



## ELECTRIC VEHICLE (EV) BATTERY MANUFACTURING MATERIALS: PRODUCTION AND RECYCLING FRIENDLY THERMAL INTERFACES

- COMPRESSIBLE, FIRE-RETARDANT AND HYDROPHOBIC THERMAL INTERFACE PAD
- HIGH FLOW DISPENSABLE FIRE-RETARDANT THERMAL INTERFACE POTTING GEL
- THERMAL-MECHANICAL INTERFACE ENGINEERED FOR MANUFACTURABILITY AND END-OF-LIFE RECYCLING



### Unique Challenges for Electric Vehicle (EV) Battery Packing and Assembly Adhesives & Thermal Interface Materials

The challenges for EV battery production and reliability include at least the following:

1. Ease in dispensing- placement for high productivity. The process depends on the design in both the cell from cylindrical to flat prismatic or pouch in forming module and module placement onto structural cooling system.
2. Reliability and safety improve with the ability to provide thermal interface to prevent any hot spots.
3. Potting, greases and thermal interfaces must be intrinsically insulating with **UL 94V-0 fire-retardancy**.
4. For long-term viability, the battery packs must not prevent them from **efficiently recycled**.

With over 30 years of experience in inventing and formulating specialty adhesives for electronic applications, AIT provides the most comprehensive line of thermal interface solutions that are engineered to facilitate manufacturability and throughput.

- Conformal compressible UL 94V-0 thermal interface pads that enable intimate module to cooling plate structure
- High flow thermal interface potting compound with long work life and UL V-0 self-extinguishing fire-retardancy.
- Other compressible thermal interface adhesive pads, patented compressible phase-change pads, non-migrating and non-drying greases.

### THERMAL INTERFACE MATERIALS FOR EV BATTERY PACKING AND ASSEMBLY



## What distinguishes AIT Electric Vehicle (EV) Battery Pack and Cooling System Interfacing solutions?

In meeting the challenges of EV battery pack and cooling system interfacing, AIT solutions engineered its materials to provide the manufacturers the following distinctive capabilities:

- Ease in dispensing and long work life for the liquid potting thermal gel forming (to prevent drying or pumped out) compound for reliable module thermal encapsulation
- Ease of placement and compressibility of thermal interface pad between modules and cooling and structural support system
- Built in halogen-free UL-94V-0 fire self-extinguishing for both the potting thermal gel and compressible thermal pad
- For long-term viability, AIT battery packing and cooling interface solutions are designed for ease of recycling with stress-free mechanical interfacing.

In addition to unparalleled and proven low thermal resistance, AIT's potting thermal gel and module mounting and heat-sink thermal interfaces offer long-term reliability and consistent performance for years of thermal shock and cycling. AIT products have built-in stress relief and molecular structures that are engineered to prevent "drying" or cracking inside the materials and along the interface surfaces. Additional features include:

- Ultra-low thermal resistance between cells to casing in the module potting with thermal gel and flexibility to produce stress-free and heat-dissipating modules. This low thermal resistance gels and cured in-situ and free from drying are pumped out.
- For module to cooling system mounting, molecular flexibility is specifically engineered in the thermal adhesive to provide stress absorption even in the most mis-matched CTE substrates and surfaces that extends to below -55°C. Depending on the design, AIT solutions can be customized as compressible thermal interfaced pad or pressure sensitive adhesive pads.
- All of AIT solutions are designed for RoHS, REACH and WEEE compliant besides intrinsically built-in UL94V-0 fire-retardancy.



