EFFICIENT PHASE CHANGE THERMAL INTERFACE MATERIAL FOR NEW ENERGY VEHICLE INVERTERS

Case Study

The customer cited in this case study chooses to be anonymous and has hence been referred to as "Zenith" in this document.

CONTACT US

Honeywell

SUMMARY

Honeywell customer (referred to as Zenith for the purpose of this document) is one of the leading manufacturers of propulsion solutions for Electric Vehicles. Their portfolio of products includes power electronics, battery systems, electric drive modules, and EV transmissions.

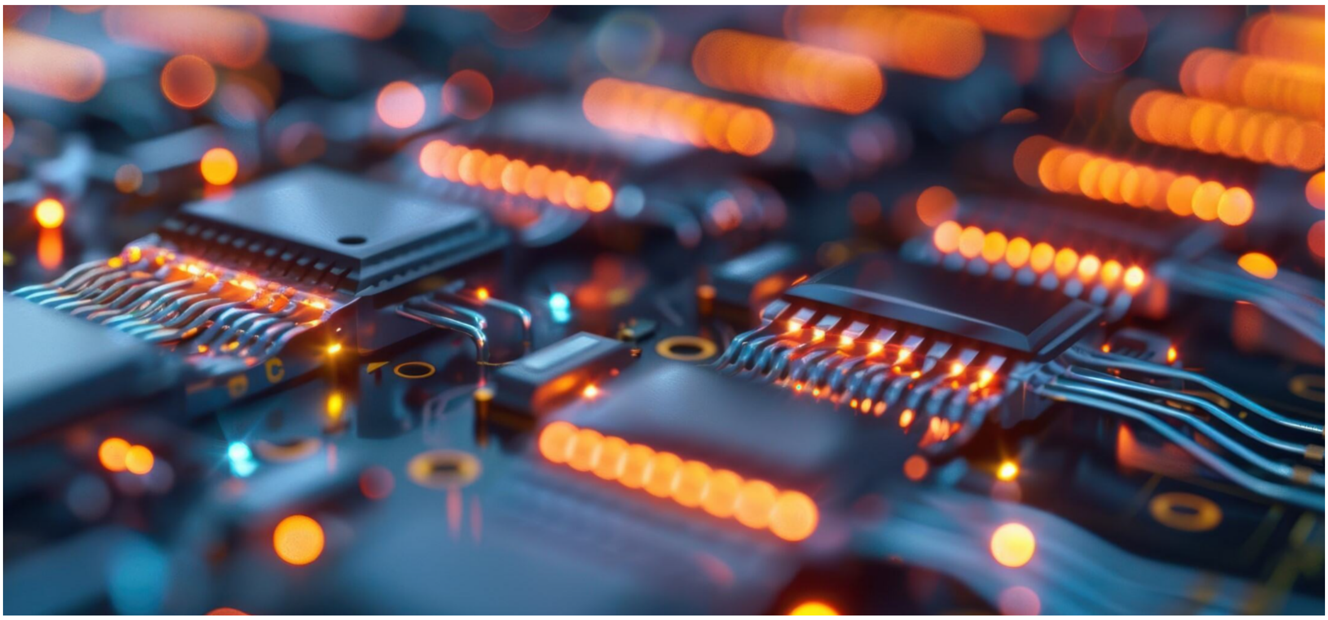
Zenith was facing the heat dissipation problem caused by the inverter and urgently needed a heat dissipation material with higher thermal conductivity, higher reliability, and thinner volume. After diligently evaluating various options, they adopted Honeywell's phase change material (PCM) thermal interface solution for its excellent thermal conductivity, high reliability, and suitability for thin gaps. Since its adoption, the Honeywell PCM solution has significantly improved the heat dissipation performance of Zenith's new energy vehicle inverter, helping them respond to industry challenges effectively.

