

The Power of Temperature Sensors in E-Mobility Applications



OUR HERAEUS NEXENSOS **EXPERTS**



Dr. Christoph Hartnig

VP BUSINESS DEVELOPMENT



Martin Bleifuß

HEAD OF GLOBAL APPLICATION ENGINEERING



The Power of Temperature Sensors in E-Mobility Applications

AGENDA



- 1 | SMD-type sensors in power electronics
- 2 | Sensor assemblies for e-motor protection
- 3 | Sensor solutions for safe charging infrastructure
- 4 | Questions & Answers

FROM MEGATRENDS TO SENSOR SOLUTIONS



E-MOBILITY



RENEWABLE ENERGIES



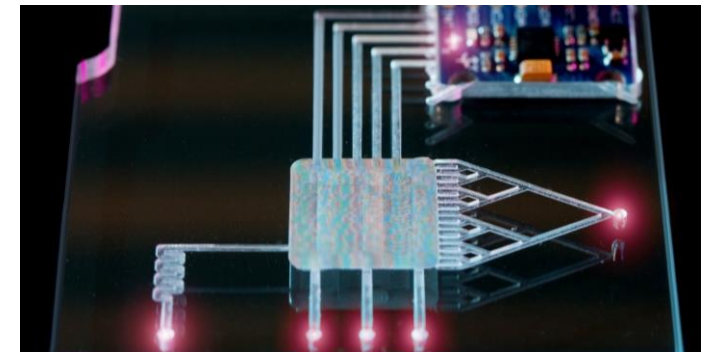
POLLUTION CONTROL



INDUSTRY 4.0

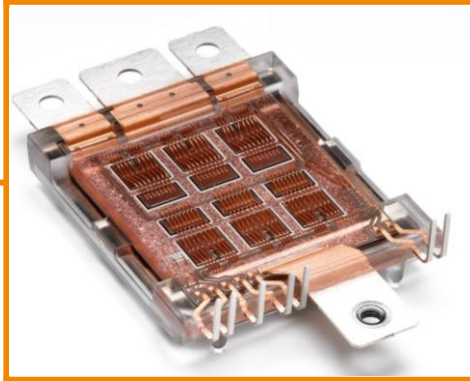


IOT – CONNECTED SENSING



HEALTH – POINT OF CARE

E-MOBILITY TRENDS



POWER ELECTRONICS

- Trend to SiC and GaN semiconductors
- Operation at higher switching frequencies and higher temperatures

[image: Danfoss]



ELECTRIC MOTORS

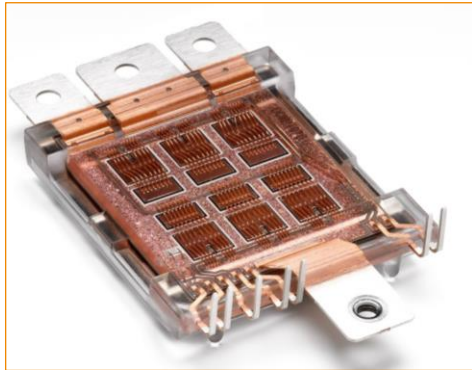
- Electrification of heavy duty and commercial vehicles
- Shared driving creates new use cases: longer operational life of passenger cars



CHARGING EQUIPMENT

- Higher charging powers
- New regulations with tighter requirements (new standard in China: GB20234.4)

FROM TRENDS TO SENSOR SOLUTIONS: POWER ELECTRONICS



[image: Danfoss]

POWER ELECTRONICS

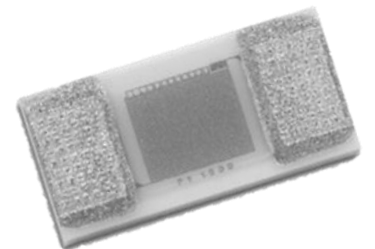
- Trend to SiC and GaN semiconductors
- Operation at higher switching frequencies and higher temperatures

APPLICATION REQUIREMENTS

- Need for new connection technologies: **sintering** turns into prevalent technology
- New designs for **optimized processing**, cost efficient production
- More accurate temperature sensing technologies to operate at the **upper temperature limit**

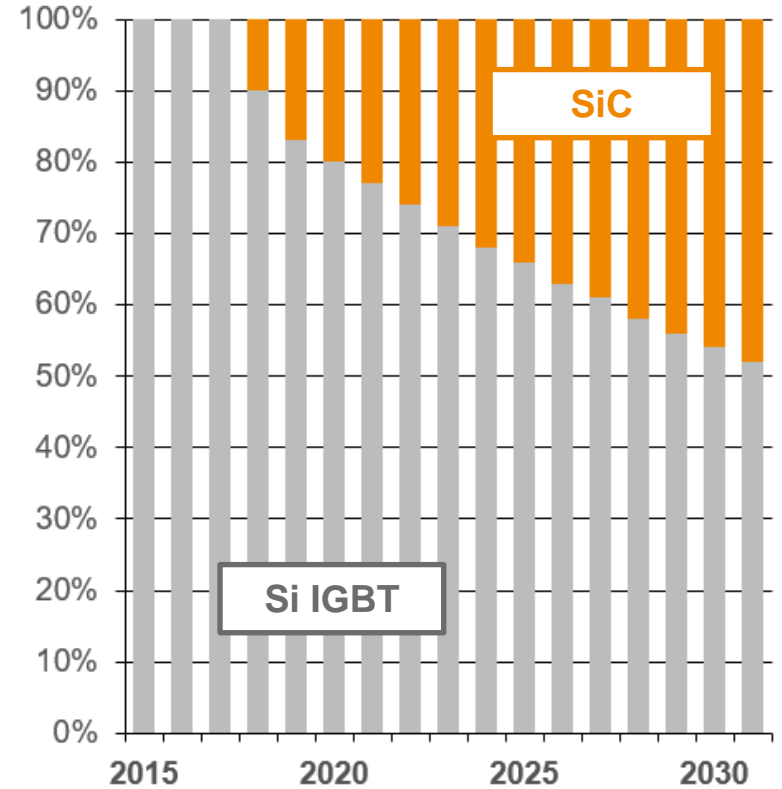
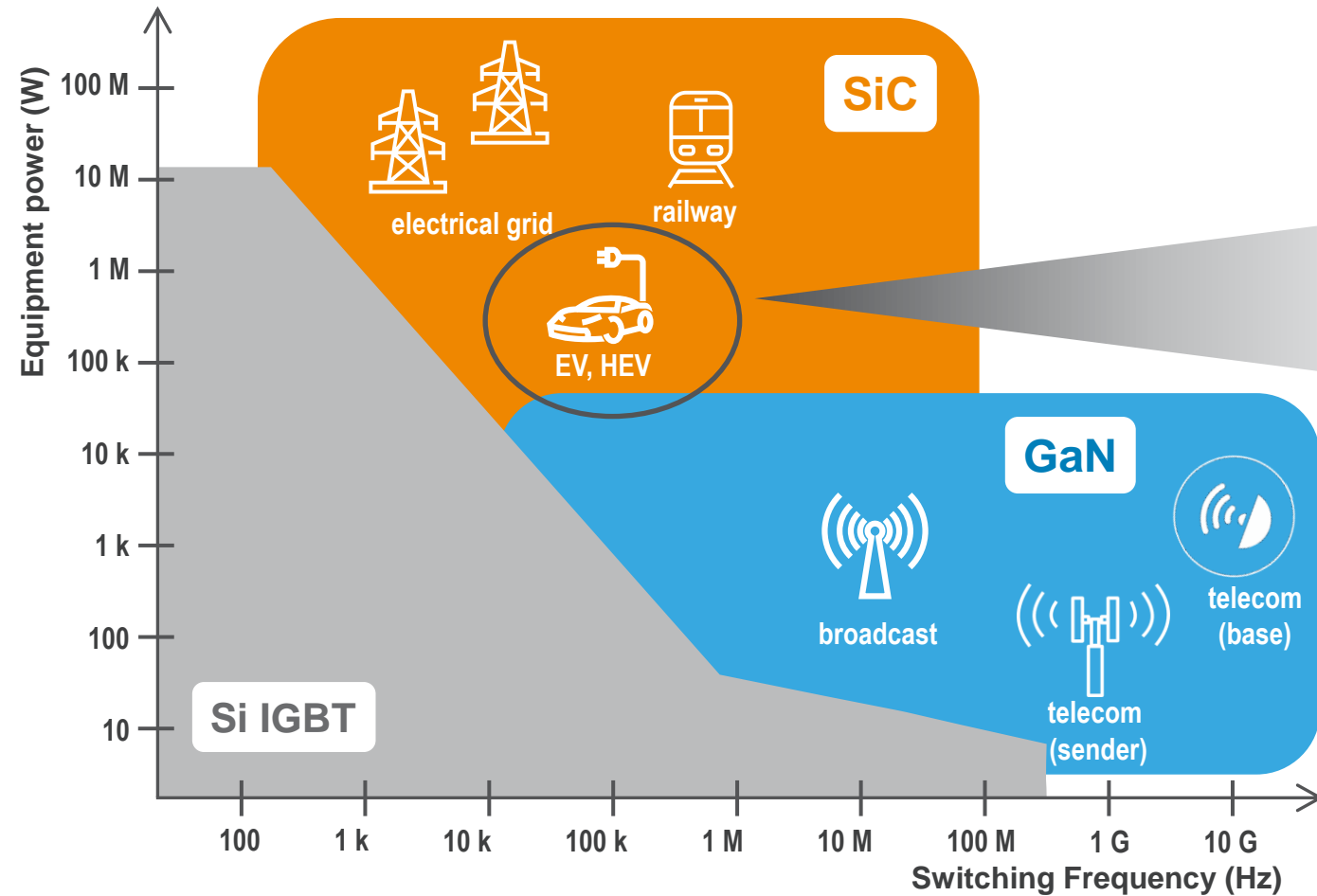
OUR TEMPERATURE SENSOR SOLUTION

