SAE 2018 New Energy Vehicle Forum

Thermal Interface Materials for Power Storage

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Henkel

Agenda

- Henkel Overview
- Introduction of Car Battery Thermal Management
- Thermal Interface Materials
- Numerical Study
- Conclusions

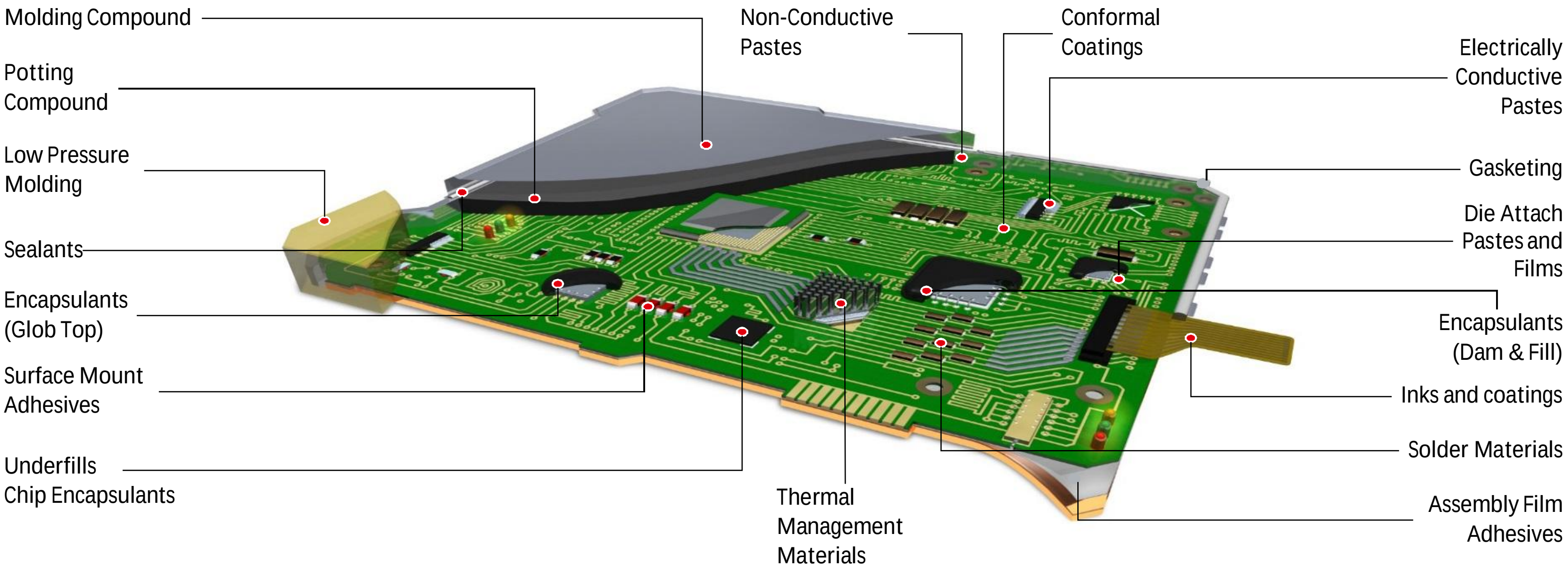
Henkel Electronics Overview

Who is Henkel?

- Henkel is a leading supplier of electronics materials covering semiconductor to board assembly to printed electronics
- Henkel acquired The Bergquist Company in November 2014
- Bergquist is the market leader in designing and manufacturing thermal management materials
- Bergquist thermal solutions quickly and efficiently transfer heat from hot components to the surrounding environment

