

Heraeus



**Materials and Material Systems
for Power Electronics**

Power Electronics in Focus

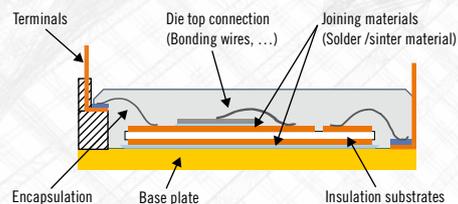
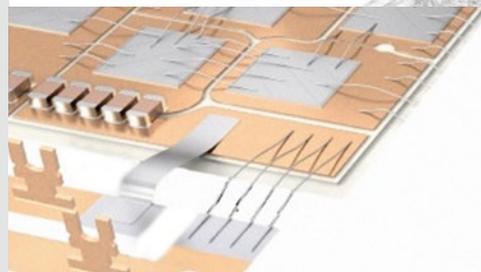
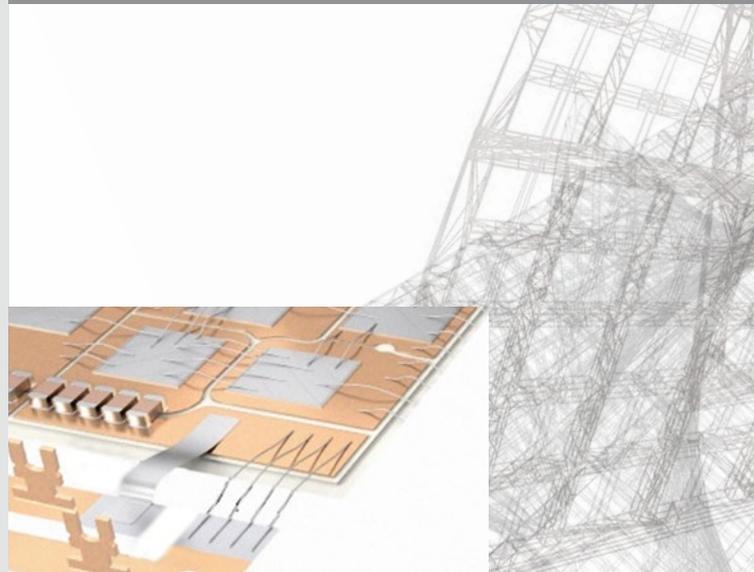
Materials and Material Systems for Power Electronics

Heraeus, the technology group headquartered in Hanau, Germany, is a leading international family-owned company formed in 1851. With expertise, a focus on innovations, operational excellence and an entrepreneurial leadership, we strive to continuously improve our business performance. We create high-quality solutions for our clients and strengthen their competitiveness in the long term by combining material expertise with technological know-how. Our ideas are focused on themes such as the environment, energy, health, mobility and industrial applications. Our portfolio ranges from components to coordinated material systems which are used in a wide variety of industries, including the steel, electronics, chemical, automotive and telecommunications industries.

In the 2014 financial year, Heraeus generated product revenues of € 3.4 bn and precious metal revenues of € 12.2 bn euros. With around 12,600 employees worldwide in more than 100 subsidiaries in 38 countries, Heraeus holds a leading position in its global markets.

Material Systems – Excellence in Solutions

- Today Heraeus Electronics already ranks as one of the leading suppliers of materials for the assembly and connection technology used in the electronics field, offering such products as bonding wires, solder and sinter pastes, adhesives and metal connectors.
- By venturing into the production of metal-ceramic substrates Heraeus Electronics will be expanding its portfolio with materials, material systems and their structural design in the important and strongly growing market of power electronics and sophisticated automotive applications.
- Heraeus offers decades of experience in electronics for industry and the automotive sector. With the establishment of the new Application and R&D Center for Power Electronics and with its proven analytical competence, Heraeus is your prime choice as innovation partner.



Applications

- Industry
- Automotive
- Traction
- Renewable Energy
- Home Appliances
- Others

Contents

	SUBSTRATES	4–5
	JOINING MATERIALS	6–7
	DIE TOP CONNECTION	8–9
	TERMINALS & LEAD FRAMES	10–11
	SENSORS	12
	MATERIAL SYSTEMS	13
	APPLICATION AND R&D CENTER POWER ELECTRONICS	14
	ANALYTICAL COMPETENCE	15



