



Designed for The Future
Power Module
Packaging Solutions

New packaging solutions mean better performance and a better environment

As the world demands more from power electronics systems, the market for power modules has correspondingly tripled in the last ten years. Coupled with the surging call for more electrical energy, the need for innovative packaging materials for power semiconductor devices has intensified to keep up with new requirements.

New packaging innovations that have emerged in recent times allow smaller die areas to reach the required current output. They also result in more reliable power electronic components, optimizing performance and improving production robustness. These power modules operate at higher efficiency, thus providing an overall better experience and fewer accidents.

Reinforced use of power modules and innovation in packaging also means employing the most efficient means of electricity conversion and reducing losses in electrical power systems, saving up to 40% of energy for industrial applications. Combined with renewable energies, power modules are the key to zero-emission mobility in electric vehicles.

The advent of new packaging solutions will continue to benefit industries such as automotive, industrial, renewable energies, traction, and aerospace. With the wide choice of materials and solutions, we can realize the new packaging concepts for your specific requirements while maintaining cost-efficiency and performance-driven demands.



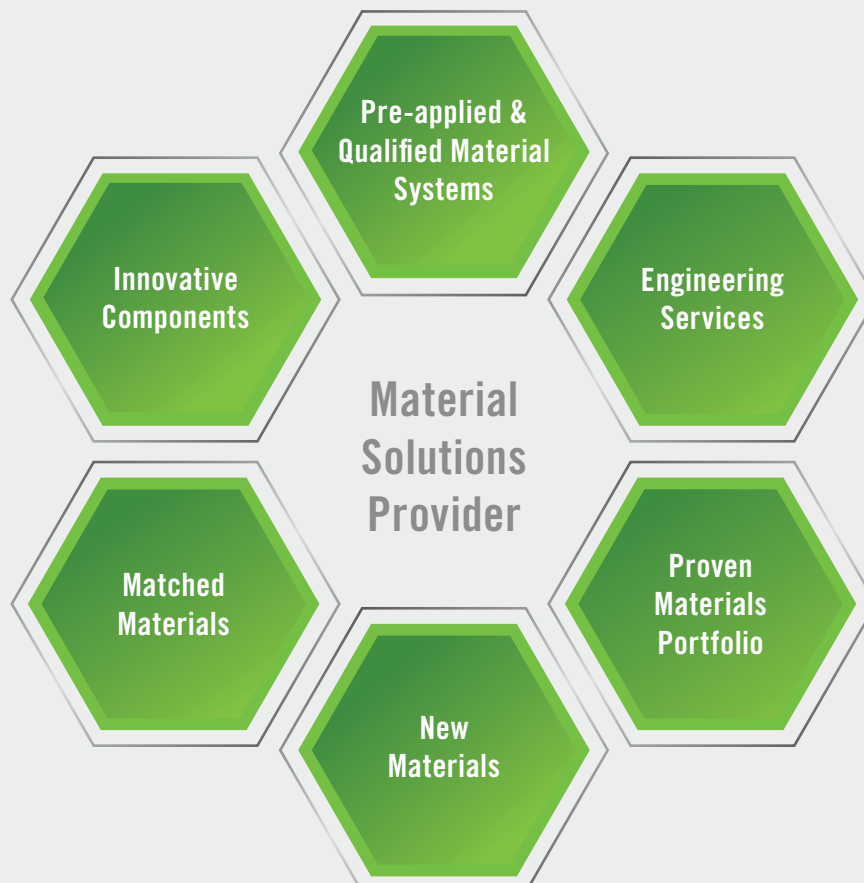


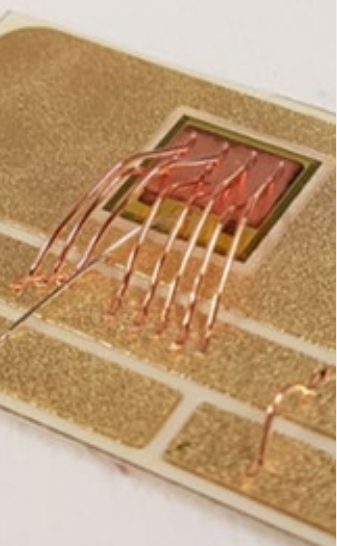
Heraeus Electronics

Your reliable material solutions partner for power modules

Heraeus Electronics develops and manufactures important materials solutions for the assembly and packaging technology of electronic devices: metal ceramic substrates, solder paste, sinter paste, bonding wires and ribbons, thick film paste, and encapsulation materials. When these materials are assembled in a single device, complexity increases. The performance and reliability of the devices depend not only on the performance of each material but also on the interplay of the materials in the end application.