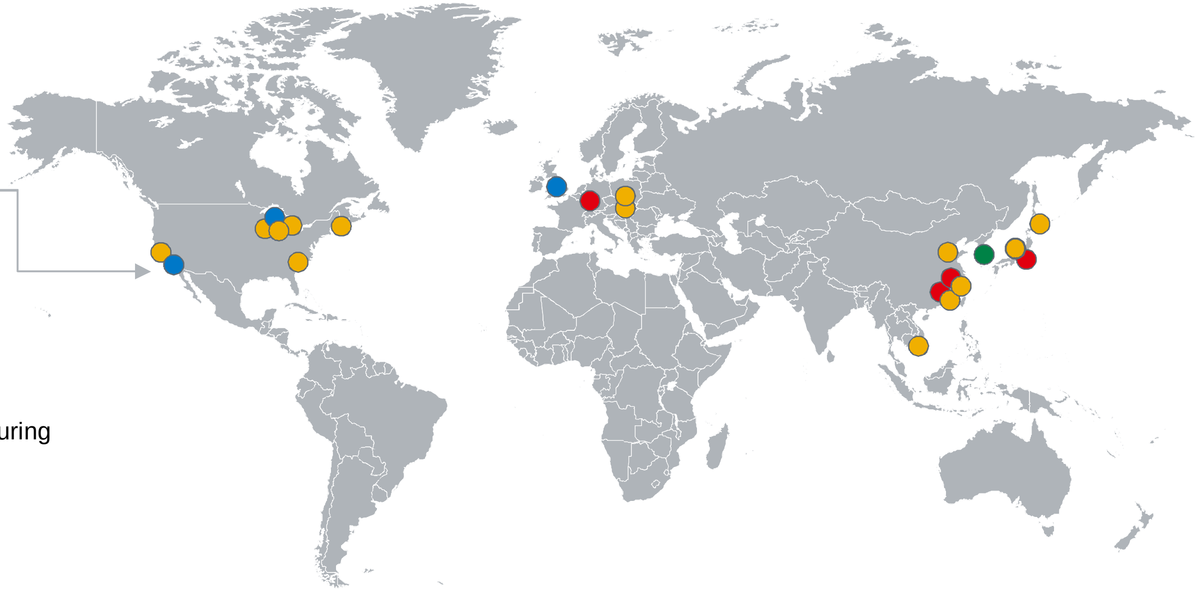
Henkel Electronics
Solutions Across the Board

Die Attach Adhesives	Molding Compounds	Assembly Adhesives	Liquids	Inks & Coatings	Solder Materials	Thermal Materials



Serving Our Customers Worldwide
Global End-to-End Business

Headquarters:
Irvine, CA USA



- R&D, Technical Service, Sales
- R&D, Technical Service, Sales, Manufacturing
- Technical Service, Sales, Manufacturing
- Manufacturing

› Henkel has a global presence with a footprint in every geography
Globally aligned infrastructure to serve our customers locally

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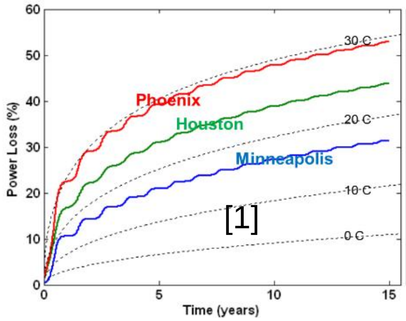
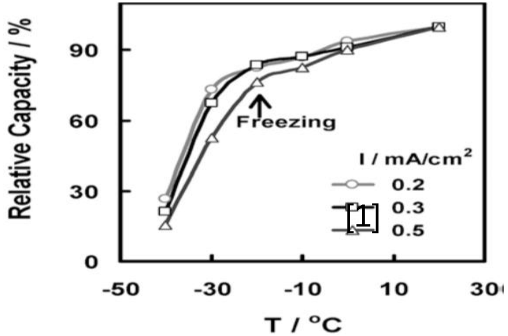
Introduction – Li-Ion Batteries

- Electronics become part of our daily lives. Batteries which power these devices play an increasingly vital role.