Substrates

DCB – Direct Copper Bonded

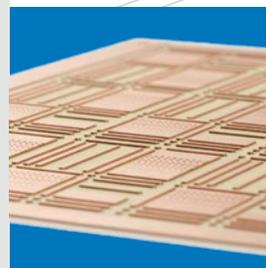
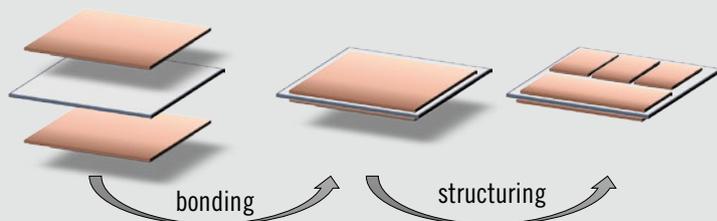
In the power electronic modules, the insulation substrate represents the “backbone part“. It is the carrier of the semiconductor die. In addition it acts as an electrical insulator for the heatsink and inverter housing.

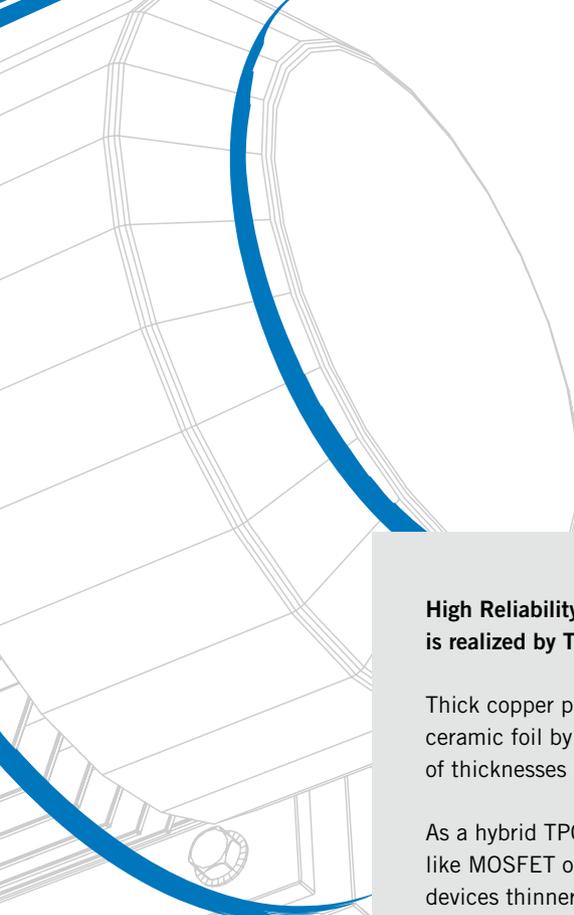
DCB is used mainly in high-performance modules. A copper foil is bonded onto the top and lower surface of the ceramic layer using a specific oven process and based on an eutectic melt effect without additional interlayers.

The top side layer is structured with a customer specific pattern for individual topological interconnection.

The correct choice of ceramic materials depends to a large extent on the particular application and various insulation, reliability and thermal specifications. Cost efficiency also plays an important role. A perfect fit for each application is sought for.

Heraeus has entered the DCB substrate business. Combined with its high-level expertise in joining materials, Heraeus can advise and offer optimized surfaces for individual requirements and application needs. Further innovations are to be announced soon. It remains an exciting time.





High Reliability and High Structuring Flexibility is realized by Thick Printed Copper (TPC) Technology

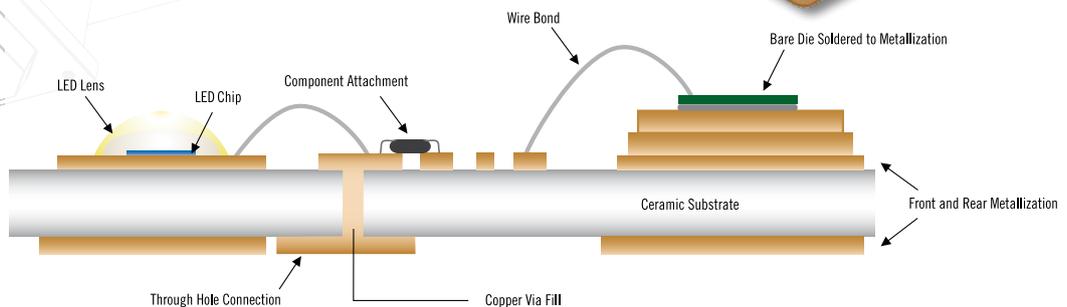
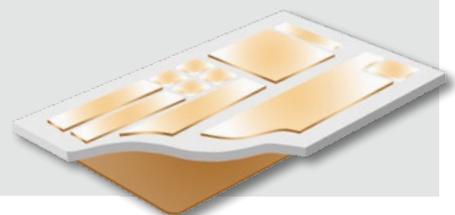
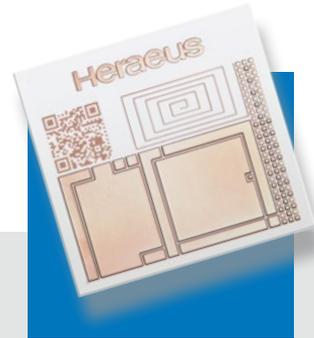
Thick copper paste is applied to Al_2O_3 or AlN ceramic foil by screen print process suitable for layers of thicknesses between 25 μm up to 300 μm .