With our broad portfolio and decades of experience in supplying materials to the automotive industry, we resolve these issues by creating perfectly matched solutions that minimize complexity and compromises. Heraeus Electronics is your partner of choice, answering your technical challenges by offering innovative materials, matched materials, and pre-applied and qualified material systems. Combined with our application knowledge and engineering service, we help you shorten your development cycles, lower your costs and bring next-generation products faster to market.





01

Market Trends

- Smaller dies
- Lower losses
- Higher efficiency
- Increased power density
- Increased current density
- Increased switching frequency
- High volume and cost-competitiveness

02

Packaging Trends

- Materials with improved heat dissipation
- Materials with increased current carrying capability
- Increased operating temperatures and reliability requirements
- Packaging solutions with reduced parasitic inductance
- Cost-effective solutions

03

Our Material Solutions

Assembly Materials

- Optimized lead-free solder paste to minimize voids and splutter
- mAgic® pressure sinter paste for high power density packages

Power Bonding Wires

- Copper wires and ribbons for outstanding long-term reliability and highly robust bonds to high resistant temperatures and mechanical stresses
- CucorAI PLUS or AI PLUS for higher operating temperatures and reliability

Material Systems & Engineering Services

- Die Top System (DTS®) for maximized power density and reliability
- Condura®+ pre-soldered and pre-sintered metal ceramic substrates for simplified and robust process and improved yields
- Condura®.classic (DCB Al_2O_3), most widely used metal-ceramic substrate with a superior cost-performance ratio
- Condura®.extra (DCB ZTA) with improved thermal cycling performance
- Condura®.prime (AMB Si_3N_4) substrates for high thermal conductivity and best-in-class reliability
- Condura®.ultra (Si_3N_4 Ag free AMB) is a cost-effective, high-performance metal-ceramic substrate for automotive traction applications
- AIN Ag free AMB is designed for medium to high voltage power such as traction, smart power grid and wind turbines applications. It has Ag free bonding technology to ultimately reduce electro-migration issue
- CemPack®* Frameless is a cost-effective inorganic encapsulation and works as a replacement for epoxy mold compounds, enabling higher operating temperatures
- CemPack®* Frame is the next inorganic encapsulation material to replace silicone potting for: improved lifetime, increased power rating, better thermal conductivity, and higher Tj
- Sensors allow potential free positioning next to the heat source or die
- Engineering services to develop customer-specific solutions

Material Solutions for Industrial Power Modules

As energy consumption of industrial plants rises, power electronics modules will be increasingly used to optimize energy efficiency. Coupled with the need for reduction in energy consumption for industrial motors and generators, the demand for greater efficiency of power electronics is driving manufacturers to source for new packaging solutions that can overcome traditional power module assemblies' limitations.

As the leading material solutions provider for power electronics packaging, Heraeus offers a broad and unique product portfolio for power electronics module assembly. From bonding wires, solder paste, sinter pastes to substrates, we have the ideal materials that optimize performance and efficiency for industrial power module applications. Our unique inorganic encapsulation CemPack®* material can also replace silicone gel while offering increased lifetime, power density, encapsulant stability and heat dissipation during power electronics operation.