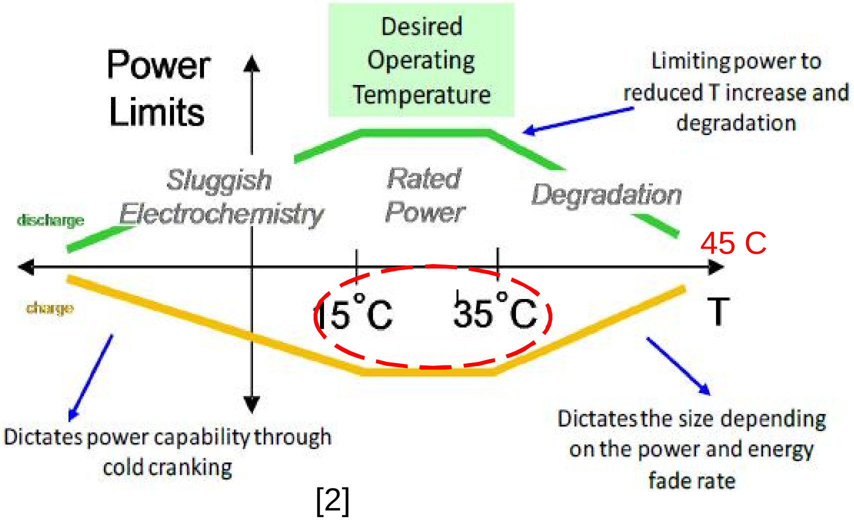
Introduction – Car Battery



Excessively high temperature leads to power loss, capacity fade, and shorter end of life



Extremely low temperature reduce battery capacity, and thus shorten driving range and degrade performance of vehicle



Temperature has a significant impact on life, performance, safety, and cost

Battery core temperature < 45 C

[1] John P. Rugh, Ahmad Pesaran, Kandler Smith, 2011, “Electric Vehicle Battery Thermal Issues and Thermal Management Techniques”, SAE 2011 Alternative Refrigerant and System Efficiency Symposium, Scottsdale, AZ, Sept 27-29, 2011.
[2] Ahmad Pesaran, 2013, “Tools for Designing Thermal Management of Batteries in Electric Drive Vehicles”, Large Lithium Ion Battery Technology & Application Symposia Advanced Automotive Battery Conference, Pasadena, CA, February 4-8, 2013

Introduction - Thermal Management Characteristics

- EV batteries are typically very large and heavy.
  - Thermal challenges are typically associated with cold starting in low temperature environment.
  - Thermal management needs to regulate the battery temperature during cold starting and operation.

- HEV batteries are typically much smaller.
  - Thermal management needs to adequately handle overheating in high temperature environment.
  - Control the battery temperature to prevent thermal runaway.

| Introduction - Market Trend and Technology Drivers

Market Trends	Market Value Drivers	Innovation Value Drivers (Product, Process, Application)
Higher Power, Longer Range	Improved Thermal Management (Active, Passive)	• Higher Thermal Conductivity Solutions • Higher Breakdown Voltage
Fast Charge	Improved Safety	• Reduced weight & volume for non-active materials
Lower Cost	Improved Manufacturing Efficiencies	• Reduced handling & processing during cell & pack manufacturing

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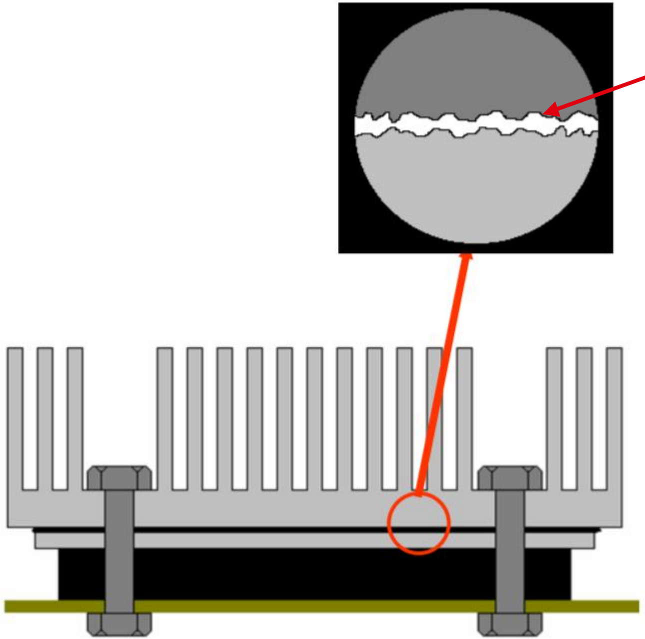
| Thermal Interface Materials - Basics