As a hybrid TPC can provide thick layers for power devices like MOSFET or IGBT while for signal tracks and logical devices thinner layers are applied on the same ceramic – this combination of power and logic components on one circuit allows for minimum inductance and optimum space utilization.

TPC is well established in automotive, aerospace, defense and other applications which require high reliability or where hybrid solution of logical and power device on same insulation substrate is needed.

Advantages of the Thick Film Solution

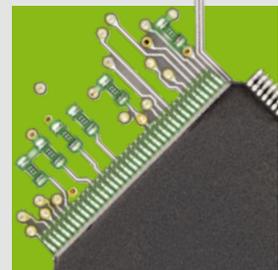
- Zero failure after 1000 thermal cycles (-40 to +150 °C)
- High mechanical robustness
- Excellent electrical and thermal properties
- Lowest inductance and maximum space utilization by combining logic and power circuits on one substrate
- Applicable to Al_2O_3 , AlN and BeO
- Excellent fired film density
- Wire bondability, solderability, plateability
- High fired film thickness (up to 300 μm)



Joining Materials

Solder Pastes for Die Attach

As one of the leading suppliers of solder pastes for power electronic applications, Heraeus has extensive experience in the development and production of soldering materials that meet the demanding requirements of power module manufactures. Heraeus' materials are suitable for vacuum soldering processes, show exceptional stable printing consistency and easy clean flux residues.



Sinter Pastes

As a leading materials supplier for the die attach industry Heraeus develops new lead-free and extremely robust solutions for power electronic applications. After long term of development the mAgic (Microbond Silver Interconnect) product family was established in 2010. The silver based sinter pastes are made for highest known thermal and reliability requirements by providing superior thermal and robustness features. The outstanding capability was proven in high power applications with special requirements and in many years of experience in close cooperation with our customers.

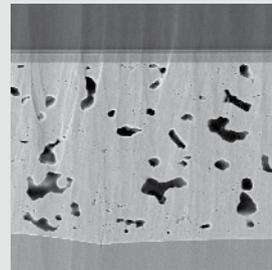
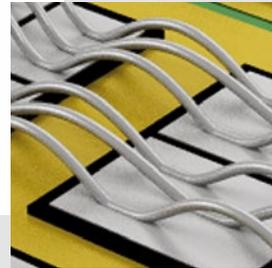
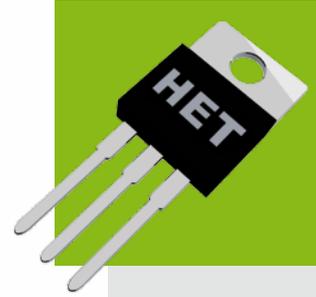
It has the potential to replace high lead solder which is still in use for power discrete devices. The sinter concept is an improved joining method especially for applications with higher reliability requirements e.g. automotive, wind energy or traction.

The mAgic product technology platform, consisting of sinter pressureless and pressure assisted pastes, will cover existing and future requirements and regulations for power packages.



Key Advantages (in Comparison to Solder)

- Significant increased life time
- Higher operation temperature
- Improved thermal conductivity
- Wide range of process window
- Flux and splattering free