SMD 1206 SC /
Pt 1000 solderable sensor

Copper ribbon
CucorAl Plus Bonding Ribbon

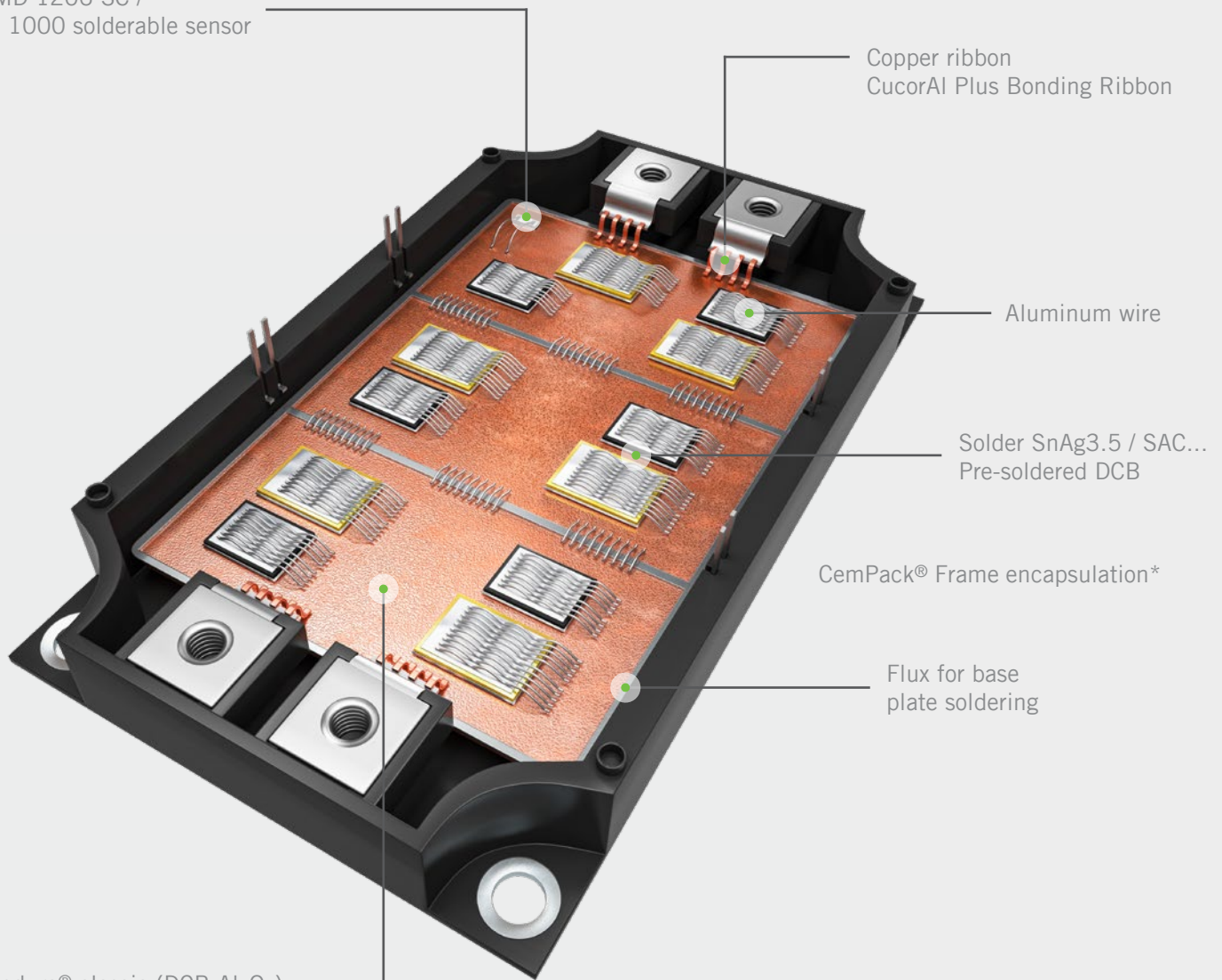
Aluminum wire

Solder SnAg3.5 / SAC...
Pre-soldered DCB

CemPack® Frame encapsulation*

Flux for base
plate soldering

Condura®.classic (DCB-Al₂O₃)



*Product under development

Challenges

- Improving lifetime in demanding electrical applications
- Innovate in standard packages
- Cost-effectiveness



