

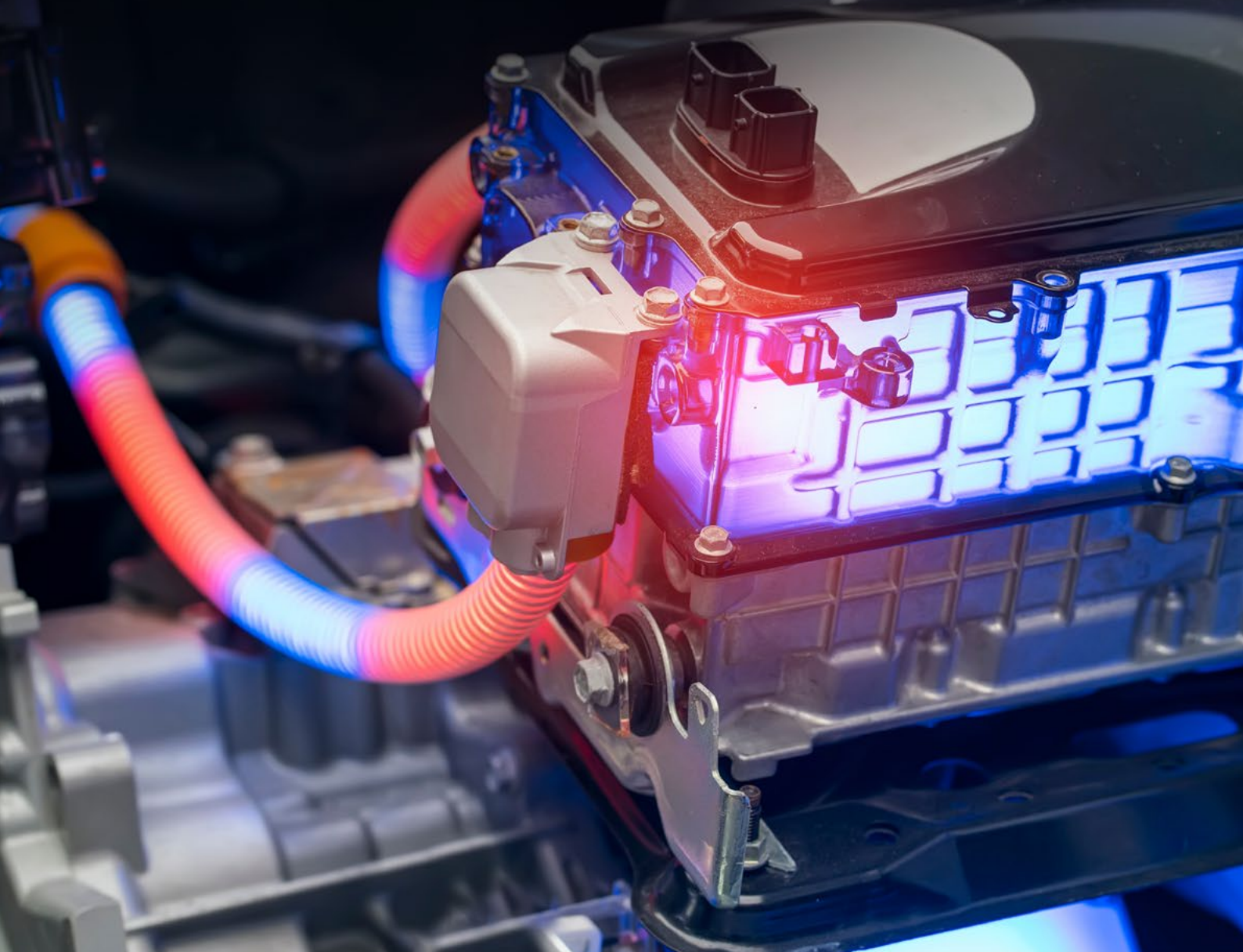
EV RELIABILITY SUPERIOR CAPABILITIES

Stay ahead of the curve with
Honeywell Phase Change Materials (PCMs)



Honeywell

For over half a century, Honeywell has been a key supplier to the worldwide electronics & semiconductor industry, providing critical materials to enhance the performance and reliability of our customers' products. No matter what the strength, resource or the best application, Honeywell ranks among the global leaders.



SOLVING INCREASING THERMAL CHALLENGES FOR TODAY AND TOMORROW

Our ongoing investment in research for more advanced materials has resulted in breakthroughs for key applications of thermal interface materials (TIMs) such as phase change materials (PCM).

The modern electronics industry is constantly advancing toward higher power consumption, more integrated functions and miniaturization, resulting in sharp thermally conductive fillers, enabling them to handle challenging heat dissipation issues with long-term reliability and low cost of ownership increase in the power density of modern electronic devices. Therefore, efficient heat dissipation has become an even more critical requirement for the design of modern electronic packages. Thermal interface materials (TIMs) are widely employed to manufacture the most critical parts in the heat dissipation system, to cool and protect integrated circuit (IC) chips.