- **SMD-type** temperature sensor element with backside metallization ready for **sintering**
- Sensor design provides electrical insulation between sensing layer and connection to substrate, which allows a
- **Potential free positioning** near the heat source for fast temperature measurement



SMD 1206 SC

APPLICATIONS AND MARKET SHARE OF SiC POWER ELECTRONICS



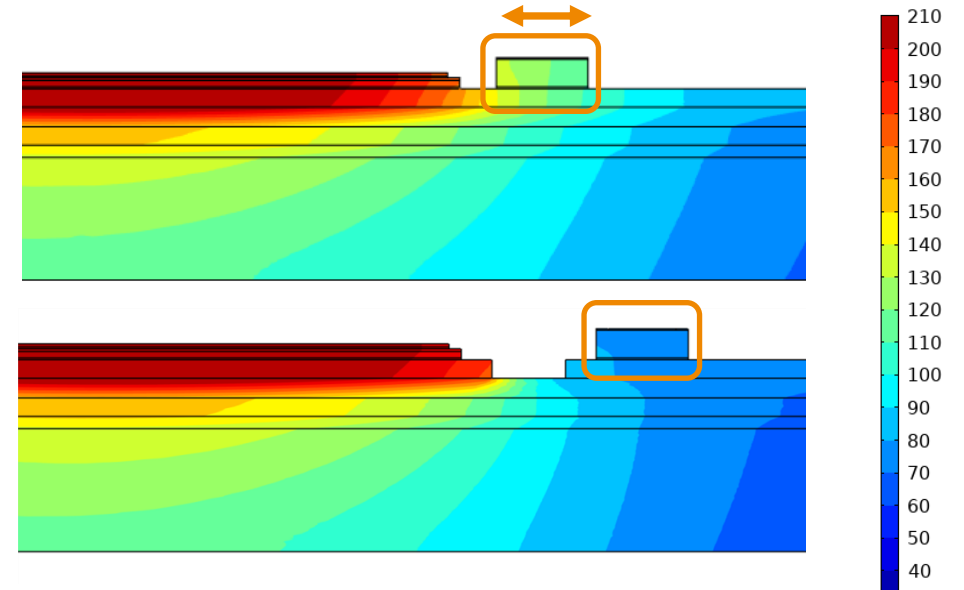
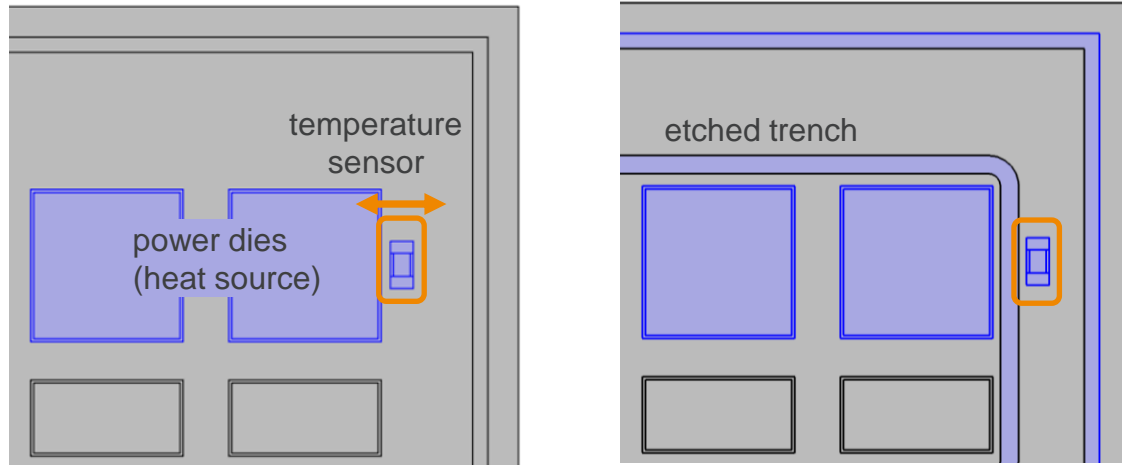
[data source: IDTechEx, 2021]

New technologies broaden application range and enable high performance power electronics – dominating market share 2030+

HOW DOES **DISTANCE TO SENSOR** AFFECT ACCURACY?