Our Solutions

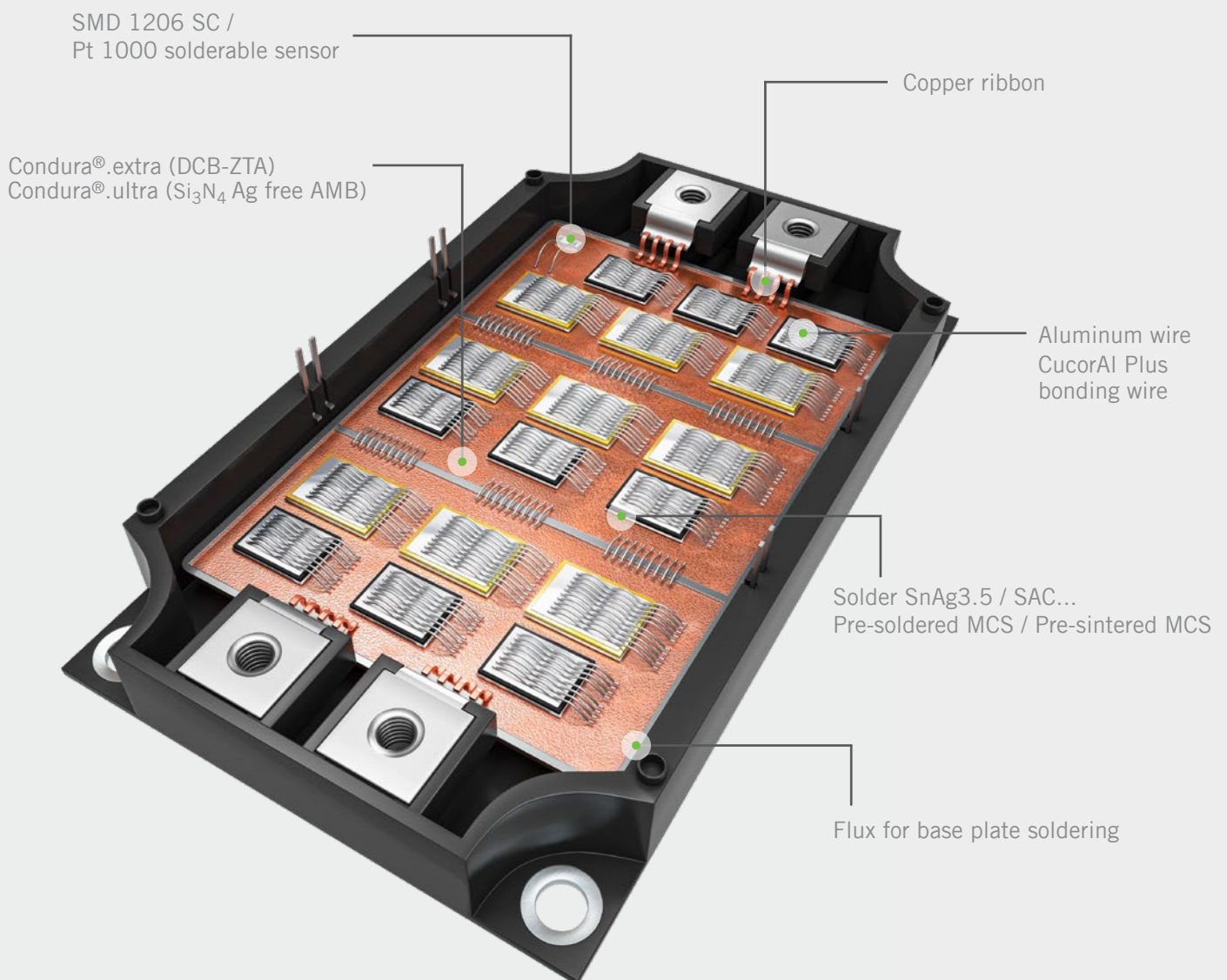
- Offer broad product portfolio for power electronics to create perfectly matched solutions
- e.g.:
 - Condura® .classic (DCB Al_2O_3)
 - Aluminum, CuCoAl and copper wires
 - Aluminum and copper ribbons
 - Solder pastes
 - Pre-soldered DCB

Material Solutions for Automotive Frame Modules

The increased use of wide-bandgap devices for electric vehicles have made new packaging solution development critical in overcoming challenges such as heat dissipation. To manage thermal challenges of SiC power modules, packaging materials with improved heat dissipation and current carrying capability must be used to maximize power density and increase power cycling reliability.

While most packaging materials cannot survive high temperatures, Heraeus' materials have the capability to do so. Our sinter pastes, Si_3N_4 AMB and Ag free substrates, DTS®, copper wires/ribbons can operate at temperatures exceeding 175°C and even 200°C.

Additionally, our new Ag free AMB bonding technology for bonding Cu to Si_3N_4 ceramic combines cost efficiency and high performance. It is available with high thermal conductivity of >80 W/mk for premium applications with SiC semiconductors and >60 W/mk for standard automotive applications.



Challenges

- Require high efficiency and high-power density for main inverters
- Fast switching speed
- Heat dissipation
- Cost-effectiveness
- Long term reliability in harsh conditions, e.g. Tj 200°C
- Robust processes with high yields