SELECTING THE BEST PHASE CHANGE MATERIALS FOR OPTIMAL ELECTRIC VEHICLE PERFORMANCE

Electric vehicle inverters face significant challenges in thermal management due to the increasing demand for higher power density. Achieving optimal thermal performance while ensuring reliability is key. Honeywell phase change materials (PCMs) help effectively dissipate heat generated by the inverter, preventing overheating and degradation, while also withstanding the demanding operating conditions of electric vehicles.

OUR APPROACH

Honeywell PCMs emphasize exceptional thermal performance through low thermal resistance, high thermal conductivity, optimal surface wetting, and minimal contact resistance. Equally important, Honeywell PCMs prioritize reliability and longevity, exhibiting resistance to bleeding, pump-out, and flow issues. Furthermore, these materials are designed for efficient manufacturing, enabling easy assembly within a broad process window, high yield rates, and minimal material waste.

DETERMINING YOUR PCM REQUIREMENTS

When selecting a phase change material (PCM) for electric vehicle inverters, several factors must be considered. Thermal performance is vital, requiring PCMs with low thermal resistance and high thermal conductivity. Product lifecycle and reliability are essential, demanding resistance to aging, bleeding, and pump-out. Manufacturability is key for seamless integration, needing easy assembly and a broad process window. Thin bondline help maximize component density. By carefully evaluating these factors, engineers can select the optimal PCM to meet the specific needs of their inverter design.

HONEYWELL PHASE CHANGE MATERIAL SOLUTIONS FOR ELECTRIC VEHICLE INVERTERS

Honeywell delivers phase change material (PCM) solutions for electric vehicle inverter power modules, outperforming traditional grease options.

Our PCMs provide exceptional thermal performance with ultra-low thermal resistance, high thermal conductivity, and optimal surface wetting for efficient heat dissipation. Unlike grease or other thermal interface materials, the Honeywell PCMs exhibit unmatched reliability and longevity, resisting bleeding, pump-out, and aging. Additionally, our materials are designed for easy assembly and high yield manufacturing, offering pad and paste formats for versatility. Honeywell PCMs achieve thin bondline to maximize component density and thermal management, ensuring optimal performance and extended lifespan for electric vehicle inverters.

high thermal conductivity (6.5 W/mK), our PCMs efficiently dissipate heat, preventing overheating and ensuring optimal operation.

The materials' ability to conform to microscopic voids and cavities enhances heat transfer, further improving thermal management. This superior thermal performance directly translates into extended component lifespan, increased power density, and improved overall system efficiency.

By maintaining optimal operating temperatures, Honeywell PCMs contribute to the reliability and durability of electric vehicle inverters, enabling longer driving ranges and reducing charging times.



EXCELLENT THERMAL PERFORMANCE

Honeywell phase change materials offer unparalleled thermal performance, making them an ideal choice for electric vehicle inverter power modules. With extremely low thermal resistance (as low as $0.06 \text{ }^{\circ}\text{C}\cdot\text{cm}^2/\text{W}$) and



HIGH RELIABILITY & LONG LIFE

Unlike grease or other thermal interface materials, Honeywell PCM eliminate issues such as bleeding, pumping, and flow-out, maintaining consistent thermal performance over time.



Rigorous testing demonstrates the stability of the Honeywell PCMs, with no degradation in thermal impedance even after accelerated aging. This exceptional reliability translates to extended component lifespan, reduced maintenance costs, and increased vehicle uptime.

By preventing thermal runaway and ensuring consistent heat dissipation, Honeywell PCMs contribute to the overall durability and performance of electric vehicle powertrains.

MANUFACTURABILITY

Honeywell phase change materials help streamlining the production process and reduce costs for electric vehicle power modules.

Our PCMs are designed with easy assembly in mind, providing a broad process window that accommodates various manufacturing techniques. This flexibility ensures seamless integration into existing production lines.

Additionally, Honeywell PCMs deliver high yields with minimal material waste, optimizing production efficiency and reducing overall costs. Furthermore, PCMs offer versatility to meet specific application requirements.

These manufacturing advantages contribute to faster time-to-market, reduced production complexity, and improved overall product quality for electric vehicle power modules.

KEY FACTORS OF TIMs PERFORMANCE

Thermal Conductivity (TC)

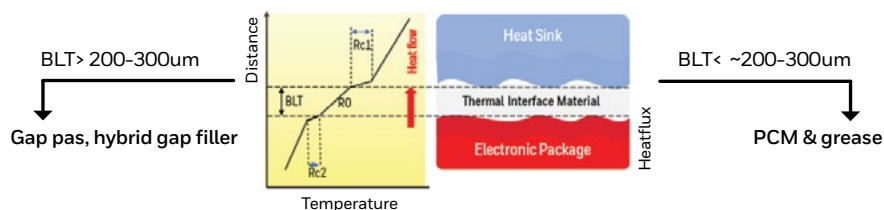
- It is only a material property and describes the ability of the given material to transfer heat through internal conduction.
- Independent of material size, shape or orientation in a homogenous material.