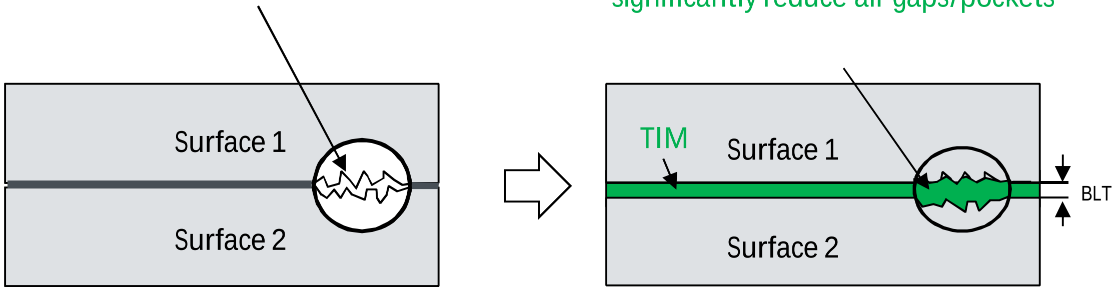


The actual contact area between the two solid surfaces is typically less than 2% of the apparent area for lightly loaded interfaces*

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

* M. M. Yovanovich and E. E. Marotta, ‘‘Thermal spreading and contact resistances”, Heat Transfer Handbook, A. Bejan and A. D. Kraus, Eds. Hoboken, New Jersey: Wiley, 2003, pp. 261–395.

Thermal Interface Materials - Fundamentals



Thermal Resistance

$$R_{TIM} = \frac{BLT}{k_{TIM}} + R_{c1} + R_{c2}$$

Effective K

$$K = \frac{BLT}{R_{TIM}}$$

Bulk Resistance

k, thickness

Interfacial Resistance

Surface compliance, wettability, pressure/force, etc.

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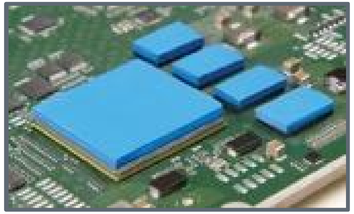
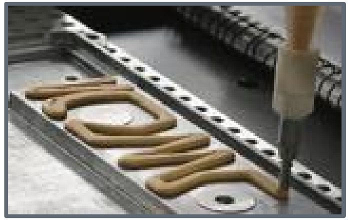
Thermal Interface Materials for NEV Batteries

