

# The Power of Temperature Sensors in E-Mobility Applications



## OUR HERAEUS NEXENSOS **EXPERTS**



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## 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



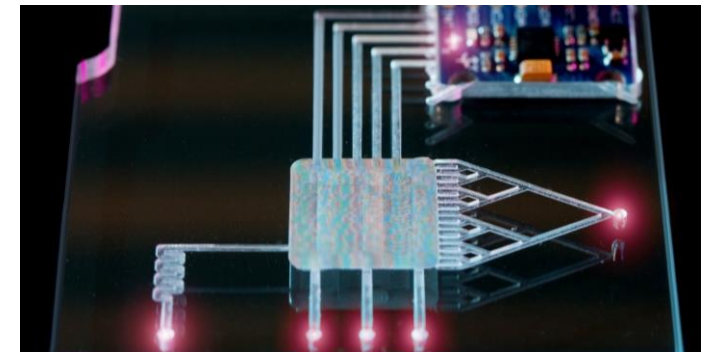
POLLUTION CONTROL



INDUSTRY 4.0

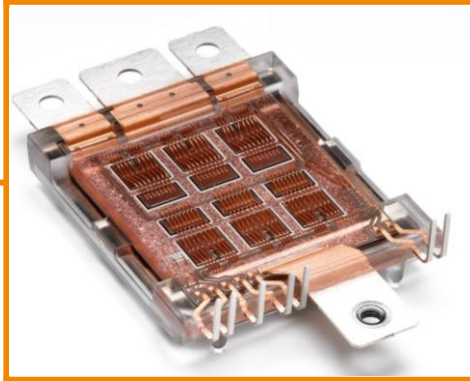


IOT – CONNECTED SENSING



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

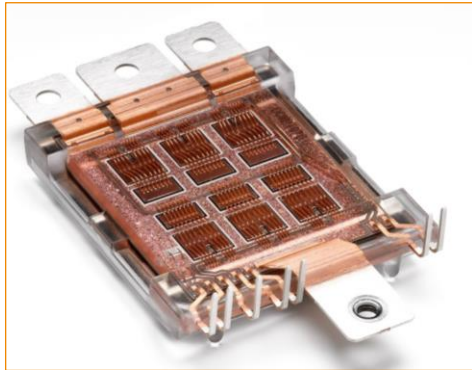
- Electrification of heavy duty and commercial vehicles
- Shared driving creates new use cases: longer operational life of passenger cars



### 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

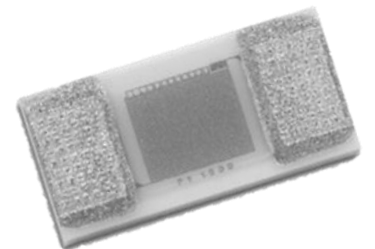
- Trend to SiC and GaN semiconductors
- Operation at higher switching frequencies and higher temperatures