As a critical component of NEVs, the Inverter converts the direct current (DC) from the vehicle's battery to alternating current (AC) to drive the electric motor. The performance of the inverter is directly related to the motor's power output and the vehicle's endurance. Inverters generate heat due to power losses in electronic components like transistors, diodes, and capacitors. The modern inverter often operates at high power densities and high frequency, increasing the amount of heat that needs to be dissipated. As such, excessive heat can lead to reduced performance and efficiency, component failure, or raise safety concerns.

In order to effectively manage this heat, thermal conductive interface materials are often used in inverter design to promote heat conduction from the heating element to the heat sink. Effective thermal management is crucial for inverters' performance, reliability, and safety.

With the trend of higher voltage platforms and smaller motor controller devices, inverters are also undergoing technological innovation. SiC MOSFET modules are gradually replacing traditional Si IGBT modules. Compared with Si IGBT, SiC MOSFET modules have smaller chip area and higher junction temperature, requiring more effective thermal management.

According to S&P Global Mobility's forecast, by 2034, the demand for SiC inverters will grow at a compound annual growth rate of 22.8% to 52.5 million units, accounting for 44% of the total global inverter demand. If each inverter is equipped with six power semiconductor switches and 12 pieces of thermal interface materials are used on both sides, by 2034, the global demand for thermal interface materials for SiC inverters will reach 630 million pieces, with a compound annual growth rate of more than 30%. These data demonstrate the urgent need for efficient heat dissipation materials in global new energy vehicle inverters.



CHALLENGE

As the new energy vehicle industry continues to increase its requirements for performance indicators such as lightweight, cost reduction, and optimized space layout, electric drive systems are rapidly evolving towards high integration, high voltage, and high power density. This transformation drives inverter technology to move towards higher power, maximum efficiency, increased voltage, and reduced weight and size and guides technological progress in the entire industry.

To adapt to this development trend, many automakers, such as General Motors, Hyundai, Volkswagen, and Lucid Motors, are leading the development of electric vehicle technology towards high-voltage platforms of 800V and above. In addition, leading automakers such as Volkswagen, Tesla, Hyundai, and BYD are switching from Si IGBT technology to SiC MOSFET technology.

In this context, Zenith actively embraces industry changes, leads electric vehicle technology to a high-voltage platform of 800V and above, and begins to apply SiC MOSFET inverters, which also puts higher requirements on the thermal management of inverters. To this end, Zenith is looking for a heat-dissipation material with higher thermal conductivity, higher reliability, and thinner volume to meet the increasingly stringent performance challenges.

SOLUTION:

To overcome this technical challenge, Zenith actively sought partners and eventually chose to work with Honeywell. With its deep technical accumulation and innovation capabilities in the field of thermal interface materials, Honeywell innovatively launched an inverter phase change material thermal interface solution. This solution has been successfully applied to Zenith's 800V platform SiC MOSFET inverter, effectively addresses the challenges of high thermal conductivity, reliability, weight, and size.

PTM7000 - TECHNICAL INFORMATION

PHYSICAL PROPERTIES	UNIT	TEST METHOD	PTM7000	PTM7000-SP
Thermal Conductivity	W/m • K	ASTM D5470	6.5	6.5
Thermal Impedance @ no shim	$^\circ C \cdot cm^2/W$	ASTM D5470 Modified	0.06	0.06
Specific Gravity	g/cm^3	ASTM D792	2.7	2.3
Viscosity	Pa • s @$2s^{-1}$,25 ˚C	Rehometer	NA	120
Volume Resistivity	Ω • cm	ASTM D257-700	2.1×10^{14}	2.1×10^{14}
Thickness Rage	mm		0.20-1.00	NA

* Typical property data values should not be used as specifications.

ADVANTAGES OF HONEYWELL'S PHASE CHANGE THERMAL INTERFACE MATERIALS:

Good thermal conductivity:

The unique design of phase change materials optimized at the molecular level achieves a high thermal conductivity of 6.5w/m·k under the condition of very low thermal resistance at 0.06, setting the current industry benchmark for water conductivity.