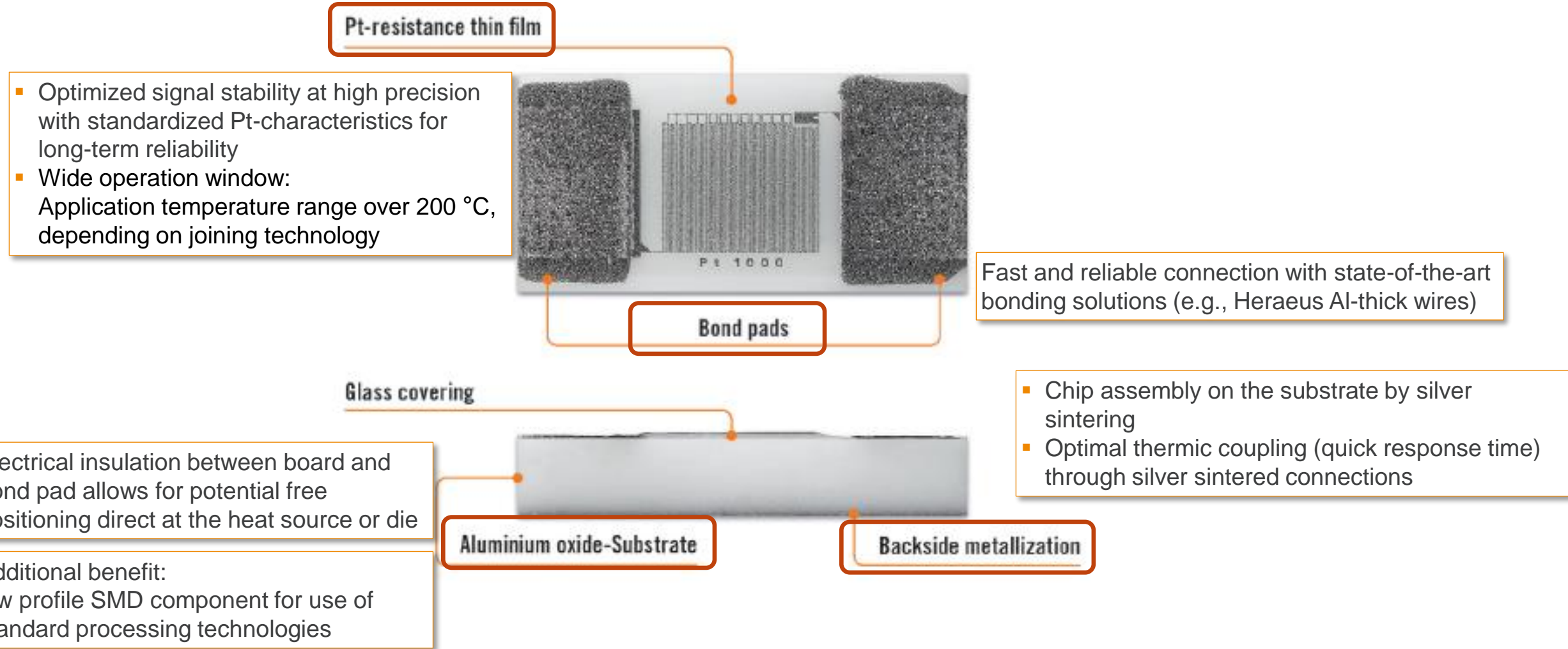
Model layout

- Design freedom by innovative sensor layout: proximity to heat source
- Additional etched trench can be abandoned compared to existing solutions



Our temperature sensor layout allows for reduced complexity of substrate and chip design: close position of the sensor next to the power die ensures fast and more accurate temperature detection

SINTERABLE TEMPERATURE SENSOR FOR POWER ELECTRONICS



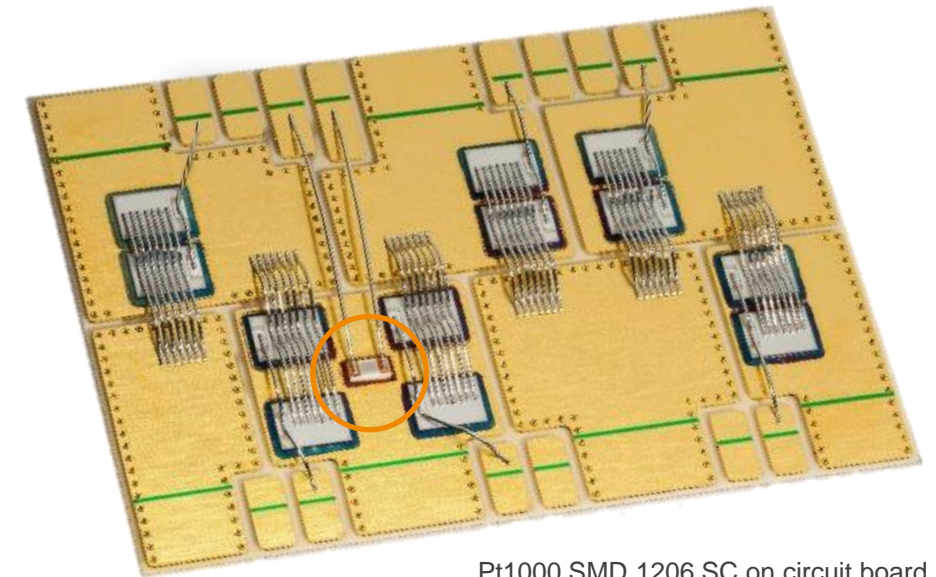
SINTERABLE TEMPERATURE SENSOR FOR POWER ELECTRONICS

Technical Parameter SMD 1206 SC

Characteristics	
Package size	SMD 1206
Nominal Resistance R_0 [Ω]	1000 Ohm
Temperature Range	-50 °C to +200 °C
Tolerance Class	F 0.6 (2B)
Temperature Coefficient	TCR = 3850 ppm/K
Measuring Current	1000 Ω : 0.1 to 0.3 mA

Passed reliability tests SMD 1206 SC

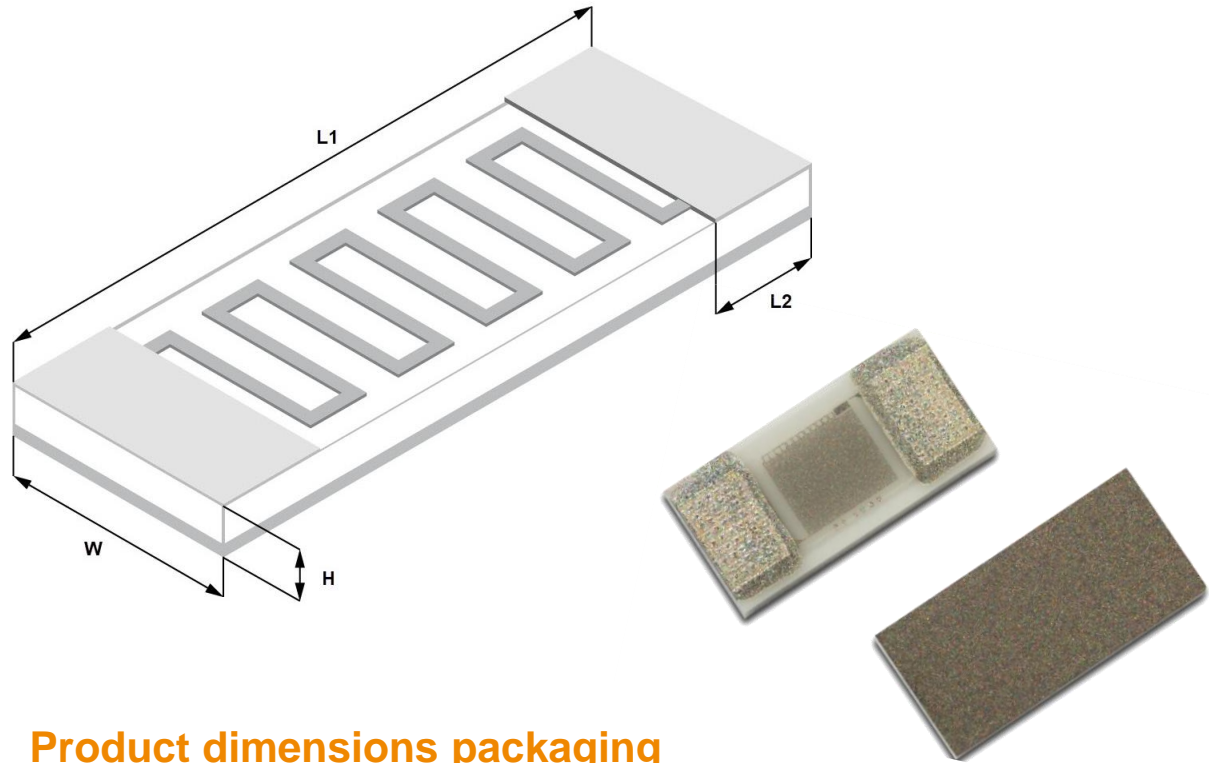
Tests	Conditions
High Temperature Storage	t = 1000 hours @ 200 °C
Low Temperature Storage	t = 1000 hours @ -50 °C
Temperature Cycling	1000 cycles @ -40 °C / +150 °C
Humidity (unbiased)	t = 1000 hours @ 85 °C / RH = 85 %
Operational Life	t = 1000 hours @ 0.1 mA (200 °C)



Pt1000 SMD 1206 SC on circuit board

Experimental setup: Pt1000 SMD 1206 SC,
Heraeus AIH11 thick wire, \varnothing 300 μ m
Design by Fraunhofer