## 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**

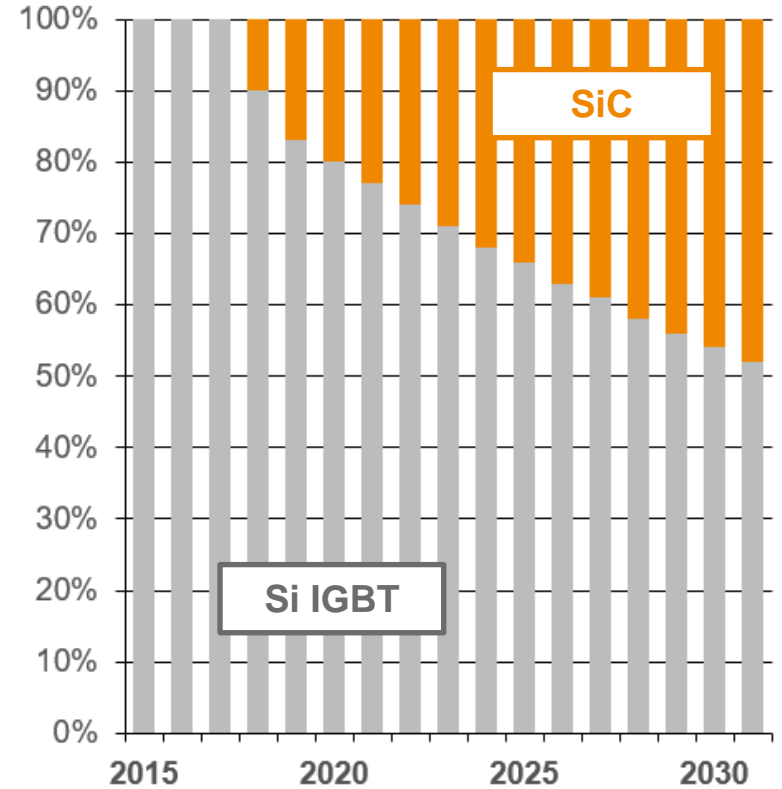
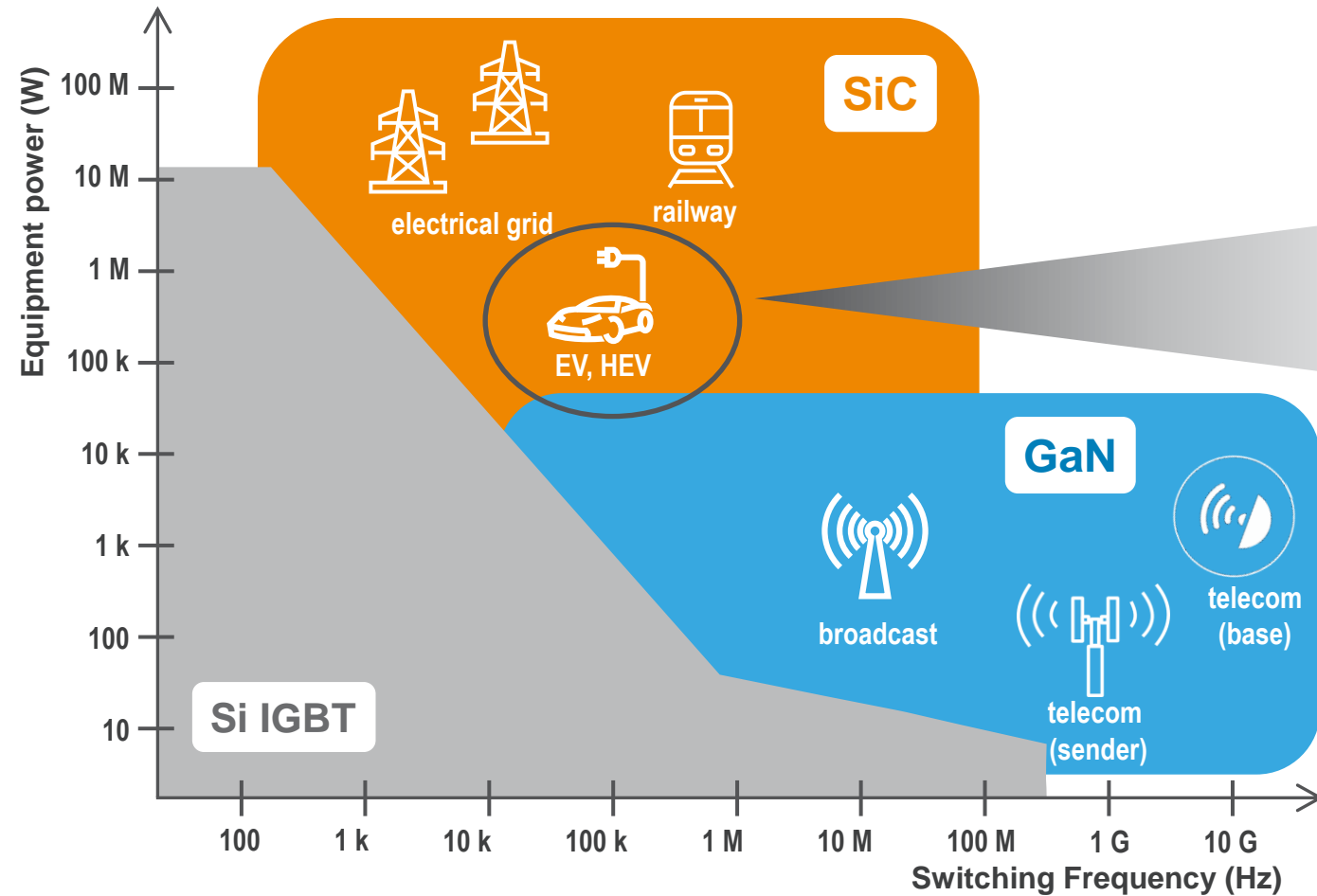
## OUR TEMPERATURE SENSOR SOLUTION

