<td>High Tg &gt;200C, Low modulus, High insulation at high temp</td>
<td>CBP</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>Reduce thermal resistance</td>
<td>T-Clad HPL</td>
<td>Low thermal impedance, reliable electrical insulative protection</td>
<td>IMS</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>Improve reliability</td>
<td>Silver Sintering</td>
<td>High die attach bonding strength for High Power Module</td>
<td>Die Attach</td>
</tr>
<tr>
<td>Increased Power Density</td>
<td>Reduce thermal resistance</td>
<td>TCP 7000 series</td>
<td>3.4W/mK, printable phase change interface material, high performance</td>
<td>TIM</td>
</tr>
<tr>
<td>Systems Integration</td>
<td>Reduction in design cycle</td>
<td>Gap Pad EMI 1.0</td>
<td>EMI absorbing, thermally conductive gap pad (1 W/mK)</td>
<td>TIM</td>
</tr>
</tbody>
</table>
Conclusions
Henkel Solutions

• Offers a wide range of innovative and high performance materials to solve your most challenging thermal needs.

• New materials have been developed that save space, assembly costs and energy, yet provide great thermal and adhesion performance.

• Henkel maintains its industry leadership position by partnering with industry leaders to develop the next generation of thermal products.

• Please feel free to contact us with your challenging thermal needs!
Thank you!