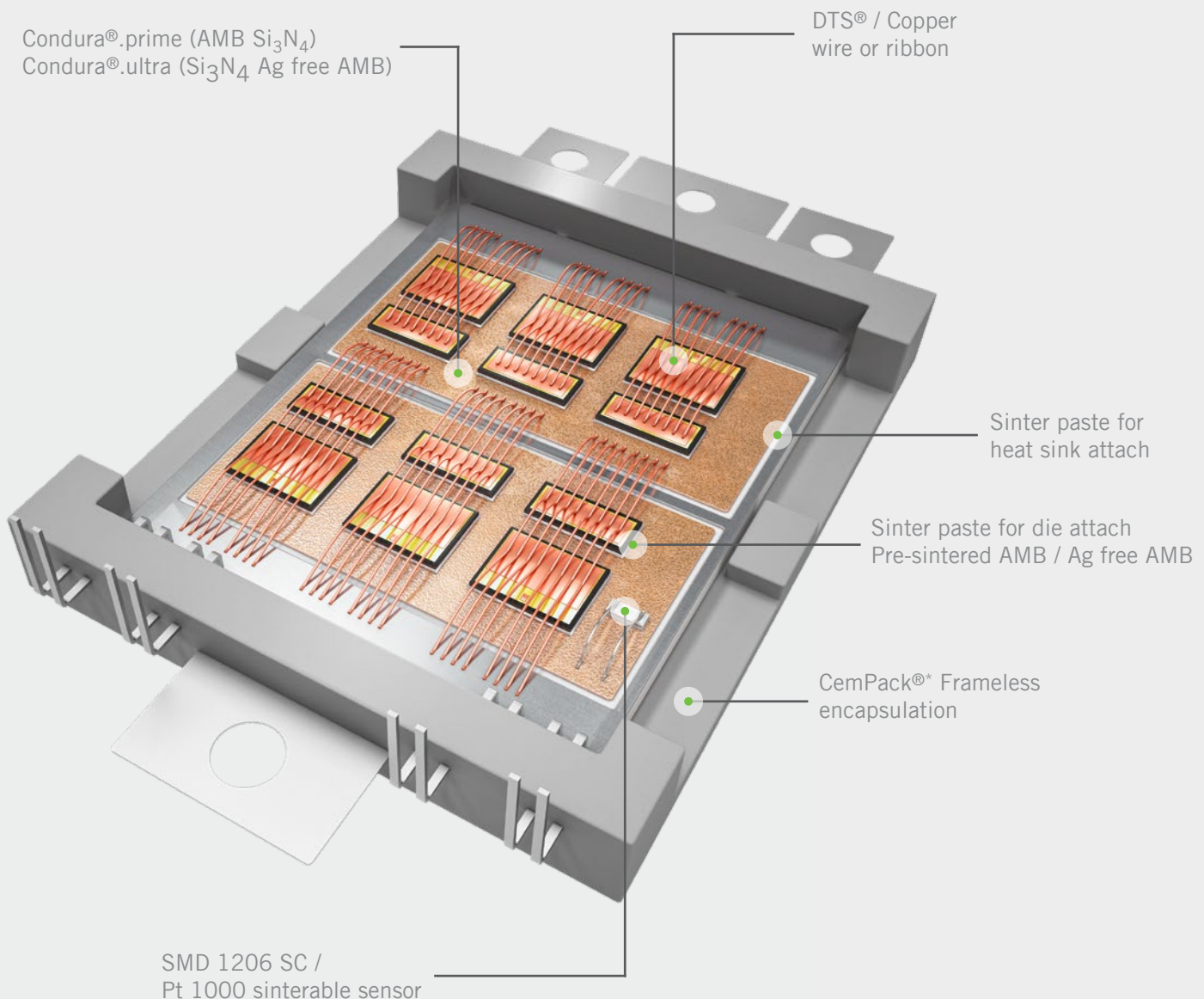
Our Solutions

- Heraeus high temperature die attach (sinter paste) can survive temperature above 175°C
- CucorAI PLUS aluminum clad copper wire for increased reliability and superior electrical and thermal performance compared to aluminum wire
- Wide range of metal ceramic substrates to optimize price-performance ratio for standard and premium applications

Material Solutions for Automotive Frameless Modules

As new material solutions are developed for power module packaging, the material combination will get increasingly complex. All it takes is just one weak material within the stack to significantly reduce thermal performance, power density and reliability.

At Heraeus, we provide a complete material system solution for electric vehicle inverter. Our sinter pastes, Si_3N_4 AMB and Ag free AMB substrates, DTS[®], copper wires/ribbons and CemPack[®]* encapsulant can operate at temperatures exceeding 175°C and even 200°C. Our new Ag free AMB bonding technology for bonding Cu to Si_3N_4 ceramic combines cost efficiency and high performance. It is available with high thermal conductivity of >80 W/mk for premium applications with SiC semiconductors and >60 W/mk for standard automotive applications.



Challenges

- Require high efficiency and high-power density for main inverters
- Fast switching speed
- Heat dissipation
- Long term reliability in harsh conditions, e.g. Tj 200°C
- Cost-effectiveness challenge
- Robust processes with high yields