Die Top Connection

Bonding Wires and Ribbons

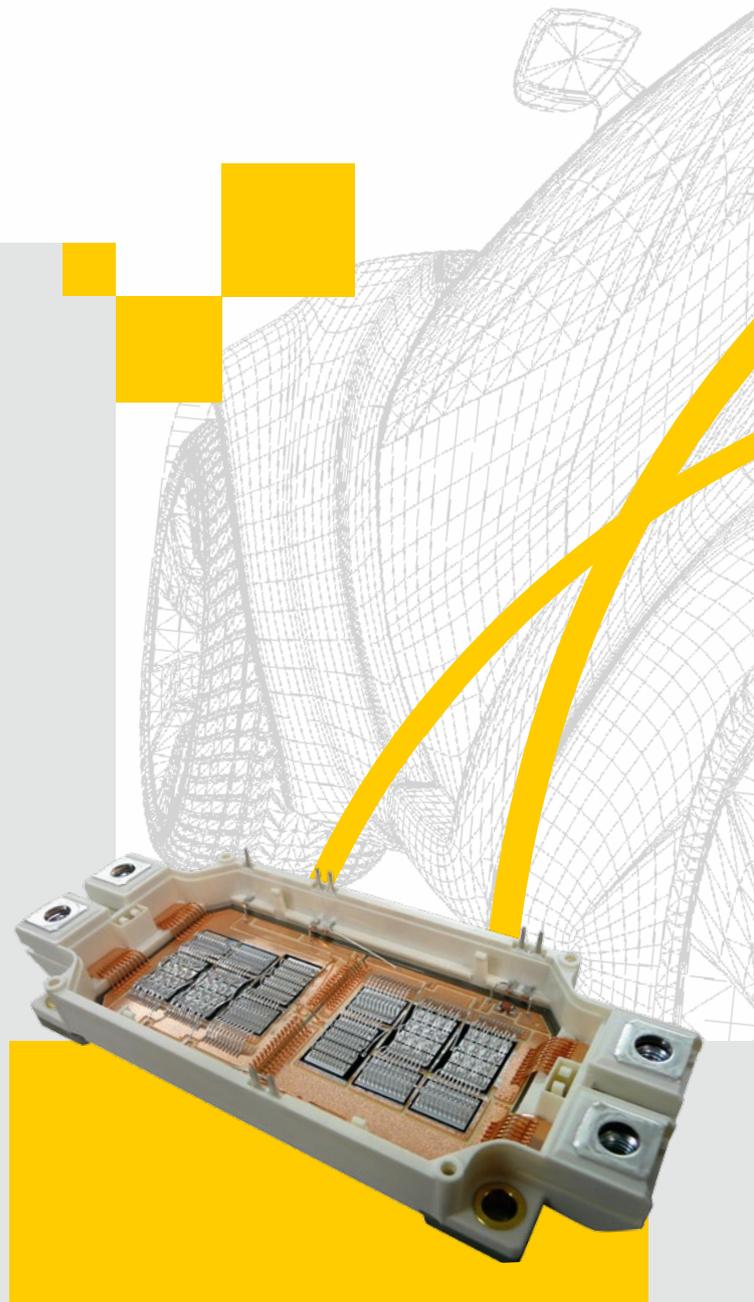
Bonding wires and ribbons, used to electrically connect the chip pads to the next level of interconnect, are an important and highly reliable constituent in the power electronics sector.

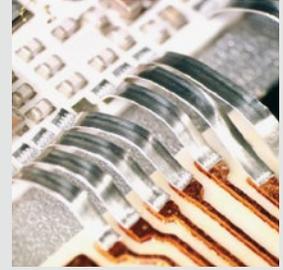
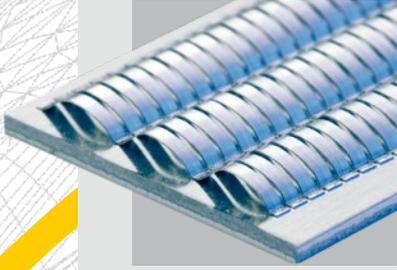
For this purpose, fine wires of diameters from 100 μm to 500 μm are in common use. During the last years, also ribbons have found their segment. Highest demands are made on their quality, especially with regard to the uniformity of the wire properties.

Bonding wires for power electronics are usually made from aluminum and aluminum alloys. They are used in areas of application with low processing temperature – in most cases at room temperature. Depending on their chemical composition and specific properties, the bonding wires are adapted to the bonding technique selected and to automatic bonding machines, as well as to the various production conditions.

Within the last years, wires made of pure copper and hybrid wires made of a combination of aluminum and copper are emerging in the market. These provide additional performance in terms of reliability and cycling test withstanding. Thick copper materials require advanced bonding technology and advanced, copper-bondable chips. Therefore, the shift from aluminum bonding to copper bonding is considered as a system change.

Even much finer gold and copper bonding wires are used in some areas of Power Electronics, for example on hybrid substrates, or in discrete parts, which in the end are built-in and adapted to power electronics units.