- **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



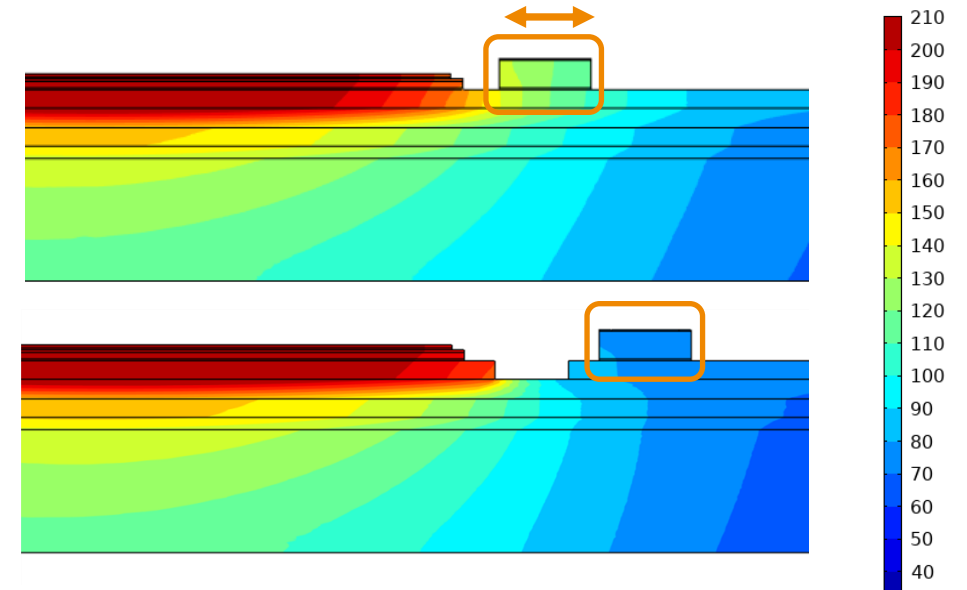
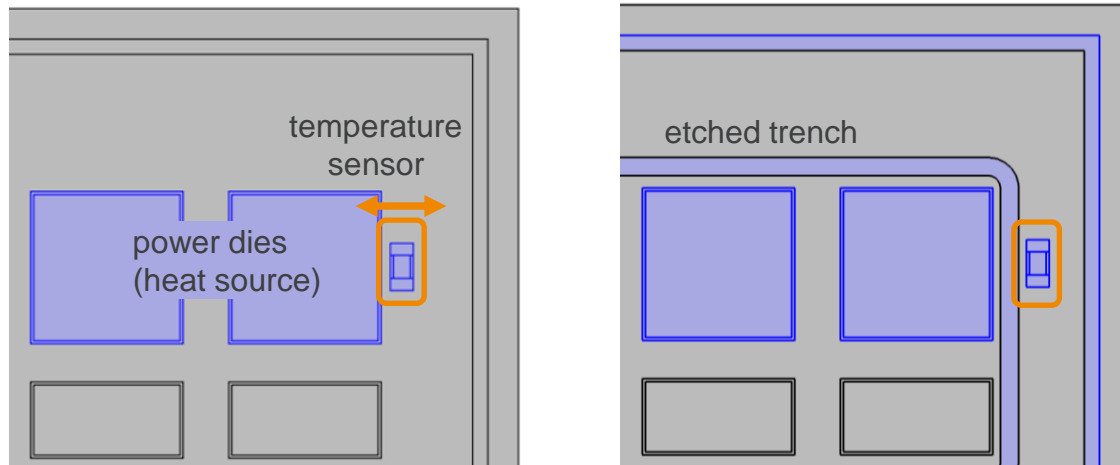
[data source: IDTechEx, 2021]