Our Solutions

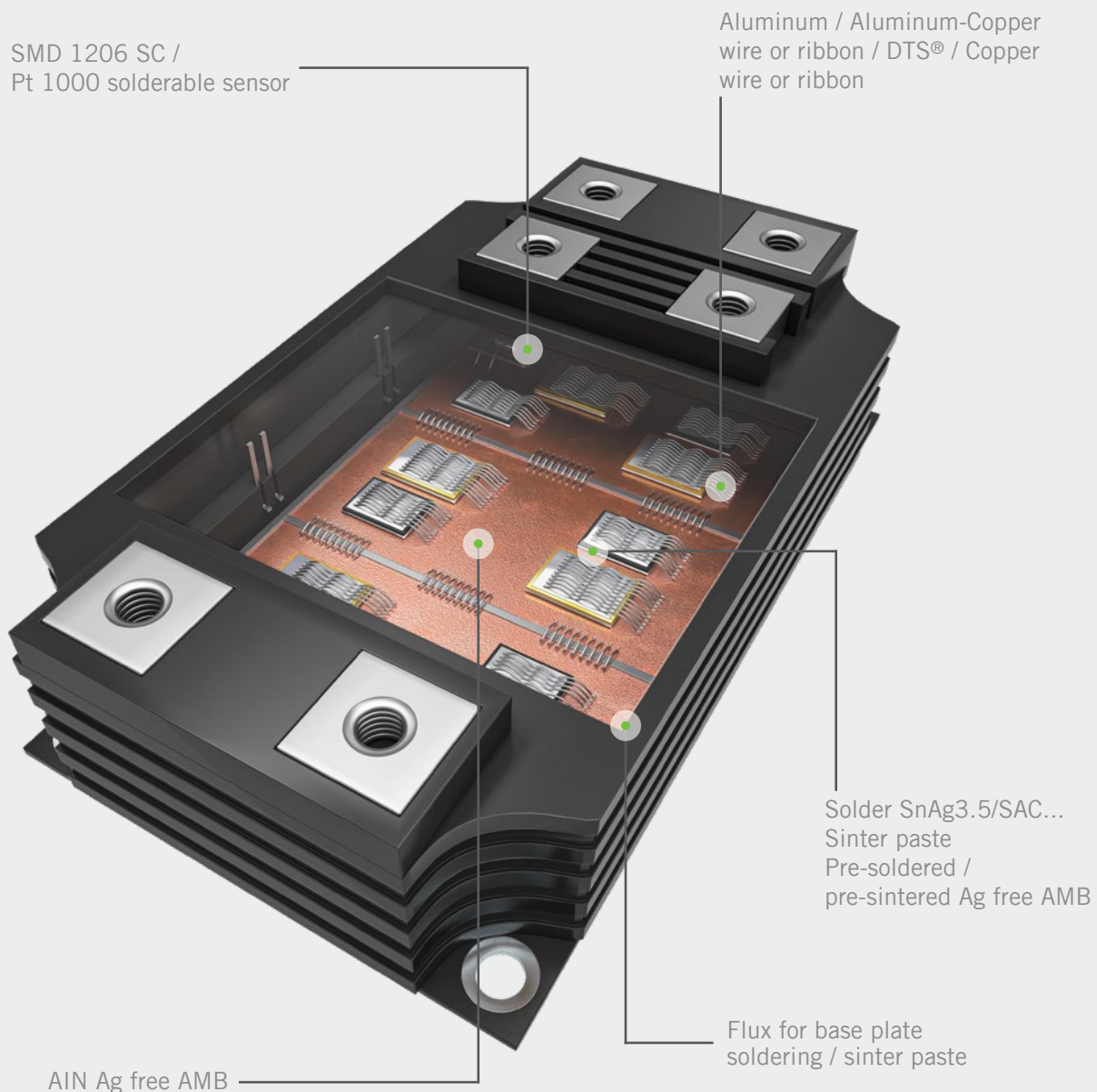
- Heraeus high temperature die attach (sinter paste) can withstand temperature above 175°C
- DTS® with pre-applied sinter paste and Cu wire or ribbon maximize power density and reliability
- Si₃N₄ metal ceramic substrates with new bonding technology Ag free AMB for high performance substrates with improved cost efficiency
- Low inductance substrates* to reduce parasitic inductance
- CemPack®* encapsulant material overcome challenges in power module stability and reliability over 200°C

*Product under development

Material Solutions for High-Voltage Power Modules

From ships and vessels, smart power grids, high powered windmills to rail transportation, the demand for high-voltage power modules is ever increasing. High reliability in module assemblies is essential for high-voltage power modules to operate smoothly. These modules must ensure long-term insulation at voltages exceeding 3.000 V and currents exceeding several thousand amperes. With traditional modules facing inherent issues such as electro-migration, high electric field/high current density and heat dissipation, improved material solutions are needed to meet new requirements.

Heraeus' packaging materials such as AlN Ag free AMB, low inductance substrate* and DTS® with pre-applied sinter paste are designed to overcome these challenges, offering significant improvement in performance and reliability for high-voltage power modules.