# HIGH FLOW, GAP-FILLING THERMAL INTERFACE GEL-FORMING POTTING COMPOUND FOR MODULE PACKING:

- DISPENSABLE FIRE-RETARDANT THERMAL INTERFACE POTTING GEL WITH LONG POT-LIFE
- THERMAL-MECHANICAL INTERFACE ENGINEERED FOR MANUFACTURABILITY AND END-OF-LIFE RECYCLING



## FIRE-RETARDANT THERMAL INTERFACE POTTING GEL ENGINEERED FOR EASE OF RECYCLING

### Gap-Filling potting compound for cells to module casing for hot-spot prevention and thermal distribution interfacing:

Cell packing within a module generally tight and required both hot-spot prevention and heat interfacing to the casing for long-term reliability. AIT solutions incorporated the following characteristics that are detailed in the attached table of EG7655-P-FR

### AIT high flow ambient curing thermal gel vs other thermal potting compounds and greases:

There are many thermal solutions to fill the gaps between cells in an EV module. In addition to unparalleled and proven low thermal resistance, AIT's gel-forming thermal potting incorporated the long-term reliability and end-of-life recycling ease as integral part of the solution. Additional features include:

- Low thermal resistance between cells to casing while providing UL 94V-0 fire-retardant as integral part of the thermal conductivity engineering.
- While providing more than 30 years in the thermal management reliability, molecular flexibility is specifically engineered in the thermal potting compound to provide stress absorption even in the most mis-matched CTE substrates and surfaces that extends to below -55°C.
- Instead of high strength potting compounds that are hard to recycle at the end-of-life, the soft AIT gel formed are easy to removed to recover the metals and other elements in the battery cells.
- AIT's ambient curing thermal gel also eliminate the drying and "pumped out" of thermal greases.
- RoHS, REACH and WEEE compliant are met besides meeting UL 94V-0 for fire safety.

### AIT Thermal Gap Filling Potting Gel (EG7655P-FR) for Ease of Recycling

Flammability	UL94 V0	Dielectric Strength	>30KV/mm
Thermal Conductivity	1.8 W/m-K	Volume Resistivity	>7x10 <sup>13</sup> ohm-cm
Mixed Ratio	1:1 (By Weight or Volume)	Hardness (Shore A)	85
Viscosity/Thixotropic Index	200,000 cps TI=1.5	Lap-Shear Bond Strength	>300 psi
Open Time (Pot-Life)	> 3 Hours	Glass Transition Temperature	-20°C
Curing Time	<48 hrs @ ambient	Coefficient Thermal Expansion	45ppm/°C(<Tg) 95ppm/°C (>Tg)
Cured Density	2.5	Elongation (Before Breaking)	>50%

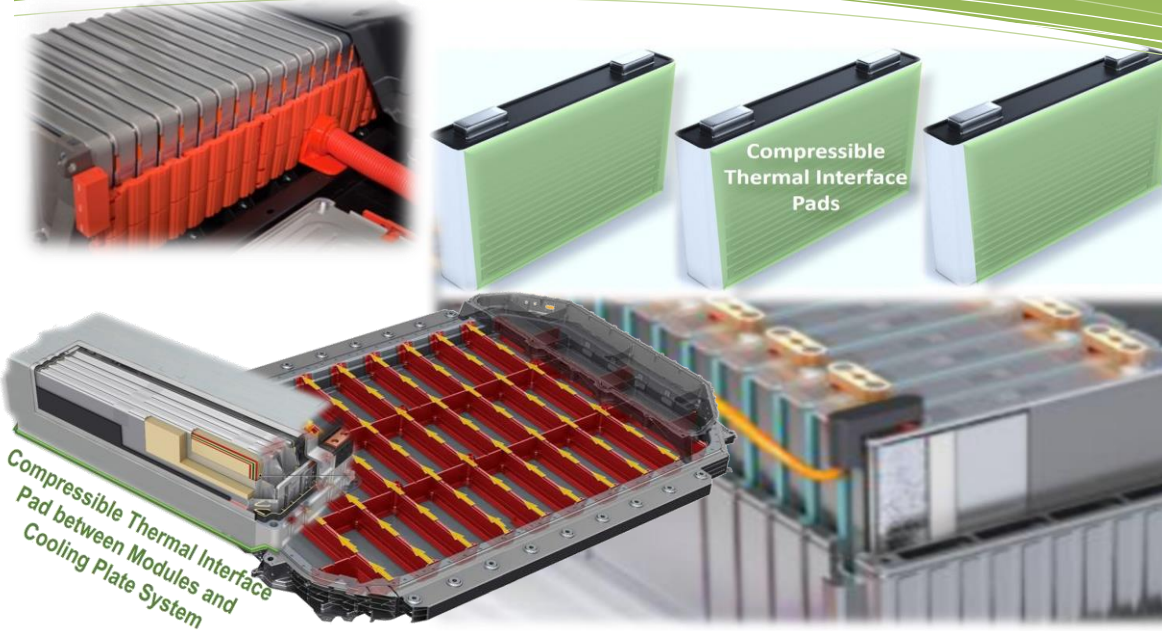
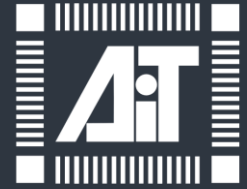
### For requirement of ease in recycling and reworkability when bonding is not required:

- **COOL-GREASE CGR7015-FR** provides one of the best heat transfer between cells to casing while providing UL 94V0 fire-retardant and proven long-term stability up to 150°C.

- The thermal interface potting compound is ambient curable to eliminate heat processing complication
- It is designed to have long pot-life to facilitate high volume production.
- The mixed potting compound has high flow and self-leveling characteristics to ensure intimate and void-free thermal interface from cells to cells and to the metal module casing.
- The 1:1 mix ratio by weight and by volume is engineered for error-free production operation.
- This 100% solid fire-retardant gel forming potting can be used in any manufacturing environment
- Different versions of EG7655 products have a long and proven history in uses from high integrity military, commercial, and automotive electronic applications.

# GAP-CONFORMING, NON-CURING, THERMAL INTERFACE PAD:

- HIGH COMPRESSIBILITY, FIRE-RETARDANT, ENGINEERED FOR HIGH TEMPERATURE INTERFACE
- SHOCK ABSORBING MECHANICAL INTERFACE ENGINEERED FOR MANUFACTURABILITY AND END-OF-LIFE RECYCLING
- LONG PROVEN HISTORY OF USAGE IN HIGH RELIABILITY THERMAL INTERFACING



Compressible Thermal Interface Pad between Modules and Cooling Plate System

## THERMAL-MECHANICAL COUPLING FOR HIGH RELIABILITY POWER EV BATTERY ASSEMBLY

### High Compressible, High Temperature, High Thermal Conduction Fire-Retardant Thermal Interface Pads for EV Battery Assembly:

AIT's compressible thermal interface pads have been carefully engineered to provide the combination of automatic assembly and placement between modules and EV structural-cooling plate system, high temperature long-term reliability and end-of-life recycling ease as integral part of the solution. Additional features include:

- Low thermal resistance between cells to casing while providing UL V-0 fire-retardant as integral part of the thermal conductivity engineering.
- Proven more than 30 years in the thermal management reliability, non-curing molecular flexibility is specifically engineered in the thermal interface padding to provide shock and stress absorption between module and the battery frame structure and cooling plate system.
- Instead of high strength thermal adhesives that are hard to recycle at the end-of-life, the non-bonding pads are easy to remove to recover the metals and other elements in the battery cells.
- AIT's ambient curing thermal gel also eliminate the drying and "pumped out" of thermal greases.
- RoHS, REACH and WEEE compliant are met besides meeting UL94V-0 for fire safety.