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

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

### Model layout

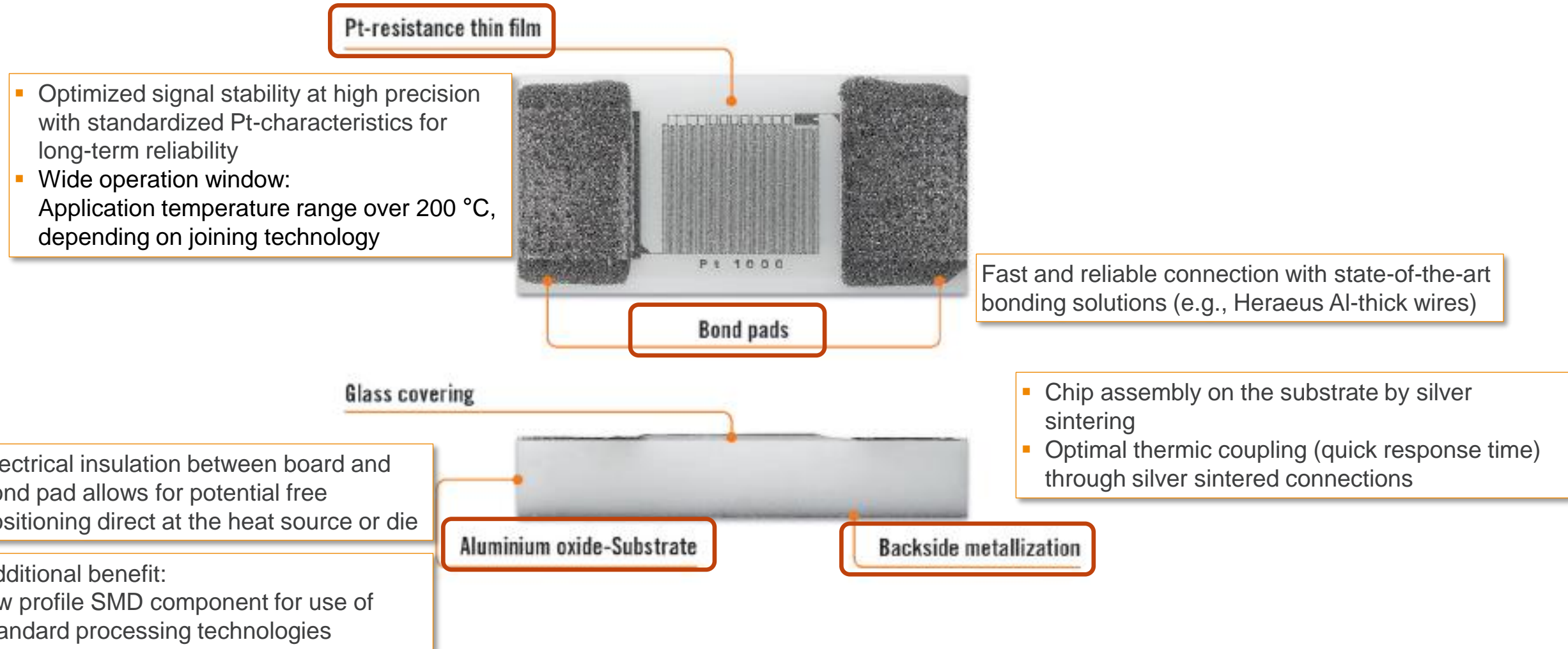
- Design freedom by innovative sensor layout: proximity to heat source
- Additional etched trench can be abandoned compared to existing solutions