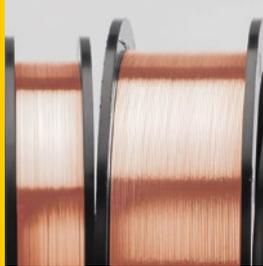
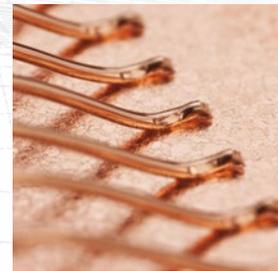


Advantages of Heraeus Aluminum Bonding Wires and Ribbons

- Well-proven easiest connecting technology
- High electrical loads
- A significant number of wires can be replaced by one ribbon
- Ribbon: "Soft bonding" due to the distribution of bond force and energy over a larger area (larger cross-section)
- High manufacturing yields
- Bondable on all common chip surfaces
- Available in a wide range of dimensions

Advantages of Heraeus Copper and Al/Cu Bonding Wires and Ribbons

- Advanced connecting technology
- Highest electrical loads
- Higher reliability and cycling achievable, compared to pure aluminum
- Al/Cu Hybrid wire and ribbon can be bonded using the common aluminum technology and machinery, while providing improved conductivity and reliability
- Al/Cu Hybrid wire and ribbon are bondable on all common chip surfaces
- Available in a wide range of dimensions



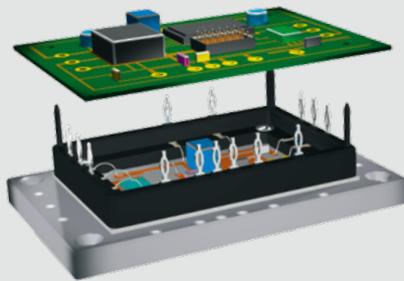
Terminals & Lead Frames

Roll Clad Strips and Precision Stamped Parts including Functional Surfaces

Heraeus deals with high precision, complexity and miniaturization for roll clad semi-finished products, precision stamped parts, flexible substrates as well as multilayer metal plastic packages. Our products meet the most demanding of functional requirements through the combination of established surface finishing processes such as selective electroplating.

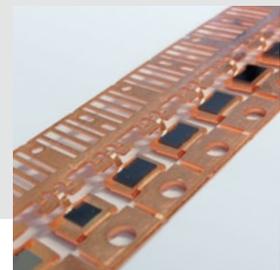
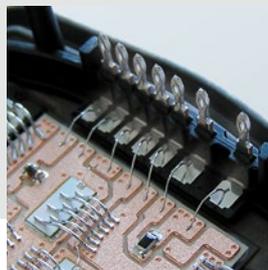
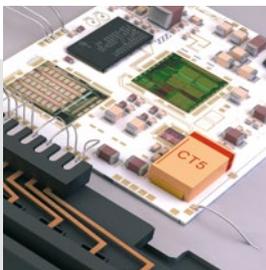
Success is guaranteed by 3D-CAD engineering and FEM-Simulation, by vertically integrated production processes, by extensive materials know-how, by different applications of the precision parts and by comprehensive analytical facilities as an additional service offer for our customers.