DIMENSIONS AND PACKAGING OPTIONS



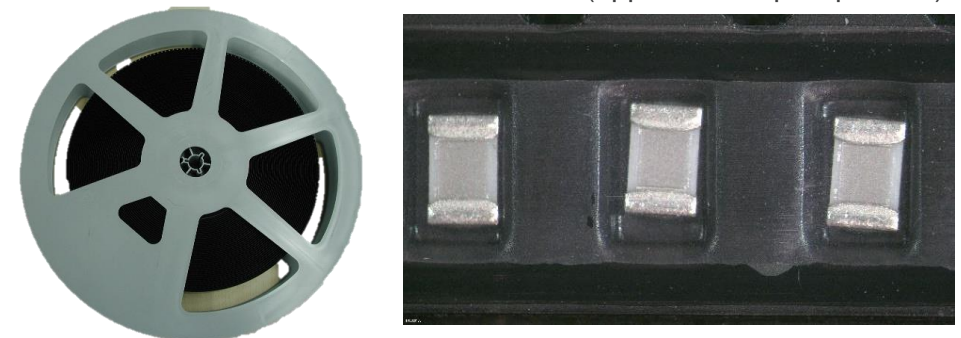
Product dimensions packaging

L1	L2	W	H
3.1 mm	0.79 mm	1.5 mm	0.55 mm

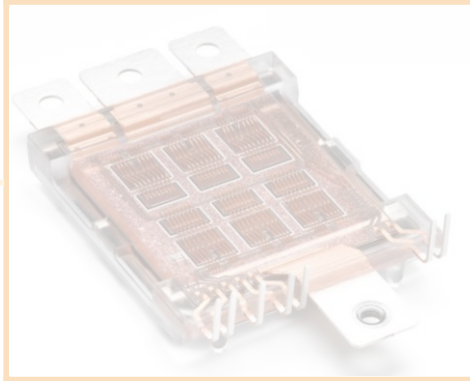
Substrate on wafer frame in plastic bag (360 - 450 pcs. per wafer)



Blister reel packaging (final validation testing) (approx. 4000 pcs. per reel)



E-MOBILITY TRENDS



POWER ELECTRONICS

- Trend to SiC and GaN semiconductors
- Operation at higher switching frequencies and higher temperatures

[image: Danfoss]



ELECTRIC MOTORS

- Electrification of heavy duty and commercial vehicles
- Shared driving creates new use cases: longer operational life of passenger cars



CHARGING EQUIPMENT

- Higher charging powers
- New regulations with tighter requirements (new standard in China: GB20234.4)

FROM TRENDS TO SENSOR SOLUTIONS: ELECTRIC MOTORS



ELECTRIC MOTORS

- Electrification of heavy duty and commercial vehicles
- Shared driving creates new use cases: longer operational life of passenger cars

APPLICATION REQUIREMENTS

- Reliability and accuracy over **long operational lifetimes**
- High torque engines require **fast response time** to protect from overheating
- Mounting is crucial: **replaceable** or **permanent** mounting options depending upon end customer specification
- Flexibility: solutions for **wound** or **hairpin** stators

OUR TEMPERATURE SENSOR SOLUTION

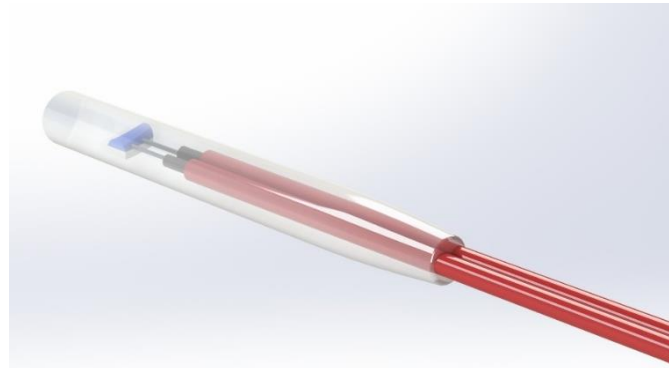
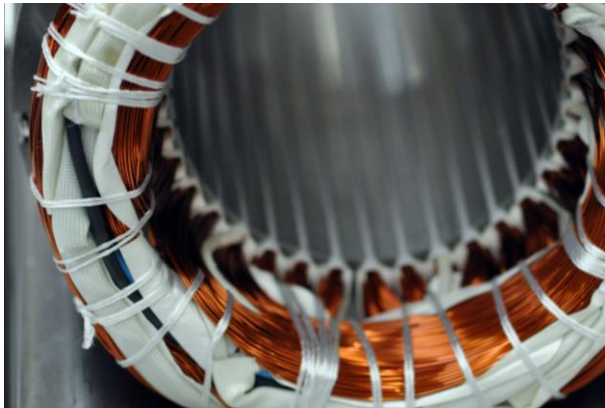
- **Fast temperature sensing** for e-vehicle motor protection
- **Drift-free** signal even after repeated temperature spikes
- **Mounting options** for sensor components to fit your needs



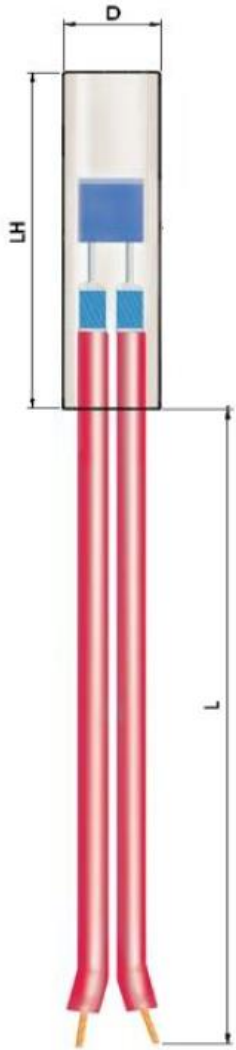
EC3032 ENCAPSULATED PRECISION TEMPERATURE SENSOR

Sensor platform EC3032 (round head): reliable e-motor protection

- Designed for applications in **e-motors**, **EV charging plugs**, **industrial automation**, **analytical equipment**
- **Round** sensor head for optimal fit in **wound stators**
- **Robust encapsulation** and extension wires, high dielectric strength for safe and sustainable operation
- **Reliable sensor elements** based on Pt technology to ensure **stable signal** over entire operational lifetime
- **Customizable** design options optional for large volume applications



EC3032 ENCAPSULATED PRECISION TEMPERATURE SENSOR



Features

- Nominal resistance: Pt 1000 Ohm (TCR = 3850 ppm/K)
- Tolerance: F 0.3 (B)
- IP67 and IP68 certified; oil resistant

Temperature Range

- -50 °C to +200 °C, short term +250 °C (up to 50 hours)

Dimensions

- Housing length LH = 30 mm
- Diameter D = 3.2 mm

Housing & Cable

- Housing: semi-rigid fluorocarbon
- Cable: PTFE insulated, 24AWG (0.24 mm²) (options available)

Cable Pull Force

- Approx. 100 N, measured between cables and sensor

Specification

- Dielectric strength: 6 kV AC, measured for 60 sec



Customization Options for High Volume Applications

- Wire length L, housing length LH, housing diameter D
- Sensor resistance, connectors

ADVANCED SENSOR DESIGN EC-MOD FOR HAIRPIN MOTOR APPLICATIONS

Features

- **Modified version** of our standard product EC3032
- **Adapted design** to optimize thermal contact with hairpin stators
- Nominal resistance: Pt 1000 Ohm
- Tolerance class: F 0.3 (B)