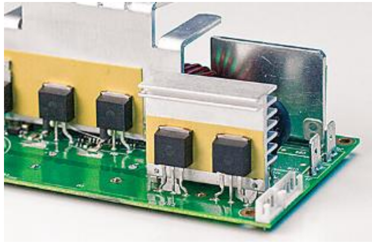
Gap Pads



Gap Fillers



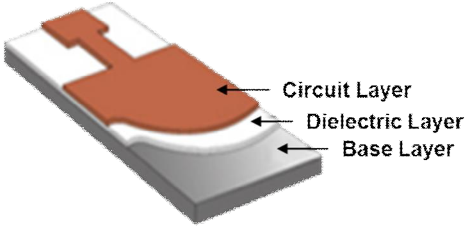
Adhesives

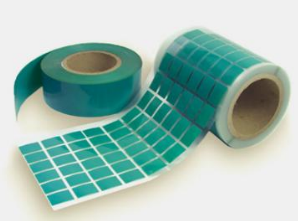


Thermal Materials for NEV Batteries

Sil Pad

T-Clad

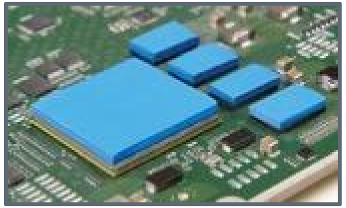




Phase change TIM

Thermal Materials for NEV Batteries

Thermal Materials for Batteries						
Insulated Metal Substrate		Thermal Interface Materials				
IMS Circuits	Coatings	Gap Filler	Gap Pad	Phase Change Materials	Thermal Adhesives	SIL Pad
BERGQUIST TCLAD HT DIELECTRIC	BERGQUIST ISOEDGE PR4305	BERGQUIST GAP FILLER 1000SR	BERGQUIST GAP PAD HC 3.0	BERGQUIST HI-FLOW 300P	BERGQUIST BOND-PLY 800	BERGQUIST SIL-PAD A2000
	BERGQUIST GAP PAD HC 5.0	BERGQUIST GAP FILLER 1500LV	BERGQUIST GAP PAD HC 5.0	BERGQUIST HI-FLOW 565UT	BERGQUIST BOND-PLY LMS-HD	BERGQUIST SIL-PAD 900S
	BERGQUIST GAP PAD 1450	BERGQUIST GAP FILLER 1450	BERGQUIST GAP PAD 1450	BERGQUIST HI-FLOW 650P	BERGQUIST BOND TLB SA 1800	BERGQUIST SIL-PAD K-10
	BERGQUIST GAP PAD 1000HD	BERGQUIST GAP FILLER 3500LV	BERGQUIST GAP PAD 1000HD		BERGQUIST LIQUI BOND TLB SA2005RT	
			BERGQUIST GAP PAD 2200SF			



Thermal Interface Materials – Gap Filler

Recommended Products

	GF1000SR	GF1450	GF1500LV	GF3500LV
Benefits	Slump resistant	Ultra-conforming with excellent wet-out	Low outgassing, ultra-conforming, excellent wet-out	Superior thermal performance, low outgassing, excellent wet-out
Thermal Cond. (W/m-K)	1.0	1.5	1.8	3.5
Viscosity at 25℃ (cP)	20 Pa-S (ASTM D5099)	Part A: 30 Pa-S (ASTM D5099) Part B: 200 Pa-S (ASTM D2196)	20,000	45,000
Dielectric Strength (V/25 µm)	500	275	400	275
Flammability Rating	UL 94 V-0	UL 94 V-0	UL 94 V-0	UL 94 V-0
Recommended Cure	20 min at 25 ℃	5 hr at 25 ℃	8 hr at 25 ℃	24 hr at 25 ℃

Thermal Interface Materials – Gap Pads

Recommended Products

	GP HC 3.0	GP HC 5.0	GP 1450	GP 2200 SF
Benefits	High thermal performance at low pressures	Exceptional thermal performance at low pressures	Excellent low-stress vibration dampening and shock absorbing	No silicone outgassing
Thermal Cond. (W/m-K)	3.0	5.0	1.3	2.0
Modulus (KPa)	110	121	110	228
Dielectric Breakdown Voltage	5000 V/ 0.508 mm	5000 V/ 0.508 mm	6000 V/ 0.508 mm	5000 VAC (@0.254 mm)
Reinforcement Carrier	Fiberglass	Fiberglass	PEN liner	Fiberglass / PET
Thicknesses (mm)	0.508 – 3.175	0.508 – 3.175	0.508 – 3.175	0.254 – 3.175
Flammability Rating	UL 94 V-0	UL 94 V-0	UL 94 V-0	UL 94 V-0