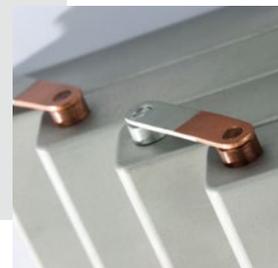
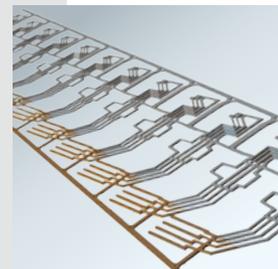
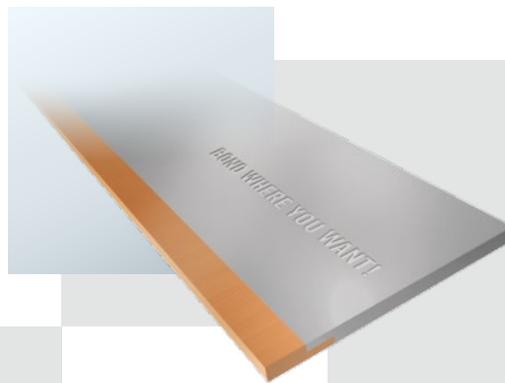
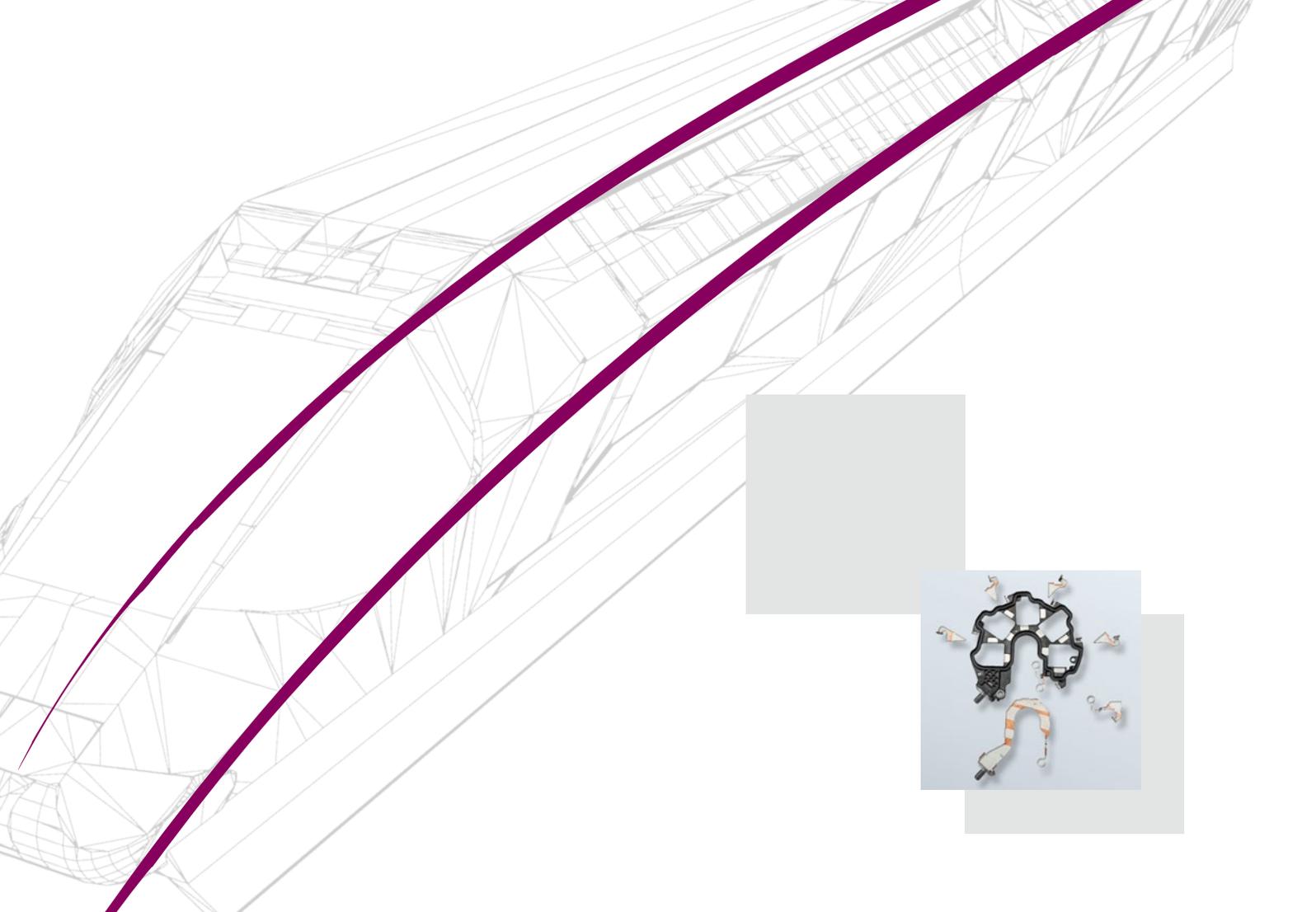
System solutions combined with SMT-materials and bonding wires complete the portfolio in electronic and power applications.



Advantages of Roll Clad Strips and Precision Stamped Parts

- High yield for next process steps in power applications
- Suitable for ribbon and wire bonding as well as sintering
- Multilayer packages with different materials and cladding layouts
- Combinations of conductive and non-conductive materials possible
- Various surface coatings with customized layouts possible
- High performance for transmitting high electrical loads
- Optimized thermal management
- Robust for sophisticated applications