### AIT Compressible Thermal Gum-Pad (CGP7155-FR) for Ease of Recycling

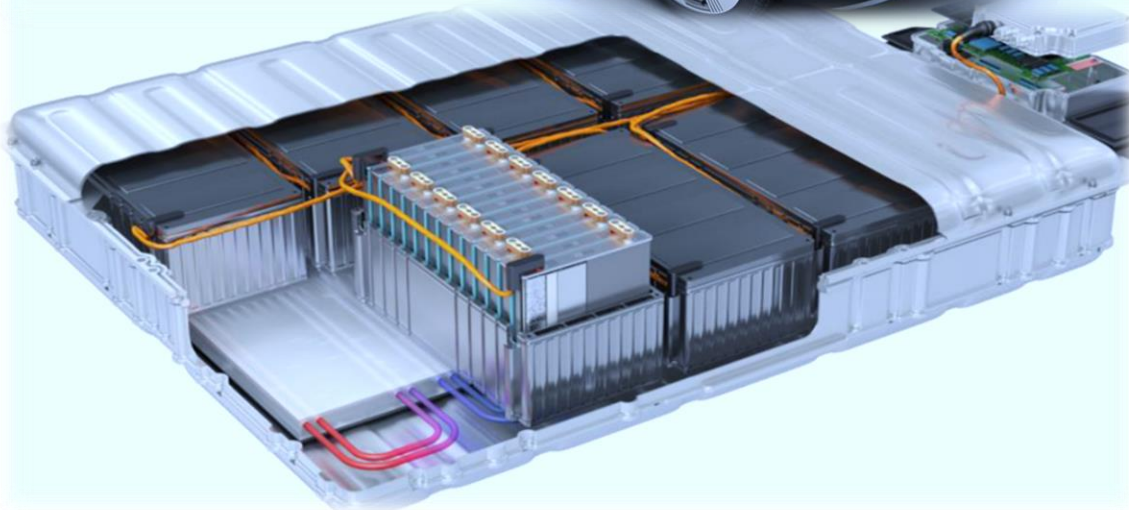
Flammability	UL94 V0	Dielectric Strength	>30KV/mm
Thermal Conductivity	>2.0 W/m-K	Volume Resistivity	>7x10 <sup>13</sup> ohm-cm
Compressibility	>50%	Hardness (Shore A)	25
Modulus	<5,000 psi	Lap-Shear Bond Strength	<100 psi
Open Time (Pot-Life)	Non-Curing Dry Pad	Glass Transition Temperature	-55°C
Curing Time	Non-Curing	Coefficient Thermal Expansion (CTE)	45ppm/°C (<T <sub>g</sub> ) 95ppm/°C (>T <sub>g</sub> )
Cured Density	2.5	Elongation (Before Breaking)	>100%

### Compressible Thermal Interface Gum-Gap

- Outstanding compressible and conformal under minimal pressure
- Proven for large area requiring thermal filling into height gaps of different components
- Ideal for large area displays and module to the enclosure
- Proven and used for the most critical thermal challenges with military grade reliability
- Non-silicone and non-contaminating
- Available in different thicknesses with one-side or both sides pressure sensitive
- CGP7155-FR is one of the COOL-GUM-PAD™ series of compressible, high temperature capable thermal interface pad has a long history of successful usages in many commercial, military and automotive thermal interface applications
- CGP7155-FR is available in different thicknesses.
- It is engineered to be tack-free for ease in pick-and-place in high volume application processes
- For more special application environment and/or production processes, CGP7155-FR can be made available in different thicknesses with one-side or both sides pressure sensitive
- CGP7156-FR is another variation of the gum-pad for even higher thermal dissipation needs

# AIT OTHER THERMAL, ELECTRICAL AND MECHANICAL INTERFACING MATERIAL SOLUTIONS FOR EV AUTOMOTIVE APPLICATIONS:

- *WORLD'S 1<sup>ST</sup> ELECTRICALLY CONDUCTIVE GREASE (ELECTRO-GREASE™)*
- *WORLD'S 1<sup>ST</sup> FLUORINATED CONFORMAL COATING PROVEN FOR SULFUR AND ACIDIC RAIN PROTECTION*
- *WORLD'S 1<sup>ST</sup> AND PATENTED COMPRESSIBLE PHASE-CHANGE THERMAL PAD*
- *ONE OF MOST COMPLETE LINES OF ELECTRONIC PACKAGING MATERIAL SOLUTIONS*



## About AI Technology, Inc. (AIT):

Since pioneering the use of flexible epoxy technology for electronic packaging in 1985, AI Technology has been one of the leading forces in developing advanced materials and adhesive solutions for electronic interconnection and packaging. Besides pioneering the use of "phase-change" materials (PCM) as thermal interface materials (TIM), AIT has also provided the electronic packaging industries with its flexible epoxy thermal adhesives. By managing interfacial stress induced by differential coefficient of thermal expansion between bonding adherents, AIT's thermal management materials have found extensive use and success in critical military and aerospace applications.