Thermal Impedance (TI)

- A better “real world” property as it makes in account that part’s thickness and tested pressure.
- Dependent of material size, shape or orientation.

Bond Line thickness (BLT)

- Bond Line thickness.
- In real case, TIM’s real thickness is more important.



TC for general comparison but TI vs pressure will be accurate to “real world”

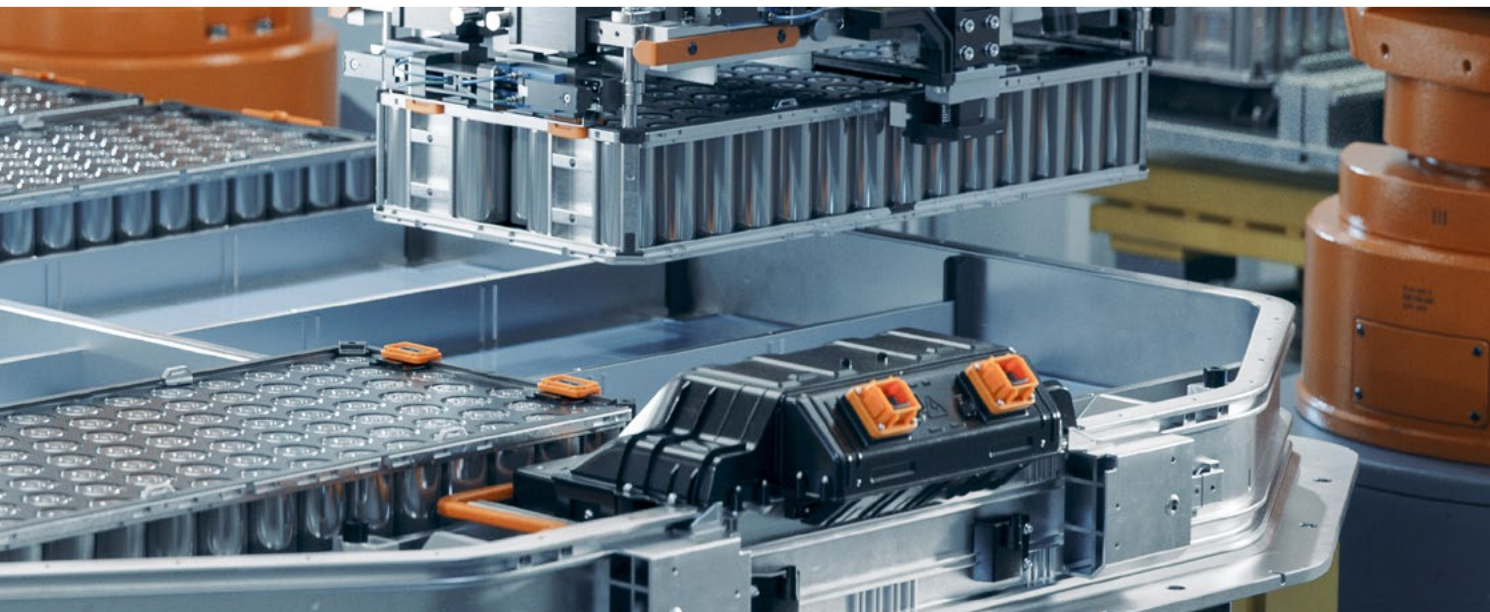
THIN BOND LINES

Honeywell phase change materials enable extremely thin bondlines, maximizing component density within electric vehicle inverter power modules.

By minimizing the gap between heat-generating components, thermal resistance is significantly reduced, enhancing heat dissipation. This results in improved thermal management, allowing for higher power densities and more compact designs.

Moreover, thin bondlines provide greater flexibility in component placement, enabling engineers to optimize the thermal performance of their designs.

The combination of high thermal conductivity and thin bondlines ensures that Honeywell PCMs deliver superior heat transfer, contributing to longer component life and increased overall system efficiency in electric vehicles.



HONEYWELL PHASE CHANGE MATERIALS (PCMs)

PCMs are often used as matrix materials for thermal interface applications, because they are solid at room temperature, and soften when heated.

They can fully fill the gaps of contact surfaces, therefore providing a thin bondline and high reliability without pump-out issues.