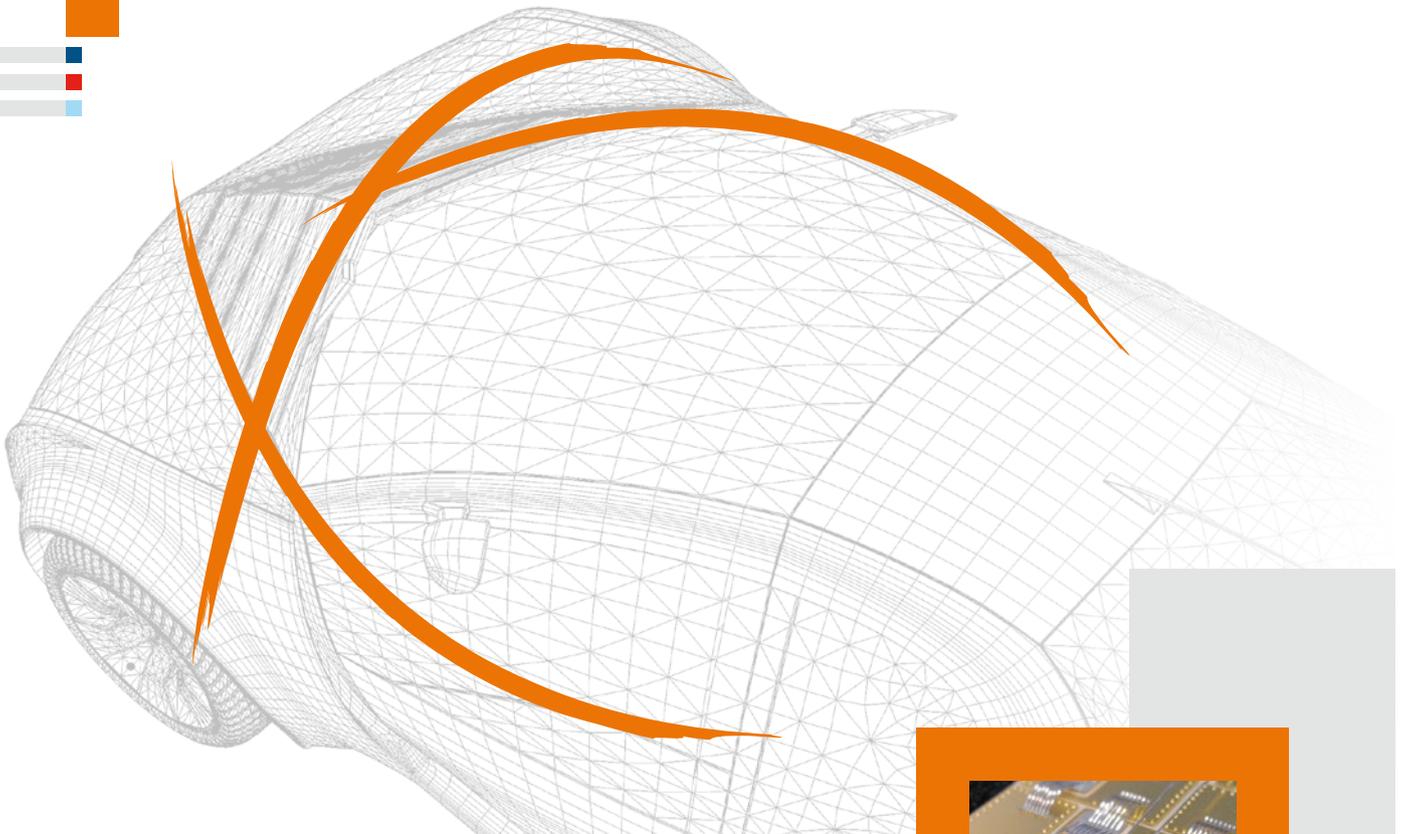
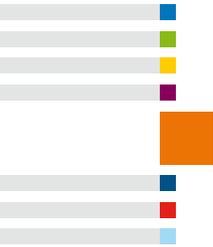


Heraeus – Your Competent Partner

In close cooperation with you, we develop the best solution to match your idea.

With our long years of experience, we are the competent partner at your side. Make the most of our expertise – for your success!

Sensors



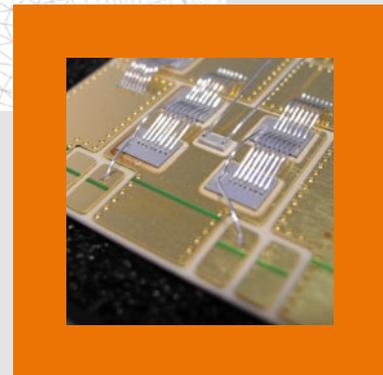
Platinum Temperature Sensors

In power electronic packages a non-insulated temperature sensor is often integrated in SMD design or as chip sensor. The insulation to base plate is made by a specific pattern of the metallized insulation substrate. The characteristic of resistance as function of temperature is nonlinear.

Heraeus has developed an insulated Platinum temperature sensor for power electronics. It is bondable on e.g. DCB metallization on the same metallization pad like the die and suitable for thick-wire bonding. With linear characteristic it enables very accurate temperature measurement.