The same stress-free dielectric adhesives are now adapted for use in insulated metal substrates with copper and aluminum clad. The key advantage of these thermal management materials is their unparalleled long-term reliability attributed to their ability to withstand repeated thermal cycling and stress-free bonding between the heat-spreader plate and the circuit layer. AIT also offers the same flexible epoxy pre-prep with high thermal conductivity for more advanced multilayer insulated metal substrate circuits and modules. This novel class of thermal management materials provides a platform and infrastructure for large area thermal management of power modules such as solar cells, LED panels, etc.

AIT has a full line of die and substrate attach films and pastes, thermal interface materials, (EMI/RFI) mitigation material solutions, conductive caulks and adhesives and advanced flexible and Insulated Metal Circuit Substrates for camber-free modules. The company has an ISO9001:2000 certified manufacturing and R&D facility on a 16-acre campus in Princeton Junction, NJ. Sales support includes company direct offices in Shenzhen-HK China and sales reps in Europe and Asia.

\* (US patent#: 7,154,046; 6,717,819; 6,580,035; 6,581,276; 6,108,210; 6,297,564; 6,665,193; 6,973,716)

## REPRESENTATIVE THERMAL, ELECTRICAL AND MECHANICAL INTERFACE PASTE AND FILM ADHESIVES, PADS, GREASES, GELS, AND COATINGS

FUNCTION	AIT PART #	THERMAL, ELECTRICAL AND OTHER RELEVANT PROPERTIES
<b>Electronic Conformal Coating</b>	<b>FLUROSEAL®</b> SC7130-CC	<ul style="list-style-type: none"> <li>• Proven with highest barrier for moisture and corrosive gases for protecting sensitive electronic circuits</li> <li>• IPC 830C certified and UL pollution specifications conformance</li> </ul>
<b>UV, Corrosion Protection Over-Coating</b>	<b>FLUROSEAL®</b> SCX7130-UVB SCX7133-PTE	<ul style="list-style-type: none"> <li>• Over-coat on existing paints and coatings for UV and corrosion protection against sulfur and other corrosive acid rain for 30 years</li> <li>• Proven with highest barrier for moisture and corrosive gases</li> </ul>
<b>Thermal Grease</b>	<b>COOL-GREASE™</b> CGR7055-FR	<ul style="list-style-type: none"> <li>• Lowest thermal resistance, electrically insulating interface grease</li> <li>• Non-curing, non-silicone, UL V0, proven long-term stability</li> </ul>
<b>Electrically Conductive Grease</b>	<b>ELECTRO-GREASE™</b> CGR8550	<ul style="list-style-type: none"> <li>• Non-curing, electrically conductive interface grease for moving parts</li> <li>• Lowest thermal and electrical resistance non-silicone grease, proven long-term stability for extreme moving electrical conduction interface</li> </ul>
<b>Thermal PSAs</b>	<b>COOL-BOND™</b> PSA-5NC-FR	<ul style="list-style-type: none"> <li>• Thermally conductive and fire-retardant pressure sensitive adhesive film with different thicknesses for instant bonding without curing</li> </ul>
<b>Thermal Adhesives</b>	<b>COOL-BOND™</b> EG7635-FR	<ul style="list-style-type: none"> <li>• Thermally conductive and fire-retardant epoxy adhesive pastes with proven long-term reliability of over 30 years</li> <li>• Easy 1:1 mix ratio with long floor pot-life and ambient curable</li> </ul>
<b>Gap-Filling Thermal COOL-GUMPAD™</b>	<b>COOL-GUMPAD™</b> CGP7156-FR	<ul style="list-style-type: none"> <li>• Fire-retardant, gap filling compressible thermal gum pad with the lowest thermal resistance, UL V0 fire-retardant</li> <li>• One-side tacky (DT) or both side tacky (TT) for different applications</li> </ul>
<b>Compressible Phase-Change COOL-PAD™</b>	<b>COOL-PAD™</b> CPR7155-FR	<ul style="list-style-type: none"> <li>• Modified fire-retardant (UL 94V-0) aluminum oxide filled with one of the lowest thermal resistances</li> <li>• Compressible, thermal phase-change pad (US patented)</li> </ul>