FEATURES

- High performance filler and polymer technology
- Phase change at 45°C
- Highly conductive filler loading to optimize performance
- Superior handling and reworkability
- Superior reliable thermal performance
- Range of thermal properties to fit different needs

THERMALLY CONDUCTIVE PHASE CHANGE MATERIALS

Thermally conductive filler to the phase change material matrix forms a phase change composite with high heat transfer performance that solves all types of pump-out issues.

The Honeywell products are designed to minimize thermal resistance at interfaces and maintain stable performance through the rigorous reliability testing required for long product life applications.

Based on a robust polymer structure, these materials exhibit effective wetting properties during typical operating temperature ranges, resulting in very low surface contact resistance. The proprietary materials provide

superior reliability and maintain low thermal impedance, making PCMs desirable for high-performance integrated circuit devices.

HONEYWELL PCM MODELS



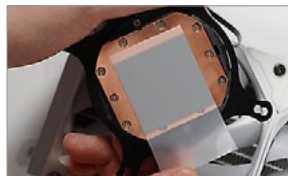
PTM6000-PAD



PTM7000-PAD



PTM7000-SPM PASTE



PTM7900-PAD



PTM7950-SPS PASTE



For almost 20 years, phase change material products have been a Honeywell mainstay for thermal solutions in a wide variety of applications.





TYPICAL PROPERTIES						
PROPERTY DESCRIPTION	LTM SERIES	PCM45F SERIES	PTM5000 SERIES	PTM6000 SERIES*	PTM7000 SERIES	TEST METHOD
Physical Properties						
Specific Gravity	1.8	2.2	2.3	2.3	2.7	ASTM D374
Thickness Range (mm)	NA	0.20-1.00	0.20-1.00	0.20-1.00	0.20-1.00	NA
Thermal Properties						
Thermal Conductivity(W/m-K)	1.8-2.4	2.0-2.5	3.5-4.5	3.5-4.5	6.0-8.5	ASTM D5470
Thermal Impedance @ no shim (°C-cm²/W)	0.12-0.14	0.09-0.12	0.06-0.08	0.06-0.08	0.04-0.06	ASTM D5470 Modified
Electrical Properties						
Volume Resistivity (ohm-cm)	3.0x10 ¹⁵	8.2x10 ¹⁴	2.1x10 ¹⁴	2.1x10 ¹⁴	2x.1x10 ¹⁴	ASTM D257

*PTM6000 has higher reliability than PTM5000 Series



RECOMMENDED APPLICATIONS

Clamping pressure and temperature are suggested to achieve a minimum bond line thickness, typically less than 1.5 mil (0.038mm) for best thermal performance.



STORAGE AND USE

Shelf Life: 12 months (Storage condition on the package for directions)



AVAILABILITY

PCM pads are available in both sheet and roll formats. Thickness Range: 0.2mm-1.0mm, Stencil printable (SP/SPM/SPS) material is available in 300cc syringes or 1kg jars.

PARTNER WITH HONEYWELL TO UNLOCK THE FULL POTENTIAL OF YOUR EV INVERTERS

Global Support Development And
Manufacturing Locations

HONEYWELL ADVANTAGES

Quality

- Industry-leading reliability over device lifetime
- More than twenty years specializing in thermal interface materials R&D and manufacturing
- Proprietary formulations optimized for the needs of specific applications
- Proven, long-standing supplier with multiple worldwide quality certifications

Customer Focused

- Serving diverse range of customers
- Thermal interface materials offered in a wide range of thermal conductivity and application forms
- Superior global technical support
- Portfolio of other materials, such as thermal spreaders, electrical interconnect pure metals



UNITED STATES

- Santa Clara, California
- Sunnyvale, California
- Spokane, Washington
- Chandler, Arizona
- Salt Lake City, Utah
- Bryan, Texas
- Mansfield, Texas
- Fombell, Pennsylvania

ASIA

- Shanghai, China
- Jincheon, Korea
- Yaita, Japan
- Chonburi, Thailand

EUROPE

- Seelze, Germany



● Research and Development Site ● Manufacturing Site



A FOUNDATION OF EXPERTISE

Honeywell’s commitment to advanced materials research is evidenced by its three global centers for excellence in the US and China. Whether adapted from our extensive portfolio of proven materials, or created for a specific customer, all Honeywell products undergo rigorous research, testing and quality control protocols.

COUNT ON HONEYWELL

- 50+ years providing materials for electronic products.
- More than 1,000 employees across the United States, Europe and Asia.
- 3 major R&D centers located in California, Washington and China.
- Continuous investment in research and development.
- Worldwide strategic collaborations.
- Approximately 400 granted and pending patents

For more information

<https://advancedmaterials.honeywell.com/us/en/products/electronic-materials/thermal-management>

Honeywell Advanced Materials

115 Tabor Road
Morris Plains, NJ 07950

advancedmaterials.honeywell.com

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FUTURE
IS
WHAT
WE
MAKE IT**

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