Applications

- Designed for hairpin motor application
- Mounting on stator loop, on busbar

Temperature Range

- -50 °C to +200 °C

Specification

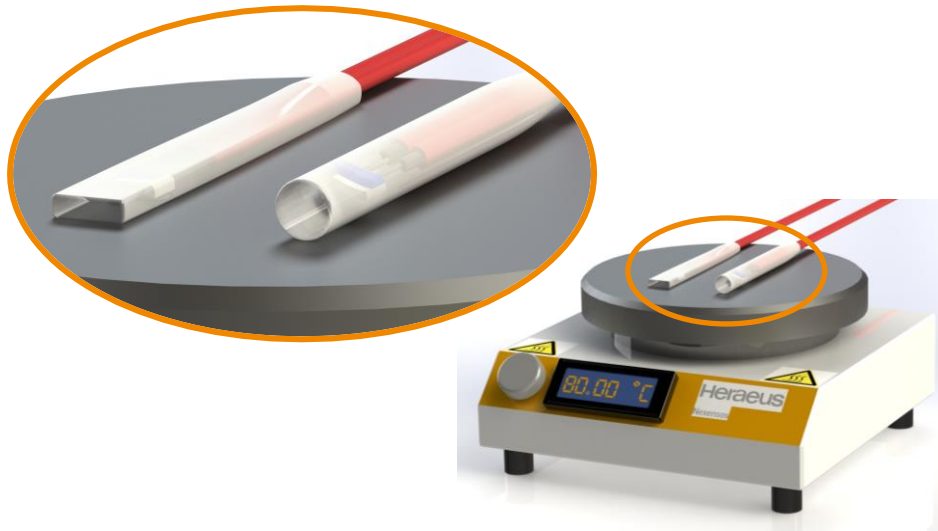
- Dielectric strength: 6 kV AC, measured for 60 sec

Customization Options for High Volume Applications

- Wire length, housing length
- Sensor resistance, connectors



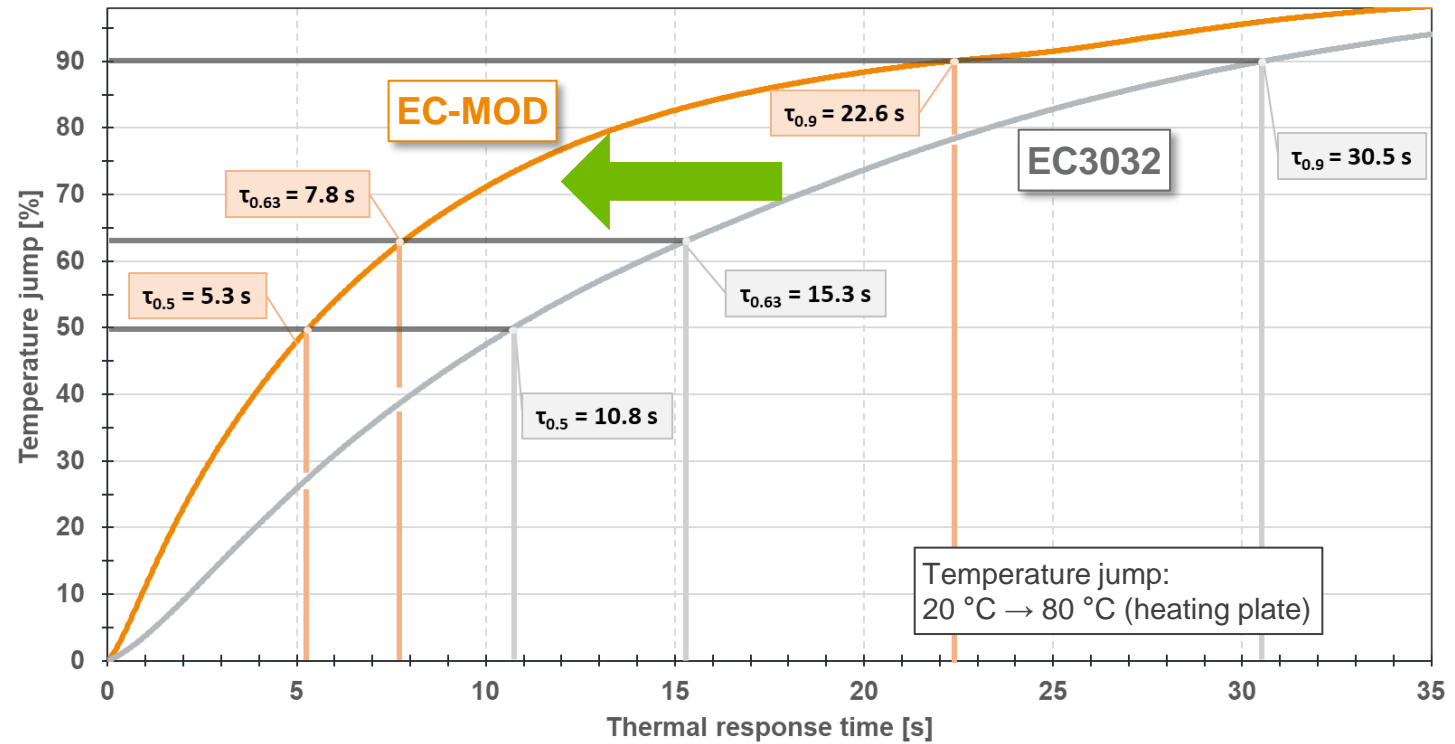
REDUCED RESPONSE TIME IN HAIRPIN MOTORS BY **ADVANCED DESIGN**



EC-MOD:

Advanced sensor and connection design result in up to **30 % reduced response time** for fast and precise temperature sensing in **hairpin motors**

THERMAL RESPONSE TIME OF ROUND AND FLAT HEAD SENSORS



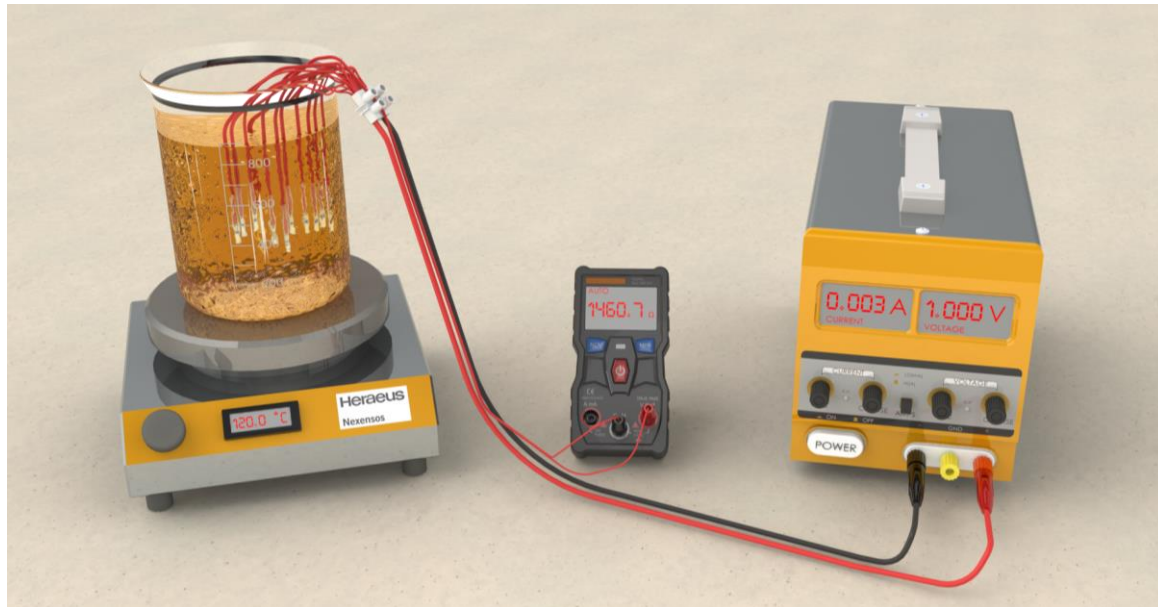
Experimental setup:

EC3032 and EC-MOD on a 80 °C heater plate to simulate a hot hairpin

Our technologies offer superior performance and reliability, making your applications more efficient and safe

SENSOR ACCURACY AFTER MOTOR OIL IMMERSION

Is sensor accuracy impacted by motor oil?