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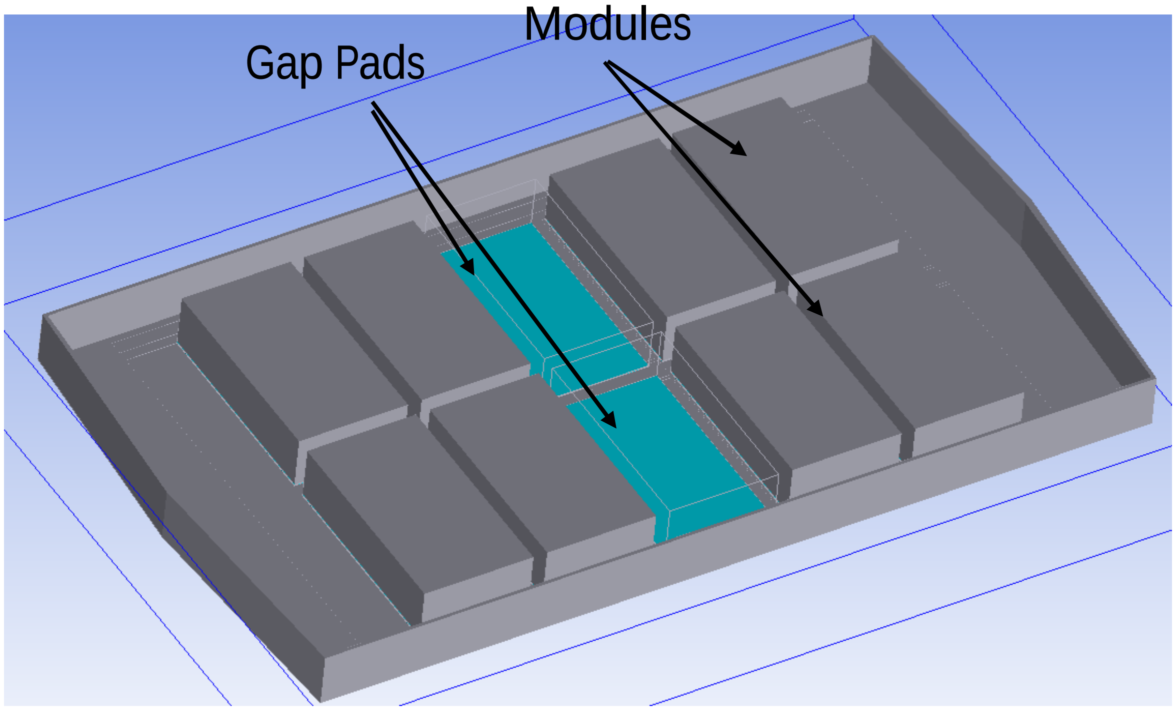
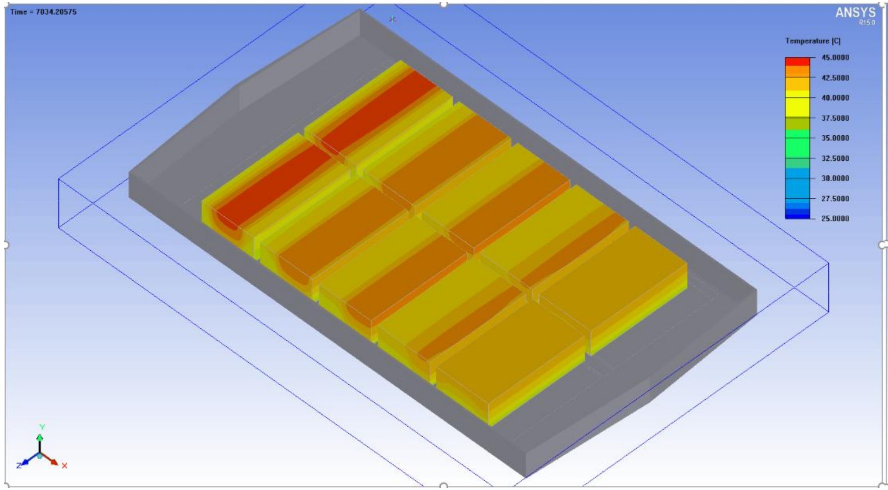
Simulation – Car Battery Thermal Management

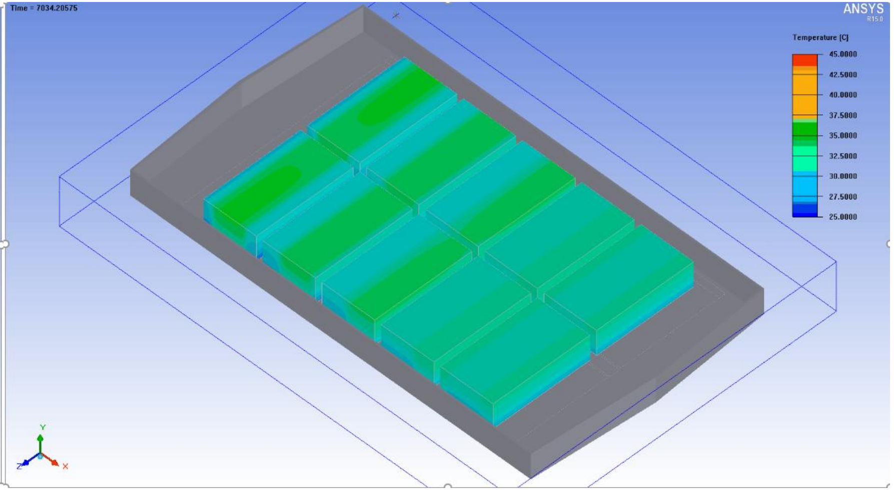


Numerical Study – Battery Pack

Regular Silicone Pad
(K = 0.2 W/mK)