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



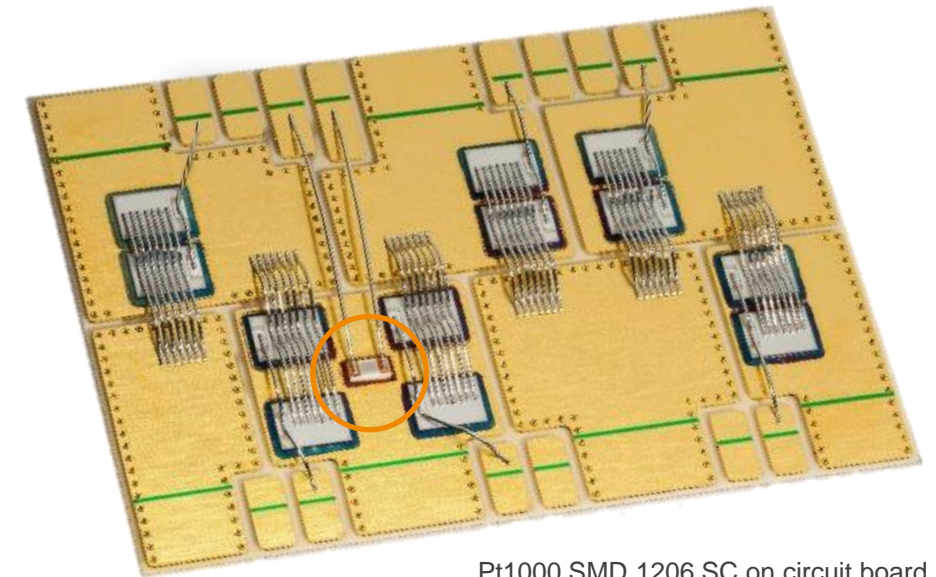
# SINTERABLE TEMPERATURE SENSOR FOR POWER ELECTRONICS

## Technical Parameter SMD 1206 SC

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

## Passed reliability tests SMD 1206 SC

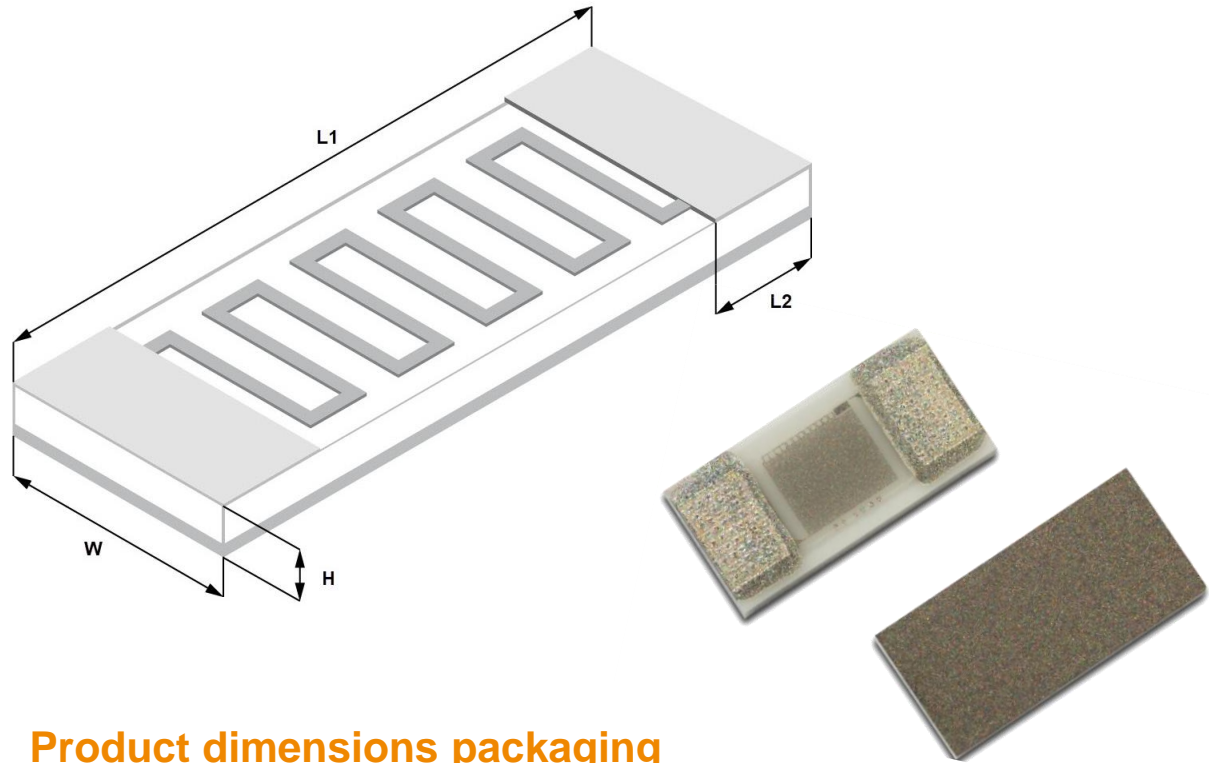
Tests	Conditions
High Temperature Storage	t = 1000 hours @ 200 °C
Low Temperature Storage	t = 1000 hours @ -50 °C
Temperature Cycling	1000 cycles @ -40 °C / +150 °C
Humidity (unbiased)	t = 1000 hours @ 85 °C / RH = 85 %
Operational Life	t = 1000 hours @ 0.1 mA (200 °C)