Challenges

- Long term insulation $>3.000\text{ V}$
- Partial discharge
- Heat dissipation
- Electro-migration in harsh environment
- High current densities $>1000\text{ A}$
- Parasitic inductance



Our Solutions

- AlN Ag free AMB reduces migration risk with Ag free bonding technology combined with best-in-class heat dissipation
- DTS® with pre-applied sinter paste combined with Cu wire/ribbon maximize current density and reliability. It enables consistent temperature distribution across die
- Low inductance substrates* for reduced parasitic inductance

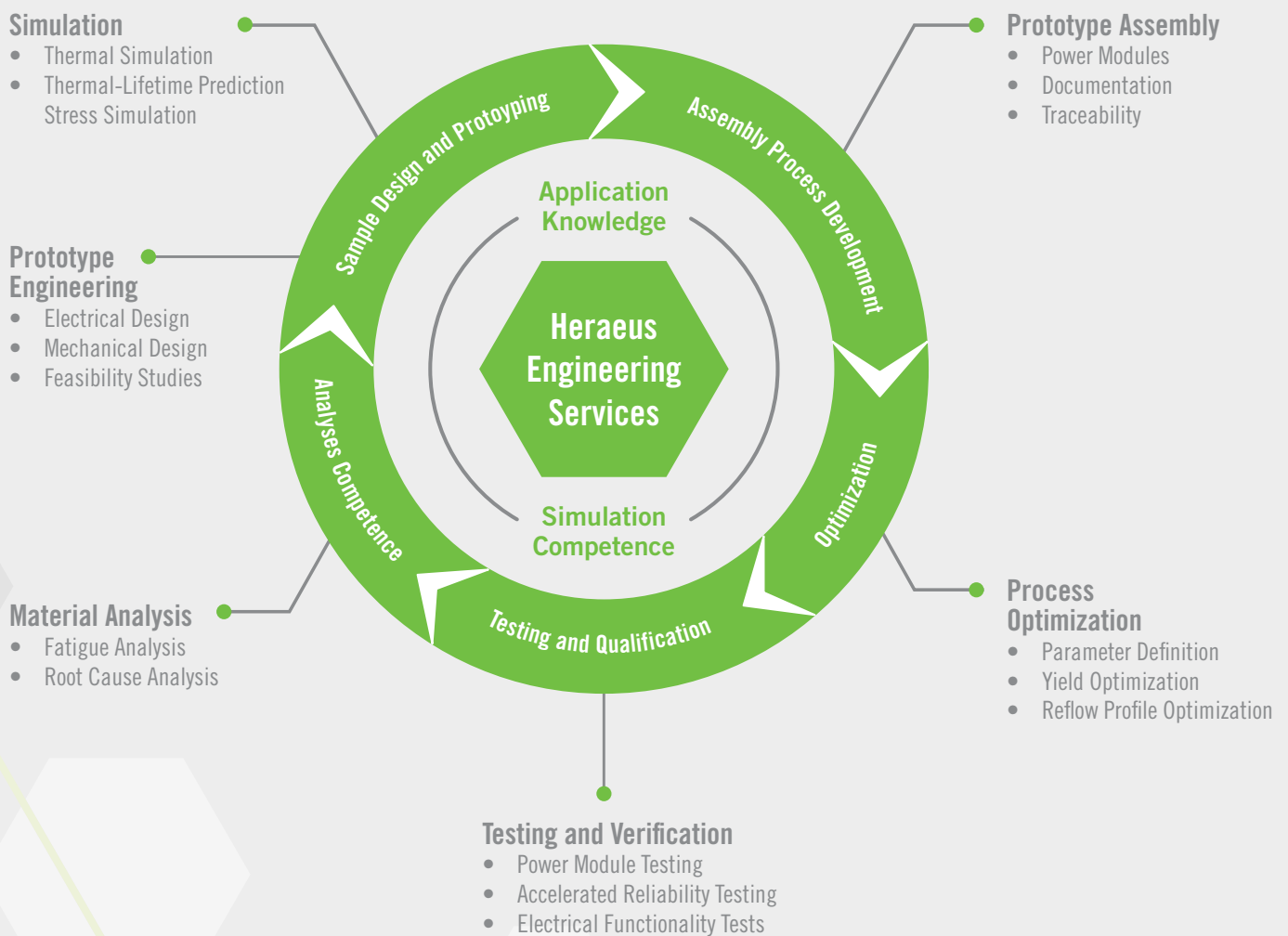
*Product under development

Providing material solutions that matter

Your reliable partner serving your needs

With an optimal infrastructure and comprehensive equipment, our engineering services shorten product development cycles through our application knowhow and expertise in matching materials, thereby lowering costs, and bringing next-generation products faster to market.

Our expertise in material integration, optimization and understanding of material combinations, and the ability to test them under simulated conditions in our lab allow manufacturers to better understand material behaviors and the reliability of their products under simulated conditions. This accelerates the development process with higher first-time success rates.



We are Heraeus Electronics

We are one of the leading manufacturers of materials for the assembly and packaging of devices in the electronics industry. We develop sophisticated material solutions for the automotive, power electronics, and semiconductor industry. Our core competencies include bonding wires, solder and sinter materials, thick film pastes, and substrates.

Headquartered in Hanau, Germany, Heraeus Electronics has a global footprint with eight production sites across six countries, ensuring a high supply chain reliability.

