Silicone Solutions for Battery Pack Assembly

July, 2018
Agenda

• Dow Performance Silicones Portfolio
  — Silicones in Standard Vehicles
  — Battery Assembly

• Why Silicone?

• Advancing Your Battery Assembly

• Thermal Management

• Thermal Isolation

• EMI Shielding

• Conformal Coatings
Performance Silicones Portfolio

- Body
- Chassis and Brake
- Cooling and Climate Control
- Weather Sealing and Insulation
- Electrical
- Interior
- Powertrain
- Safety
- Lighting
Silicones are already used for many automotive applications.
Why Silicone for Battery Applications?

Thermal Stability
• High temperature resistance
• Wide temperature range retention of elastomeric properties

Tunable: Modulus/Hardness/Cure chemistries
• Hardness range from hard to soft depending on application
• Flexible/compliant, retains flexibility at high filler (thermal, electrical) content with high elongation at break
• Fast RT cure for large component fixing and increased productivity

Thermal management performance
• Wide thermal conductivity range available
• Silicone provides low thermal resistivity

Thermal event isolation
• Slow the spread of thermal events in lithium ion battery

Light weighting
• Silicone foams meet UL requirements with low weight
Silicones in Battery Pack Assembly

**Cylindrical**
- Silicone foam, gel, encapsulant or gap filler for thermal management
- Silicone sealants to contain pressure releases

**Prismatic and Pouch Modules**
- Compressible silicone for thermal management
- Encapsulant or conformal coating for protection
- Thermally conductive silicone
- Lithium-ion prismatic cell
- Electronic control unit
- Cold plate
- Silicone adhesives to assemble components

**Packs**
- Silicone adhesives to adhere components
- Silicone foam, gel, encapsulant, or gap filler for thermal management
- Silicone sealants help prevent thermal runaway propagation and leakage of coolant systems
- EMI Shielding materials

**Common requirements met by silicones:**
- Thermal management
- Adhesion
- Protection
- EMI shielding
Battery Assembly

Assembly and integration of EV/HEV batteries and modules require mechanical fixing, thermal management and vibration damping. **We provide DOWSIL™ solutions for all of these applications.**

**Silicone-based materials** enable customers to cost-effectively manage the challenges in their next-generation EV/HEV battery designs.

**Silicone Solutions from Dow**

- Encapsulant or Conformal Coating
- Thermally Conductive Gap Filler and Printable Pads
- Thermally Conductive Encapsulant
- Thermally Conductive Adhesive
- Structural Sealing and Bonding
- Foam Gasket Material
Advancing Your Battery Assembly

- **Heat Cure**
  - Reactive Hot Melt – A New and Innovative Technology
  - Condensation Cure, 1-part
  - Low-temperature Cure Technology Provides Reliable Adhesion at 80°C

- **RT Cure**
  - Addition Cure, 1-part
  - Thermal Radical Cure™ Technology Expands Design Options
  - Condensation Cure, 2-part
  - RTV Cure Technology - Innovation Continues

- **2017 Launch:** DOWSIL™ EA-6060 Adhesive

- **EMI Shielding Functional Option**
# Portfolio of Advanced Thermally Conductive Materials: Focus on Gap Fillers