Pt1000 SMD 1206 SC on circuit board

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

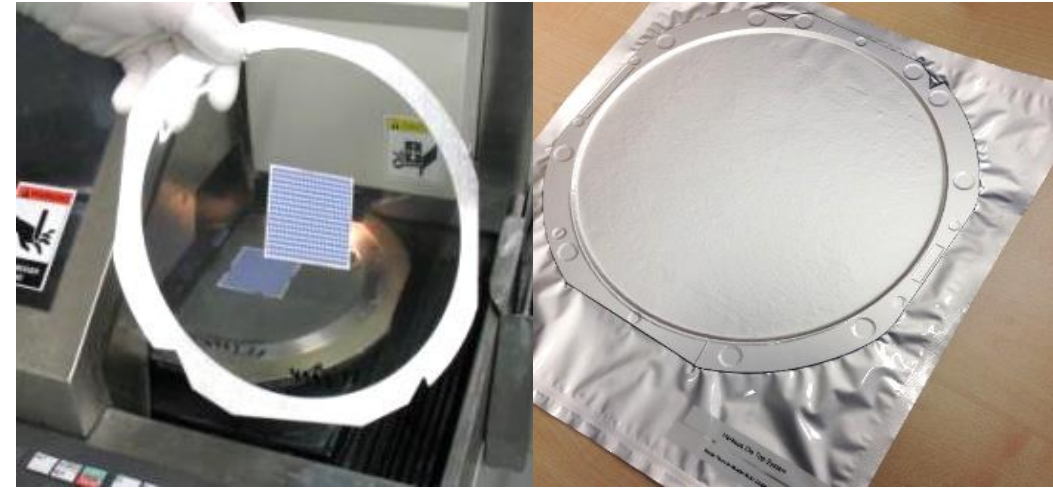
# DIMENSIONS AND PACKAGING OPTIONS



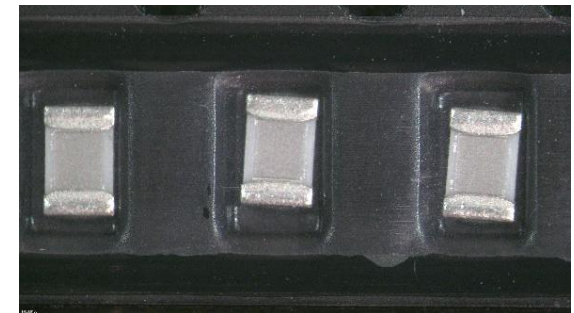
## Product dimensions packaging

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

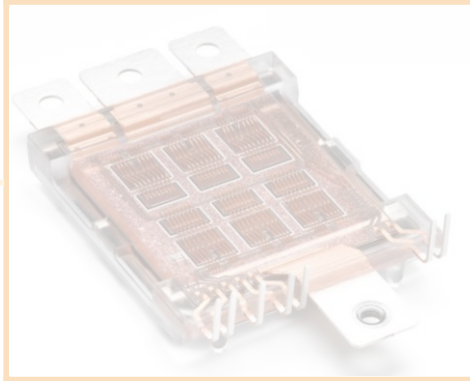
## Substrate on wafer frame in plastic bag (360 - 450 pcs. per wafer)