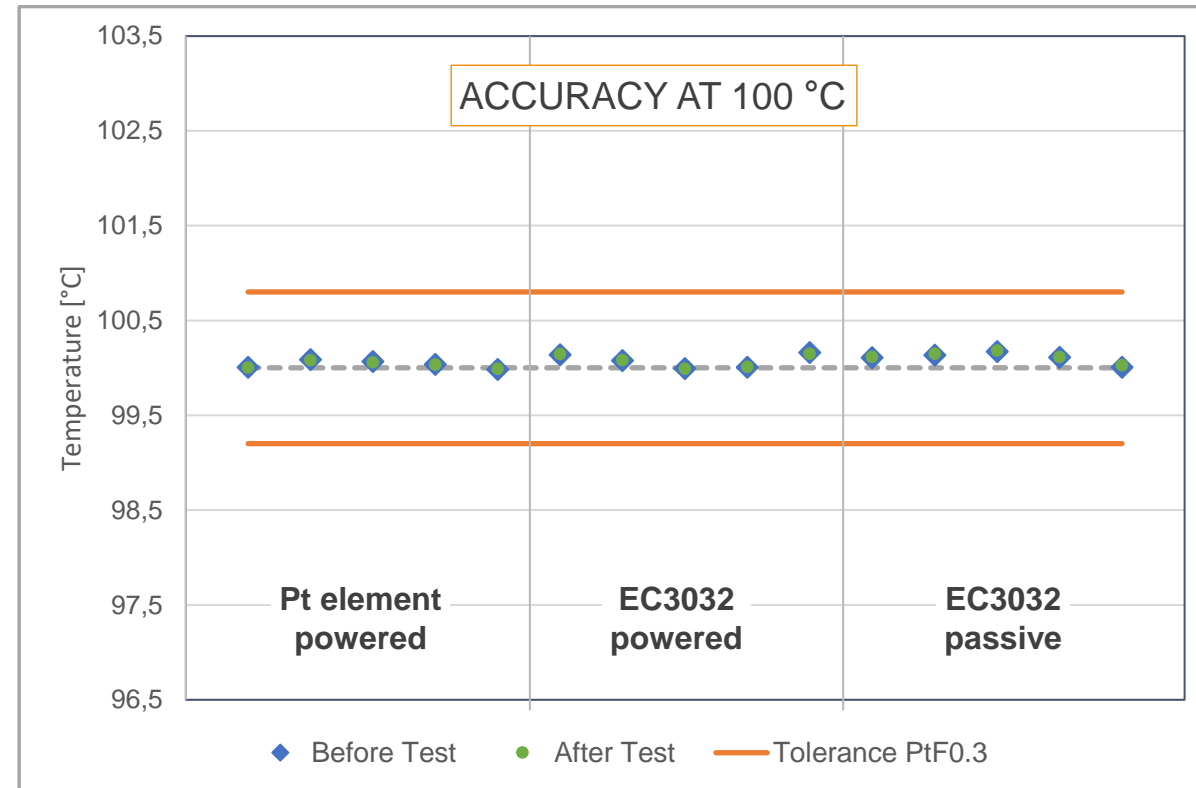


Experimental setup:

- Exposure of sensor elements (powered) and EC3032 sensor assemblies (powered and passive) in automatic transmission fluid
- Temperature range during energizing process: 100 °C – 140 °C
- Exposure time: 21 days, 100 h in heated condition

Test results:

- Stability against motor oil proven on multiple levels of integration
- Both elements and sensor assemblies prove to be resistant against oil immersion

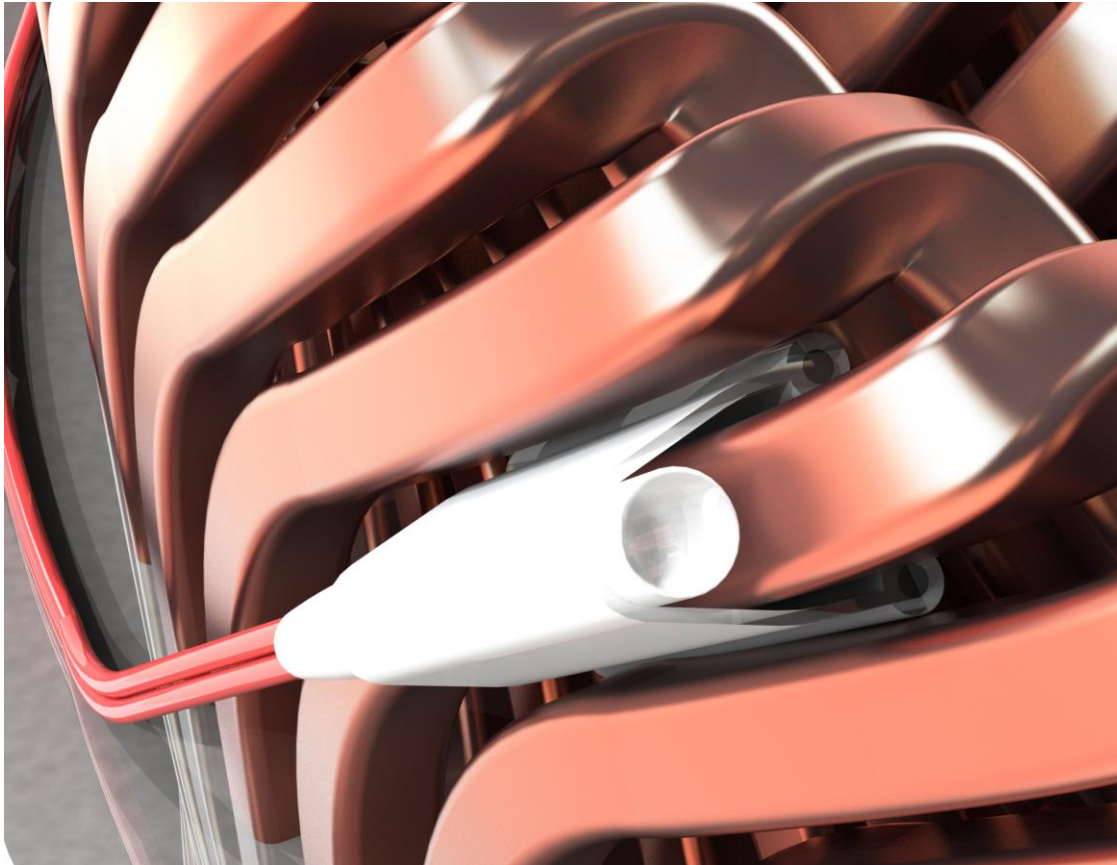


A close-up, high-angle photograph of a copper heat exchanger. The image shows multiple rows of copper tubes with a wavy, corrugated design. A white plastic connector is visible, attached to one of the tubes. The lighting is dramatic, highlighting the metallic sheen and the complex geometry of the heat exchanger.

MOUNTING OPTIONS

Replaceable and permanent solutions

MOUNTING SOLUTION



Requirement:

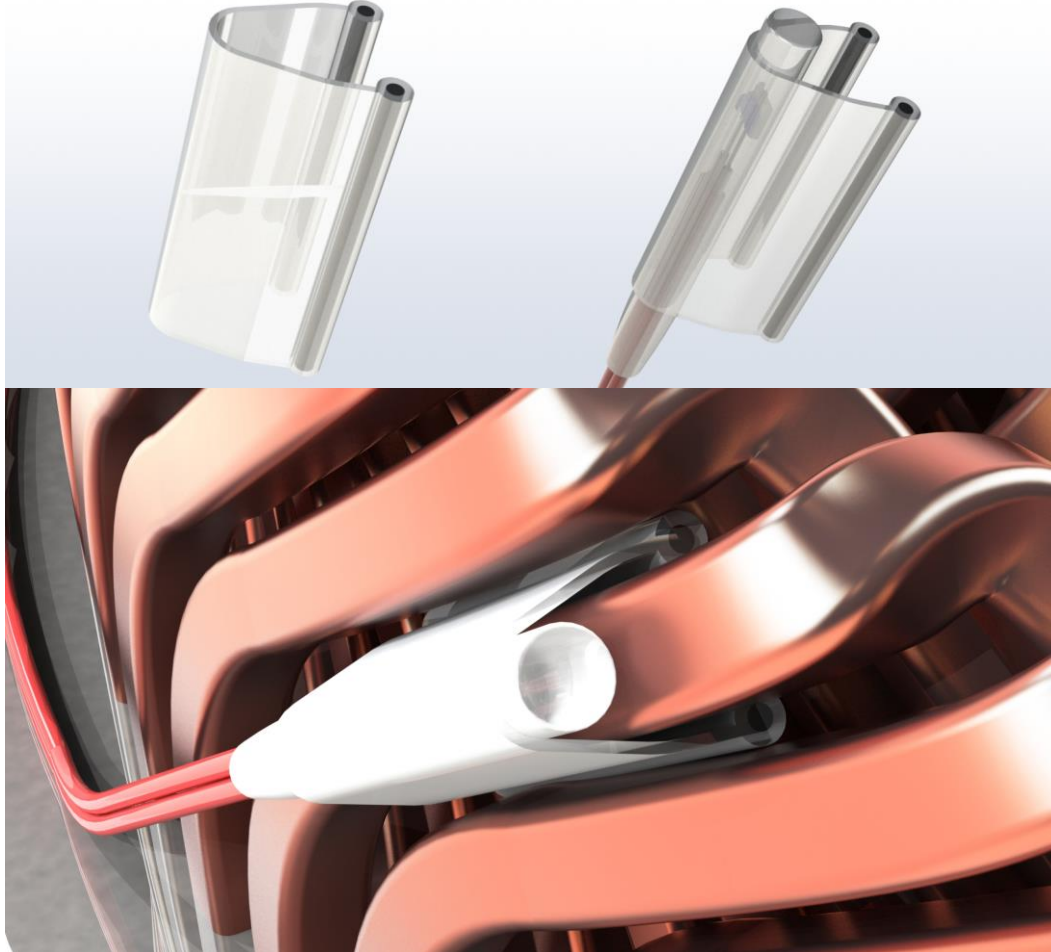
Solutions for hairpin designs needed for **replaceable** or **permanent** mounting of sensors



Our solution:

Sensor-Slide-In of shrink sleeve to fit in between hairpin rods

SENSOR-SLIDE-IN: POSITIONING OPTIONS & FEATURES



Sensor-Slide-In – Key Features:



- Solution for sensor replacement
- Customized removable mounting

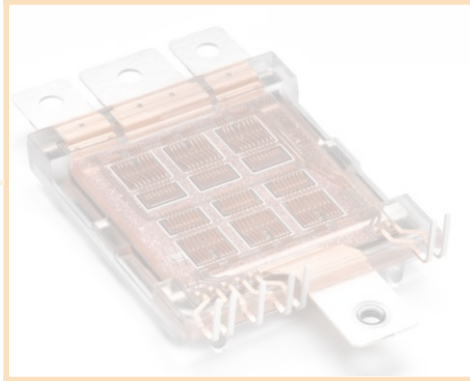


- Materials with well-known properties
- Flexible choice of materials and dimensions



Ready for series processing

E-MOBILITY TRENDS



POWER ELECTRONICS

- Trend to SiC and GaN semiconductors
- Operation at higher switching frequencies and higher temperatures

[image: Danfoss]



ELECTRIC MOTORS

- Electrification of heavy duty and commercial vehicles
- Shared driving creates new use cases: longer operational life of passenger cars



CHARGING EQUIPMENT

- Higher charging powers
- New regulations with tighter requirements (new standard in China: GB20234.4)

FROM TRENDS TO SENSOR SOLUTIONS: CHARGING



CHARGING EQUIPMENT

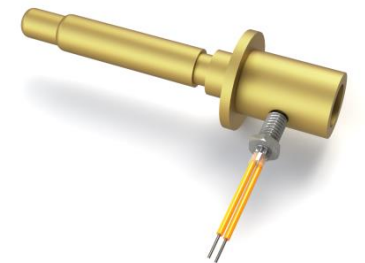
- Higher charging powers
- Increased safety requirements

APPLICATION REQUIREMENTS

- Higher charging power requires **reliable** and **drift-free** temperature surveillance
- **Miniaturization** of sensor solutions to get close to potential hotspots and to **shorten response times**
- **Certainty** for new regulation: new standards (China GB20234.4) might turn Pt-sensors mandatory

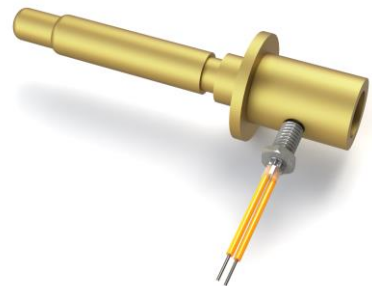
OUR TEMPERATURE SENSOR SOLUTION

- **Fast temperature sensing** with options to integrate in charger pins
- **Drift-free signal** even after repeated temperature spikes
- Sensor assemblies for **plugs** and **connectors**



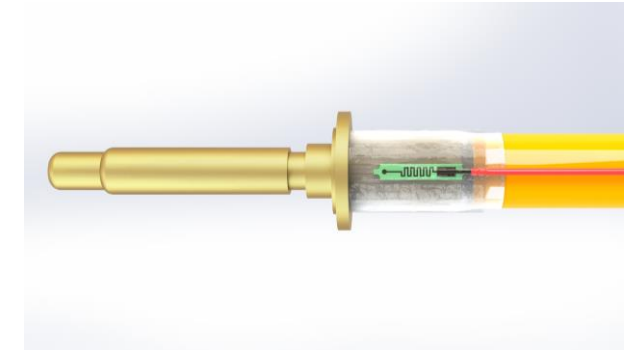
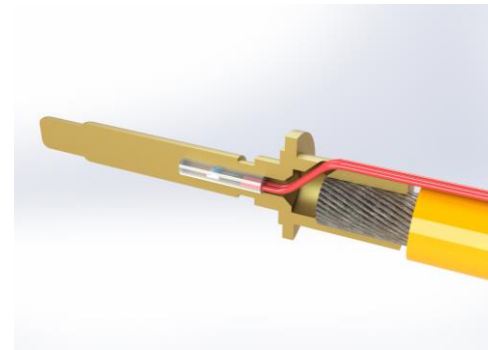
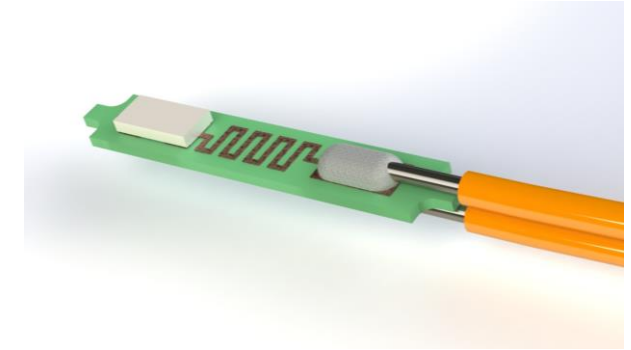
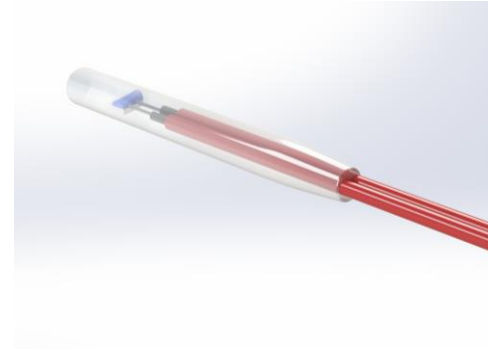
PORTFOLIO & CONCEPTS FOR CHARGING PIN APPLICATIONS