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Launched in 2017</th>
<th>DOWSIL™ TC-4515</th>
<th>Gap Filler</th>
<th>Launched in 2018</th>
<th>DOWSIL™ TC-4535 CV</th>
<th>Thermally Conductive Gap Filler</th>
<th>New DEVELOPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap Fillers (thick BLT applications)</td>
<td>DOWSIL™ SE 4490 CV</td>
<td>Thermally Conductive Compound</td>
<td>DOWSIL™ SC 102 Compound</td>
<td>DOWSIL™ SC 4471 CV</td>
<td>Thermally Conductive Compound</td>
<td>DOWSIL™ TC 5351</td>
<td>Thermally Conductive Compound</td>
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<tr>
<td>Greases (thin BLT applications)</td>
<td>DOWSIL™ Q1-9226</td>
<td>Thermally Conductive Adhesive</td>
<td>DOWSIL™ SE 4486</td>
<td>Thermally Conductive Adhesive</td>
<td>DOWSIL™ TC 2035</td>
<td>Thermally Conductive Adhesive</td>
<td>DOWSIL™ TC-XXXX</td>
</tr>
<tr>
<td>Adhesives (structural adhesion)</td>
<td>DOWSIL™ 1-4173</td>
<td>Thermally Conductive Adhesive</td>
<td>DOWSIL™ TC-2035</td>
<td>Thermally Conductive Adhesive</td>
<td>DOWSIL™ TC-XXXX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispensable Pads</td>
<td>DOWSIL™ TC-4015</td>
<td>Dispensable Thermal Pad</td>
<td>DOWSIL™ TC-4025</td>
<td>Dispensable Thermal Pad</td>
<td>DOWSIL™ TC-XXXX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heat Transfer Performance (W/mK):**

1. 2. 3. 4. 5.
Introducing: Thermal runaway propagation prevention

- Silicones can slow the spread of thermal events in lithium ion battery applications

- Filled or unfilled silicones available:
  - Gap fillers
  - Foams
  - Encapsulants
  - Gels

- Application requirements determine material selection
Silicone foams can be a light weight alternative to traditional encapsulant and sealant options. Foam encapsulant can provide cell protection in the case of a thermal event.
Silicone Foam flammability testing

UL94 standard => 50W flame-power ->
After 44 s +-2 s set to 700°C
Dwell for 10 min
## Dow Silicone Foam Products – Commercially Available

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>DOWSIL™ 3-6548</th>
<th>DOWSIL™ 3-8209</th>
<th>DOWSIL™ 3-8259</th>
<th>SILASTIC™ 3-8186</th>
</tr>
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<tbody>
<tr>
<td>Typical application</td>
<td>NA</td>
<td>Potting/ sealing</td>
<td>Potting/ Gasket</td>
<td>Gasket</td>
<td>Gasket</td>
</tr>
<tr>
<td>Color</td>
<td>CTM0176</td>
<td>Dark Grey</td>
<td>Grey</td>
<td>Grey</td>
<td>Black</td>
</tr>
<tr>
<td>Mix ratio</td>
<td>NA</td>
<td>1:1</td>
<td>1:1</td>
<td>1:1</td>
<td>1:1</td>
</tr>
<tr>
<td>Viscosity (Pas)</td>
<td>CTM 0050</td>
<td>A: 4-6; B: 5-7.5</td>
<td>A: 21; B: 12</td>
<td>A: 35-75; B: 20-70</td>
<td>A: 135; B: 125</td>
</tr>
<tr>
<td>Flowability</td>
<td>CTM 0062</td>
<td>Flowable</td>
<td>Flowable</td>
<td>15 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Density*</td>
<td>CTM 0097</td>
<td>0.2-0.4</td>
<td>0.2-0.29</td>
<td>0.24-0.38</td>
<td>0.22-0.26</td>
</tr>
<tr>
<td>Snap time (mins)*</td>
<td>CTM 092A</td>
<td>0.5-1.5</td>
<td>1-4</td>
<td>1-3.5</td>
<td>3.5-15</td>
</tr>
<tr>
<td>TFT (mins)</td>
<td>CTM 0095</td>
<td>NA</td>
<td>8 (RT)</td>
<td>6-7 (RT)</td>
<td>Heat Cure</td>
</tr>
<tr>
<td>Hardness (00)</td>
<td>CTM 0099</td>
<td>NA</td>
<td>46</td>
<td>50</td>
<td>NA</td>
</tr>
<tr>
<td>Compression Deflection (kpa)</td>
<td>CTM0525</td>
<td>35.8 (20%); 69.6 (40%); 146(60%)</td>
<td>74 (50%)</td>
<td>150 (50%)</td>
<td>32.4 (25%) 85.5 (50%) 335 (75%)</td>
</tr>
<tr>
<td>Compression set (%)</td>
<td>CTM0085</td>
<td>NA</td>
<td>4 (postcured)</td>
<td>5 (postcured)</td>
<td>3</td>
</tr>
<tr>
<td>Cell structure,open Cell (%)</td>
<td>CTM0826</td>
<td>10-20</td>
<td>30-50</td>
<td>~20</td>
<td>~10</td>
</tr>
<tr>
<td>Height/Base Ratio</td>
<td>NA</td>
<td>0.25</td>
<td>0.28</td>
<td>0.45</td>
<td>0.5</td>
</tr>
<tr>
<td>UL94 (DC internal test*)</td>
<td>UL 94</td>
<td>V0(8-9 mm)</td>
<td>V0(8-9 mm)</td>
<td>V0(4-5 mm)</td>
<td>V0(8-9 mm)</td>
</tr>
</tbody>
</table>
Introducing: EMI Shielding