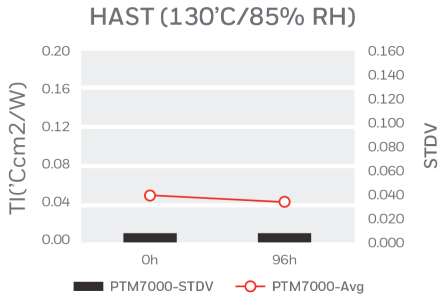
HIGH RELIABILITY

After professional reliability testing in the new energy automobile industry, the material has successfully passed various rigorous tests such as high- and low-temperature cycles, high- and low-temperature shocks, long-term high-temperature baking, power cycles, HAST, vibration, shock, dripping test, etc. Honeywell tightly wraps the fillers and substrates by carefully designing the molecular structure and applying multi-chain fillers to further enhance stability and long-term reliability.

HIGHLY-ACCELERATED STRESS TEST (HAST)

Test Condition: 130˚C, 85%RH, 96 hours

- Standard: JESD22-A110-B
- Testing Condition: 130˚C, 85%RH, 96 hours
- Objective: Accelerate the corrosive impact of high humidity and temperature on the thermal performance of the test structure
- Sample size: 8 pieces



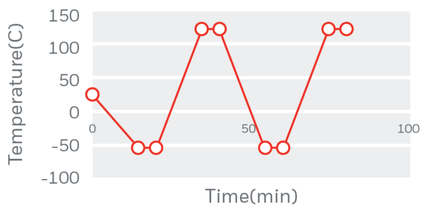
HAST chamber

PTM7000 remain reliable up to 96hrs for HAST

TEMPERATURE CYCLING TEST TESTING

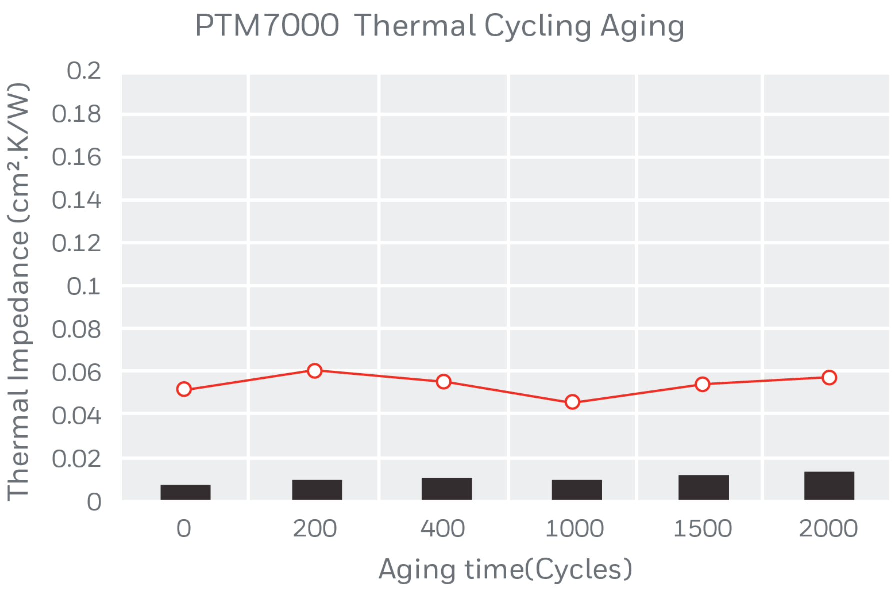
Test Condition: -55~+125˚C, 2000 cycles

- Standard: JESD22-A104C
- Testing Condition: -55~+125˚C, 2000 cycles
- Objective: Determine the resistance of TIM to extremes of high and low temperatures, and its ability to withstand cyclical stresses
- Sample size: 8 pieces



TC chamber

- **Ramp time: 15mins**
- **Dwelling time @-55˚C and 125˚C: 5mins**
- **Every cycle: 40mins**