Key Advantages

- Assembly by soldering, pressured or unpressured silver sintering, adhesive bonding
- Contact pads suitable for thick-wire bonding
- Save substrate area – it can be allocated potential-free close to the heat source / die
- Long-term stable, high precision temperature with standardized characteristics
- Application temperature range up to 300 °C (depending on joining technology)
- RoHS compliant



Connecting Competence to Solutions

The packaging and joining technology used in power electronic modules has an influence on the actual module performance that cannot be underestimated. It influences, for example, insulation and surge current capability, stray inductance, thermal dissipation etc. It also plays a major role in the areas of reliability and endurance.

Merely optimizing individual joining and packaging materials is only of limited benefit to the performance of the power module. The reason being obvious: Improvement is only possible within the limited scope of accelerated stress tests, load or temperatures cycles. However, this is of short duration only, since as soon as one weak mechanism is improved, the next weakness appears. For this reason, a suitable range of improved materials must be considered to ensure an optimal longterm effect on performance.

Heraeus therefore adopts a system approach strategy. Starting as of now, Heraeus is the leading partner offering a superlative range of materials developed in close collaboration with the customer for power electronic systems. Apart from offering materials such as bonding wires, joining materials, insulated substrates, and stamped parts Heraeus provides an R&D oriented partnership with specialist knowledge in the field of materials application and testing know-how. We are in a position to develop and test on a par with our customers. The new Application Center is a vital step in this direction.

Application and R&D Center Power Electronics

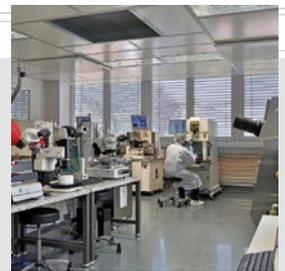
Heraeus has established a new Application and R&D Center for Power Electronics that includes a state of the art clean room and ESD laboratory. With this Heraeus offers a unique advantage for customers as it covers the full production and testing process for power electronics. Using the latest equipment Heraeus is able to assemble prototypes and to test modules according to latest standards or customer requirements. The customer benefit is a partnership exchange on a high level of process and development capability.

Abstract of Processing Capability:

- Vacuum reflow process
- Screen printing
- Mounting, placement and dispensing
- Sintering
- Wire bonding

Abstract of Testing and Analysis Capability:

- Scanning acoustic microscopy
- Laser Flash
- Electrical testing
- Environmental test
- Endurance tests



With Heraeus' decades of experience in electronics industry and with the establishment of the new Application Center customers will get pre tested material sets for power electronic applications.

Heraeus Electronics, the R&D partner

Analytical Competence

The Central Department for Chemical Analyses in Hanau specializes in both physical and chemical analysis. Working in tandem with the Applications Center, it means that it is possible to perform deep material and failure cause investigations. In particular with regard to power electronic applications, the department offers, amongst others, the following services:

Bonding Technology Laboratory

A wide variety of bonding machines and test procedures are available for investigations into the bondability and electrical properties of wires and substrates.

Metallography

Using a broad range of preparatory equipment and microscopes with a precise selection of illumination and contrast methods it is possible to characterize the microstructure of a wide range of metallic samples, composite materials and components.

Surface Analysis

High resolution SEM in combination with EDX and WDX allows the investigation of small structures down to nm scale as well as the analysis of local compositions. AES, XPS and SIMS aim for the characterization of the atomic composition of the surface and of thin layers and provide concentration depth profiles.

Elemental Analysis of Inorganic Materials

Highly sensitive elemental analyzers provide a fast and accurate analysis of C, O, H, N, and S for a wide range of solid materials, right down to the low ppm range, as well as the quantification of carbon and hydrogen present at the surface.

Mechanical Testing Methods

Equipment designed for tensile, bending and hardness test methods enable the determination of the mechanical properties of materials, for example tensile strength, elastic modulus or elongations.

Nondestructive Testing Methods

Ultrasonic scanners and radiographic inspections are at hand to detect material defects in metal, ceramic and plastic components.

Thermal Analysis

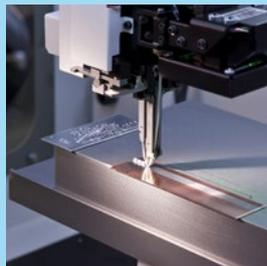
Different kinds of thermal analysis methods such as temperature coefficient measurement, dynamic scanning calorimetry and thermo mechanical analysis are available.



Scanning-Auger electron spectrometer for surface analysis



Scanning electron microscope (SEM, EDX, WDX)



Equipment for heavy wire bonding



Bonding laboratory

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