## 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

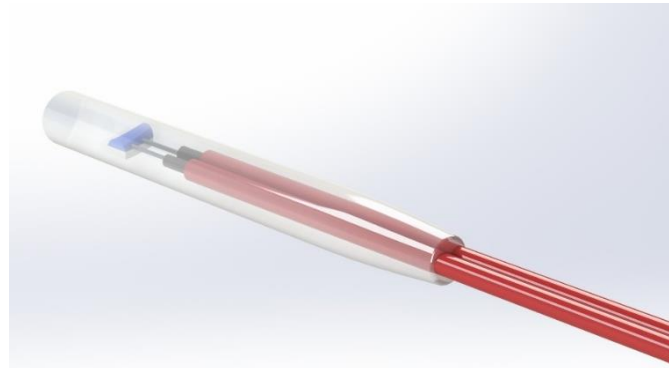
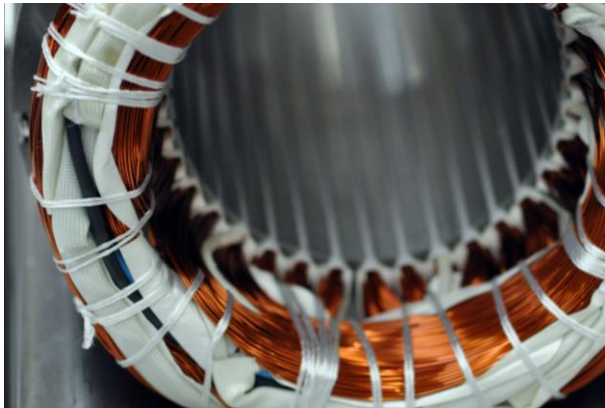
- **Fast temperature sensing** for e-vehicle motor protection
- **Drift-free** signal even after repeated temperature spikes
- **Mounting options** for sensor components to fit your needs



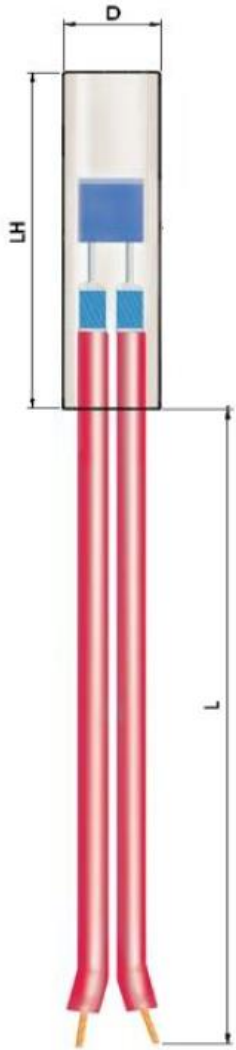
## EC3032 ENCAPSULATED PRECISION TEMPERATURE SENSOR

### 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 mm<sup>2</sup>) (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

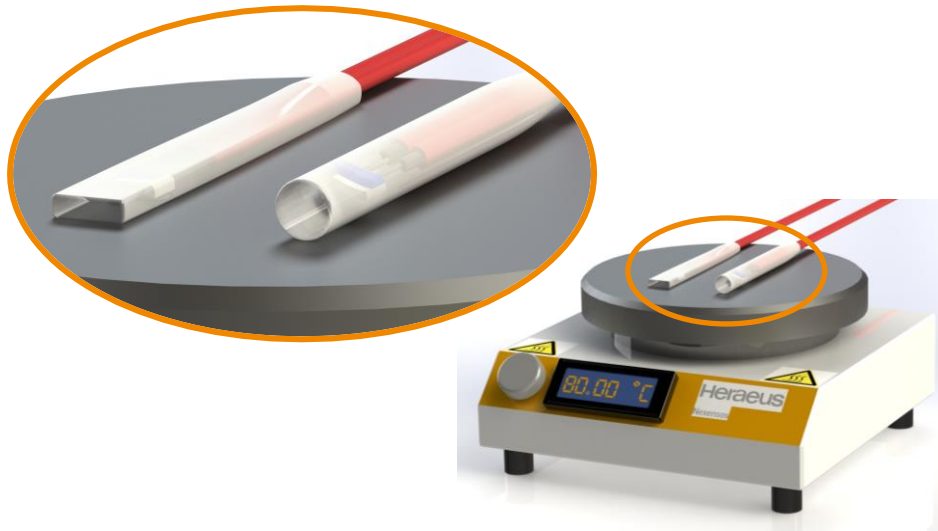
## Customization Options for High Volume Applications