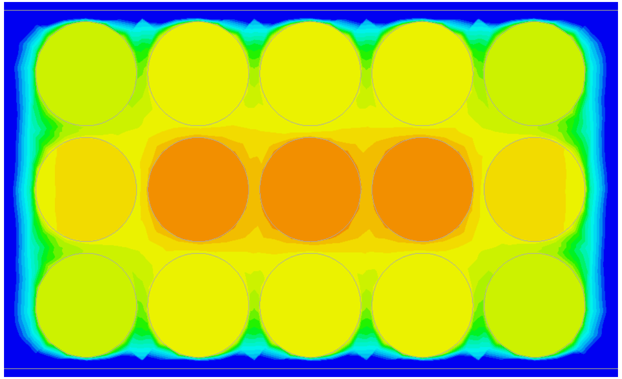


Gap Pad HC3.0

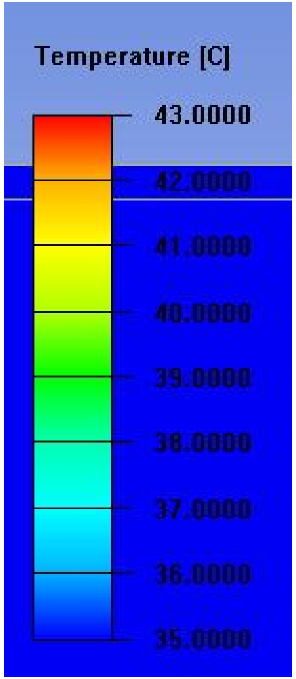


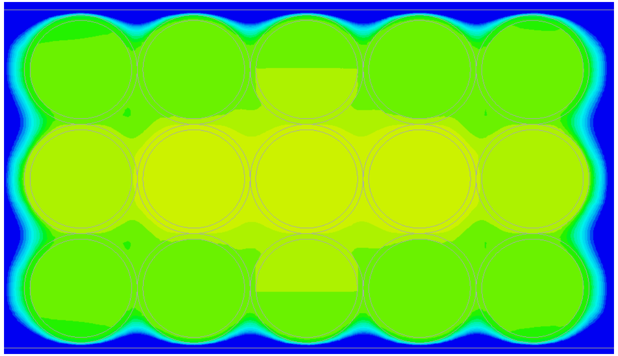
- Decrease maximum temperature.
- Improve temperature uniformity.
- Fast establish steady state.