SCREW TYPE SENSOR ASSEMBLIES



Screw diameters: M4 / M5 / M6

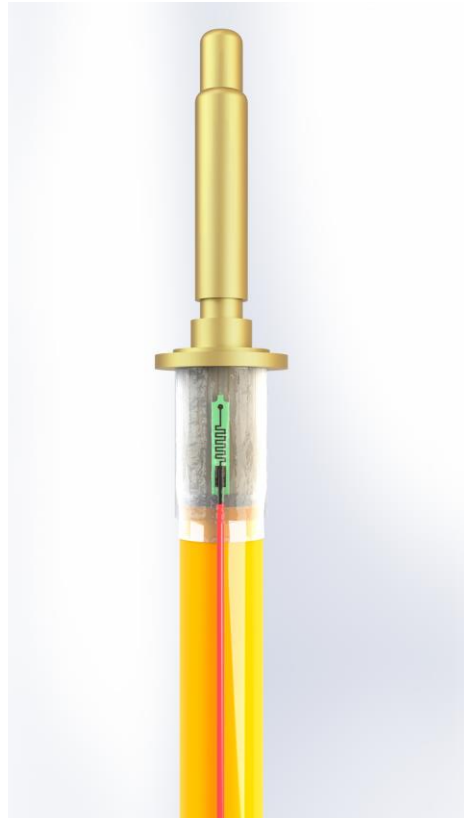
PCB MOUNTED SENSOR SOLUTIONS



We develop and produce sensor elements and assemblies with highest quality standards to

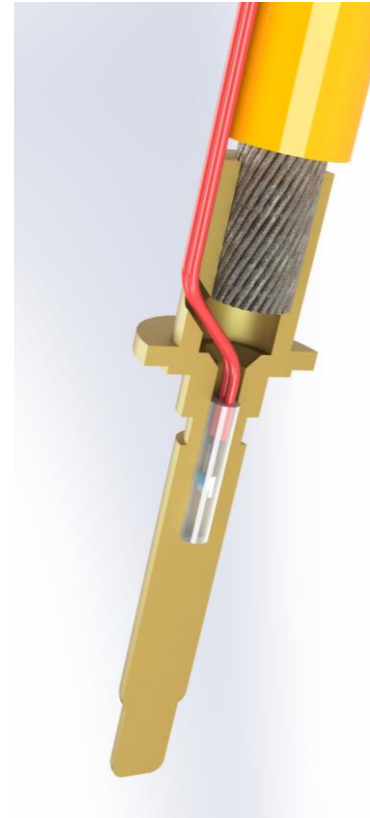
- Ensure stable and long-lasting mounting solutions for your application
- Contribute to long life time and drift free operation

ADVANCED SENSOR DESIGNS FOR CHARGER PIN APPLICATIONS



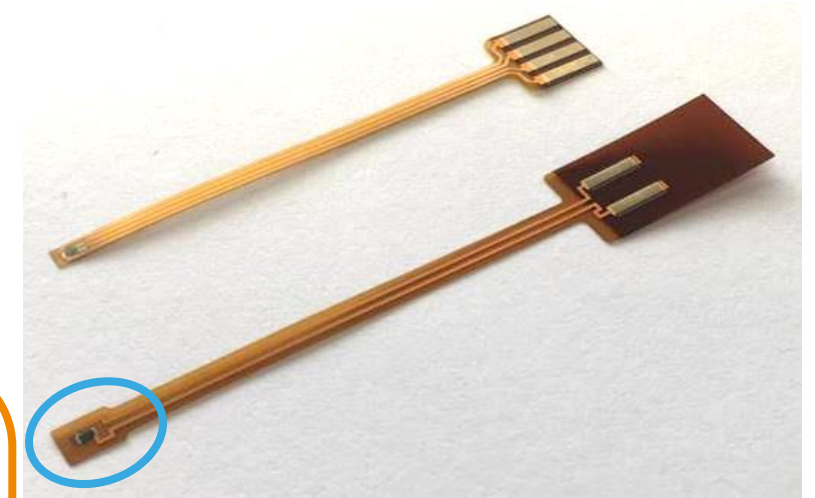
Application support

- Dedicated engineering teams support your volume projects
 - Integration and assembly support
 - Performance data
 - Customization
- Strong production competence and teams at different locations ensure fast transfer to mass production level



We deliver innovative solutions reliably – worldwide and in large quantities

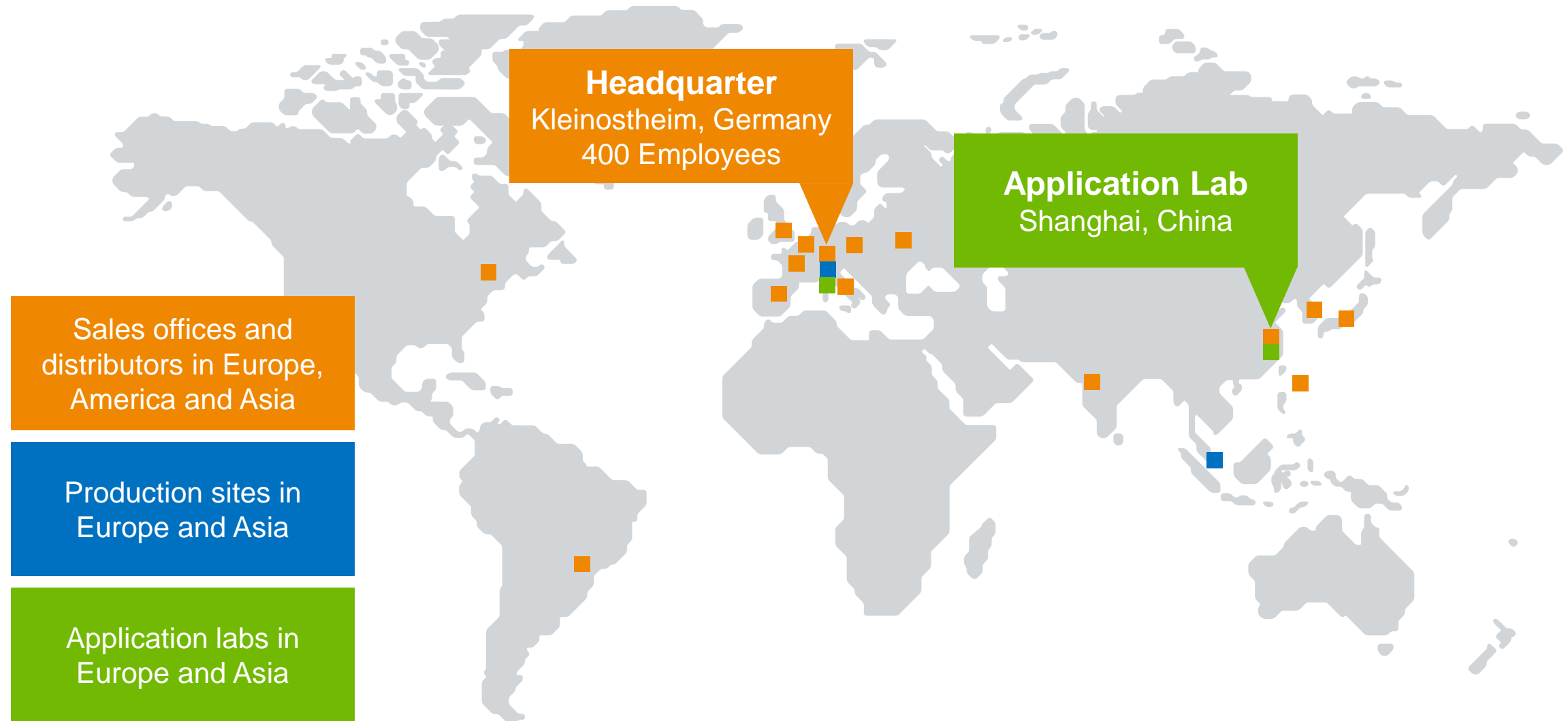
INNOVATION POWER: GETTING EVEN CLOSER TO THE CRITICAL SPOTS



Sensor innovation:
 Nexensos microRTD with footprint down to 0.6×0.3 mm and low profile of ~ 40 μ m
 Position in closest distance to potential hotspots ensures maximum detection speed

Sensor miniaturization allows for close monitoring of potential hotspots

HERAEUS NEXENSOS: CLOSE TO WHERE YOU ARE



WE RELY ON OUR EXPERTISE AND COMPETENCES TO SUPPORT YOUR E-MOBILITY APPLICATIONS