Additional four application centers located across Asia, USA and Europe enable us to support the needs of local markets, ensuring proximity and quick response time for our regional customers. Our customers benefit from shortened development cycles with higher first-time success rates, leading to faster time to market.



Headquartered in
Hanau, Germany



Over **1200+**
employees worldwide



More than **50 years**
of experience in providing
materials for the electronics
industry



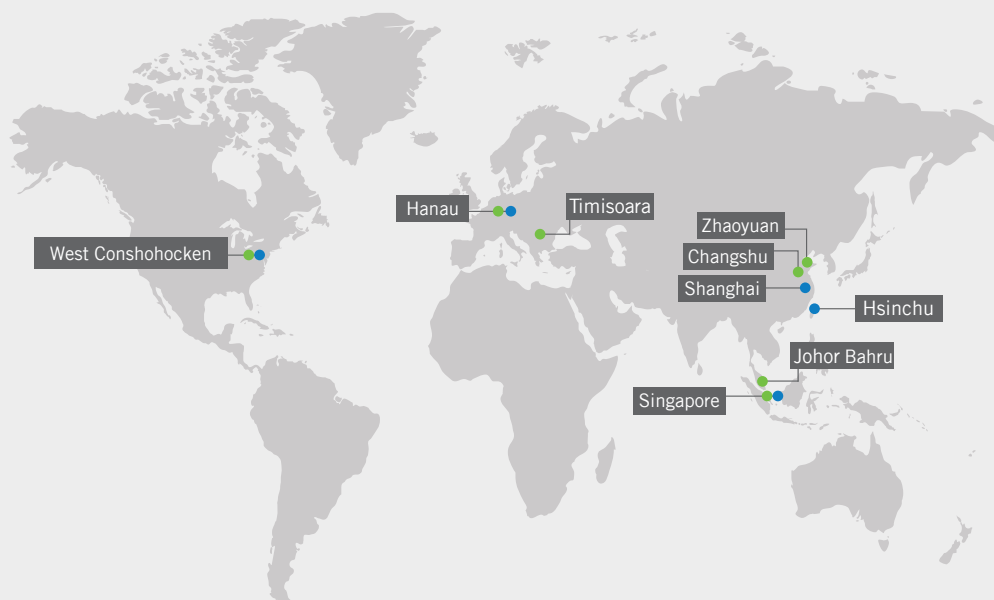
8 production sites
across **6 countries**



Product distribution to
over 50 countries

Production sites and application centers

Strategic locations to support our customers worldwide



PRODUCTION SITES

Hanau
Timisoara
West Conshohocken
Johor Bahru
Changshu
Zhaoyuan
Singapore (2x)

APPLICATION CENTERS

Hanau
West Conshohocken
Shanghai
Hsinchu
Singapore



HERAEUS GROUP

THE GLOBAL TECHNOLOGY COMPANY

The Heraeus Group is a broadly diversified and globally leading family-owned technology company, headquartered in Hanau, Germany. The company's roots go back to a family pharmacy started in 1660. Today, Heraeus bundles diverse activities in the Business Platforms Metals and Recycling, Healthcare, Semiconductor and Electronics as well as Industrials. Customers benefit from innovative technologies and solutions based on broad materials expertise and technological leadership.

In the 2022 financial year, the group generated revenues of €29.1 billion (US\$30.6 billion*) with approximately 17,200 employees in 40 countries. Heraeus is one of the top 10 family-

owned companies in Germany and holds a leading position in its global markets.

(* calculated with 2022 average exchange rate, 1€ = 1.0530 US\$)

About Heraeus Electronics

Heraeus Electronics is a leading manufacturer of materials for the assembly and packaging of devices in the electronics industry. The company develops material solutions for the automotive, power electronics and advanced semiconductor packaging market and offers its customers a broad product portfolio - from materials and material systems to services.

The data given here is valid. We reserve the right to make technical alterations.

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The descriptions and engineering data shown here have been compiled by Heraeus using commonly-accepted procedures, in conjunction with modern testing equipment, and have been compiled as according to the latest factual knowledge in our possession. The information was up-to date on the date this document was printed (latest versions can always be supplied upon request). Although the data is considered accurate, we cannot guarantee accuracy, the results obtained from its use, or any patent infringement resulting from its use (unless this is contractually and explicitly agreed in writing, in advance). The data is supplied on the condition that the user shall conduct tests to determine materials suitability for particular application. The Heraeus logo, Heraeus, Condura®, DTS®, Die Top System® and the Condura, DTS, Die Top System figurative mark are trademarks or registered trademarks of Heraeus Holding GmbH or its affiliates. All rights reserved.

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Document Number: HET71010ENG-0922-2 | Version: 02/2022