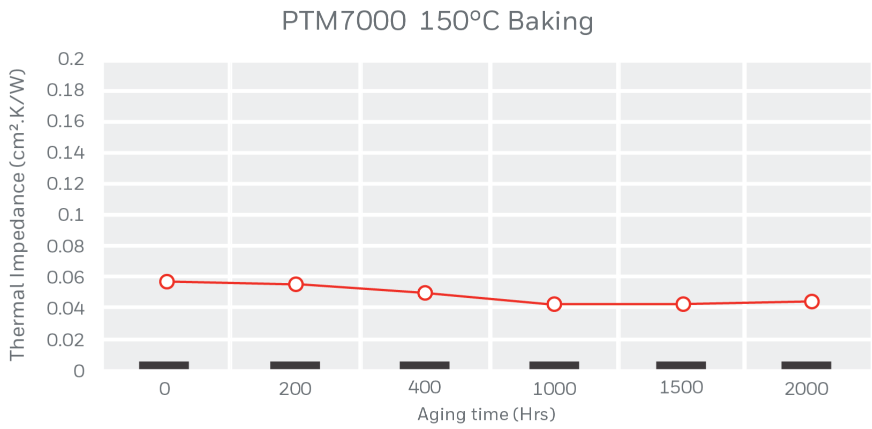


PTM7000 remain reliable up to 2000 cycles for thermal cycling text.

HIGH-TEMPERATURE BAKING

Test Condition: 150˚C, 2000 hours

- The samples were placed into the test chamber at 150˚C for 2000 hours. After a certain interval, the sandwich samples were taken out and cooled down at room temperature. Measurements of the samples for each were taken after a minimum of 2 hours. The process was repeated every 500 hrs.
- Sample size: 8 pieces



Oven

PTM7000 remain reliable up to 2000hrs for 150˚C baking.

PTM7000 PASSED DRIPPING TEST WITH 800X CYCLE WITH POWER DEVICES

PRODUCT	UNIT	ANTI - DRIPPING RESULT (TEMPERATURE CYCLE)	
		400X	800X
PTM7000 - Pad	No shim	Pass	Pass

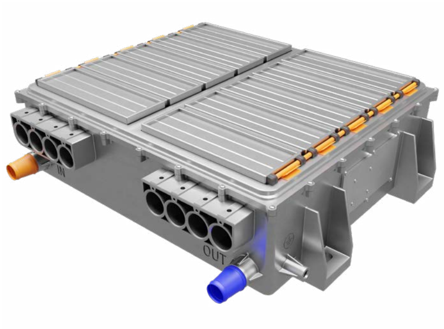
SUITABLE FOR THIN GAPS

The actual application thickness of this material can be as low as 0.03~0.05 mm. Compared with traditional thermal interface materials, it can reduce the thickness by 3-4 mm, which is very conducive to reducing the size of the inverter and optimizing the design.

OUTCOME

By adopting Honeywell's phase change thermal interface material solution, Zenith is expected to significantly improve the inverter's heat dissipation efficiency and operating stability while effectively reducing heat loss during operation and the risk of overheating. This will lead to performance degradation and the risk of failure, thereby extending the inverter's service life.

The new inverter enables 40% weight reductions, 30% overall size reductions, and 25% higher power densities. SiC devices offer 2–3 times lower on-state voltage drop than Si and 10x higher breakdown field than Si. It has better thermal conductivity and better high-temperature stability. It also has a smaller power size than silicon and a faster switching speed, leading to lower switching losses, with SiC reducing these by 70%. Therefore, it is especially suitable for high switching speed or power occasions. The advantages of SiC power electronics are particularly evident in 800 V battery systems.



The ultra-thin design of the PCM will also help Zenith:

- Achieve miniaturization design, bringing dual benefits of cost-saving and space optimization for their inverter
- Further improve inverter's performance, promoting its widespread application
- Enhance market competitiveness in the new energy vehicle industry

Learn more

Connect with us to learn about our thermal management solutions for modern electric vehicles.

Visit
hwll.co/PCM-for-EV

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THE FUTURE IS WHAT WE MAKE IT

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