Increasing density of electronic components in many market segments

Shielding prevents cross-talk of electronic circuits, detectors, RF signals

Silicones provide flexibility over a wide range of temperature and environmental conditions
Electrically Conductive Silicones

• Formulation
  • Polymer – Able to tune rheology, mechanical performance, adhesion, stability
  • Filler – Electrical performance, rheology, cost, stability
  • Additives – Cure dynamics, stability, shelf life

• Characterization
  • Mechanical
  • Electrical
  • Chemical

• Application Testing
  • Dispensing
  • Accelerated stress testing
  • Electro-mechanical characterization
Conformal Coatings

Key Benefits

• Improves **reliability** in humid environments
• Protects PCBs and other electronic components against **environmental particles, moisture and contaminants**, preventing **short circuits and corrosion** of conductors and solder joints
• Protects circuits and components from **abrasion and solvents**
• **Stress relieving**
• Protects **insulation resistance**
• Reduces **conductor spacing** on PCBs
• Good **dielectric properties** (insulation, moisture resistance, breakdown voltage)
## Conformal Coatings Solutions

<table>
<thead>
<tr>
<th>Key Properties</th>
<th>Units</th>
<th>DowSil ™ CC 3122 Conformal Coating</th>
<th>DowSil ™ 1-2577 Low VOC RTV Coating</th>
<th>DowSil ™ 3-1965 Conformal Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td>Elastoplastic</td>
<td>Elastoplastic</td>
<td>Elastomeric</td>
</tr>
<tr>
<td>One- or Two-part</td>
<td></td>
<td>One</td>
<td>One</td>
<td>One</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>Translucent</td>
<td>Transparent</td>
<td>Translucent</td>
</tr>
<tr>
<td>Viscosity</td>
<td>cP</td>
<td>80</td>
<td>1,050</td>
<td>115</td>
</tr>
<tr>
<td>Specific Gravity(Cured)</td>
<td></td>
<td>1.03</td>
<td>1.12</td>
<td>0.99</td>
</tr>
<tr>
<td>Tack-free Time at 25ºC</td>
<td>minutes</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Durometer, Shore A</td>
<td></td>
<td>75</td>
<td>85</td>
<td>33</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>kV/mm</td>
<td>32</td>
<td>13</td>
<td>17</td>
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<tr>
<td>Volume Resistivity</td>
<td>ohm·cm</td>
<td>2.3E+16</td>
<td>1.90E+14</td>
<td>8.7E+15</td>
</tr>
<tr>
<td>UL Flammability Classification</td>
<td></td>
<td>TBD</td>
<td>UL94 V-0</td>
<td>UL94 V-0</td>
</tr>
</tbody>
</table>

New
Customer Satisfaction Starts with Design

DOWSIL™ Solutions can help with:

**Process Optimization**
- Energy-saving (Lower temperature of cure, shorter time)
- Minimize substrates preparation
- Reduce equipment maintenance

**Product Handling Optimization**
- Storage
- Shelf life
- Dispensing
- Assembly
- Cure

**Improving Product Robustness**
- Void-free
- Vertical holding
- Cure
- Adhesion
Thank You