Numerical Study – Battery Pack

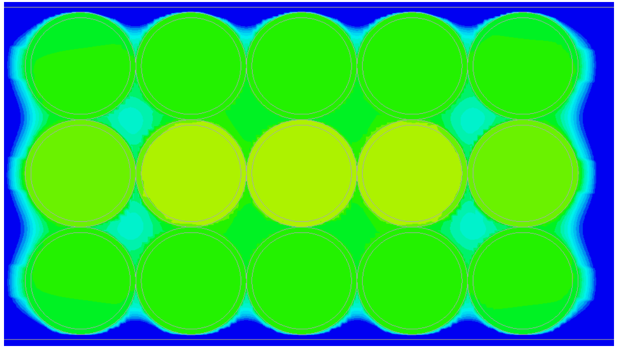


Base Case



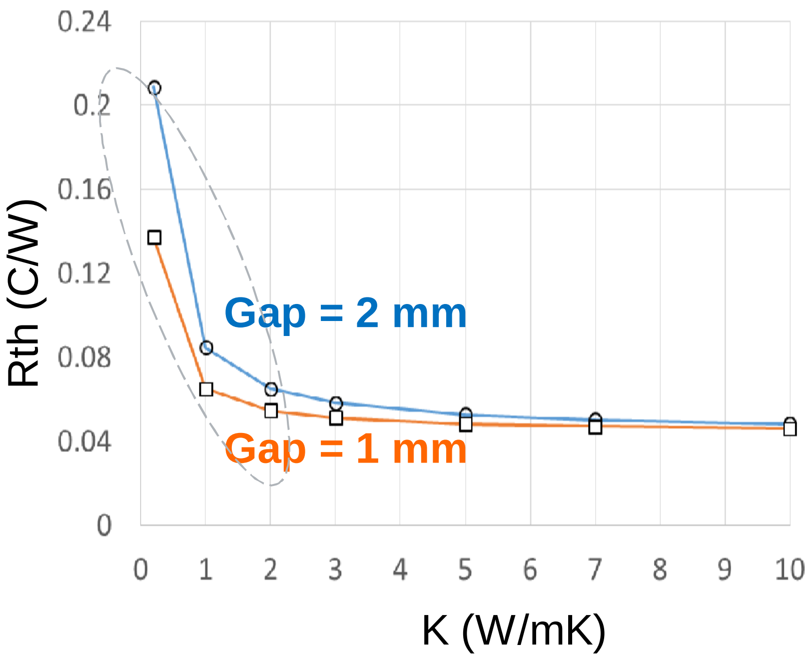


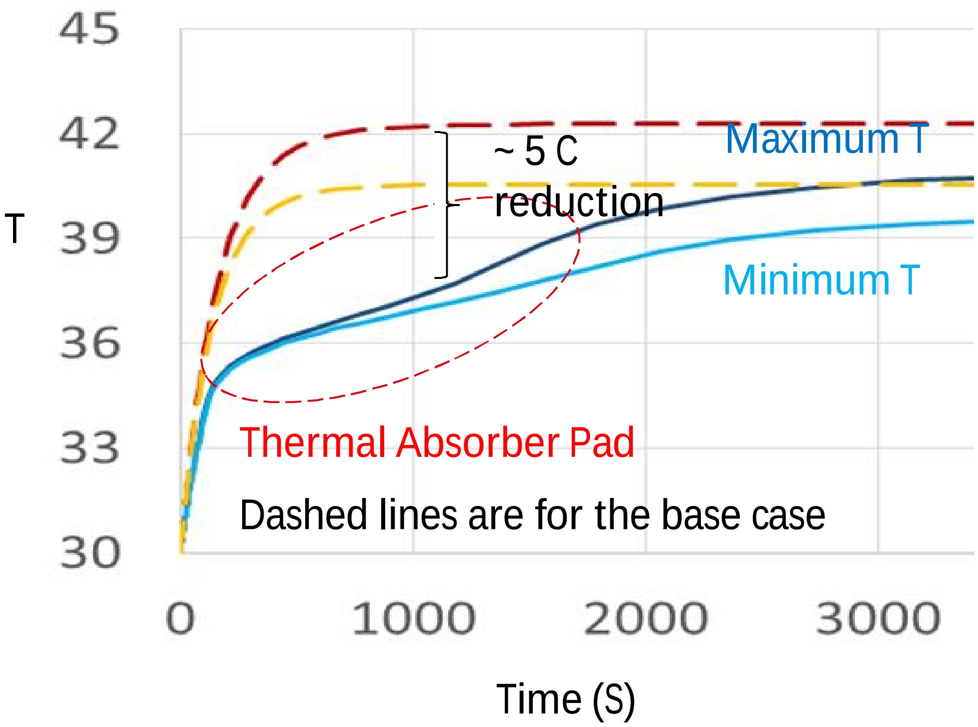
PCM Solution



Gap Pad Solution

Numerical Study – Battery Pack (Cont.)





Conclusions

- Using thermally enhanced gap pads can
  - Decrease maximum temperature by approximately 5 C.
  - Improve temperature uniformity across entire battery assembly.
  - Fast establish steady state.

- For typical car battery applications, high thermal conductivity-based approaches have a limit.
  - When thermal conductivity of a gap pad/filler exceeds 3 W/mK, its thermal advantages become less pronounced.

- Incorporating PCM in battery thermal management can offer thermal benefits during transient state.
  - Hybrid high thermal and high latency gap pad is a promising concept for future NEVs

Thank you!