- Wire length, housing length
- Sensor resistance, connectors





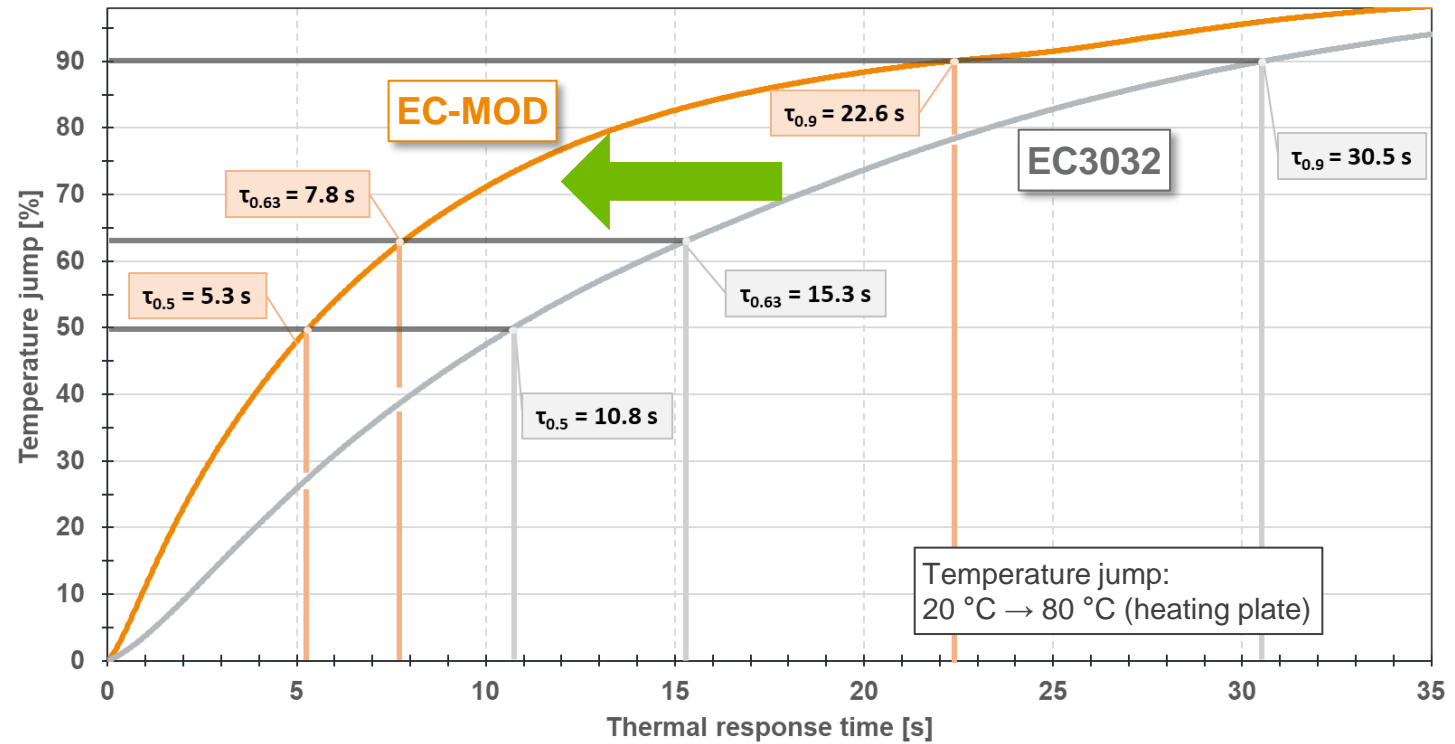
# REDUCED RESPONSE TIME IN HAIRPIN MOTORS BY **ADVANCED DESIGN**



### 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



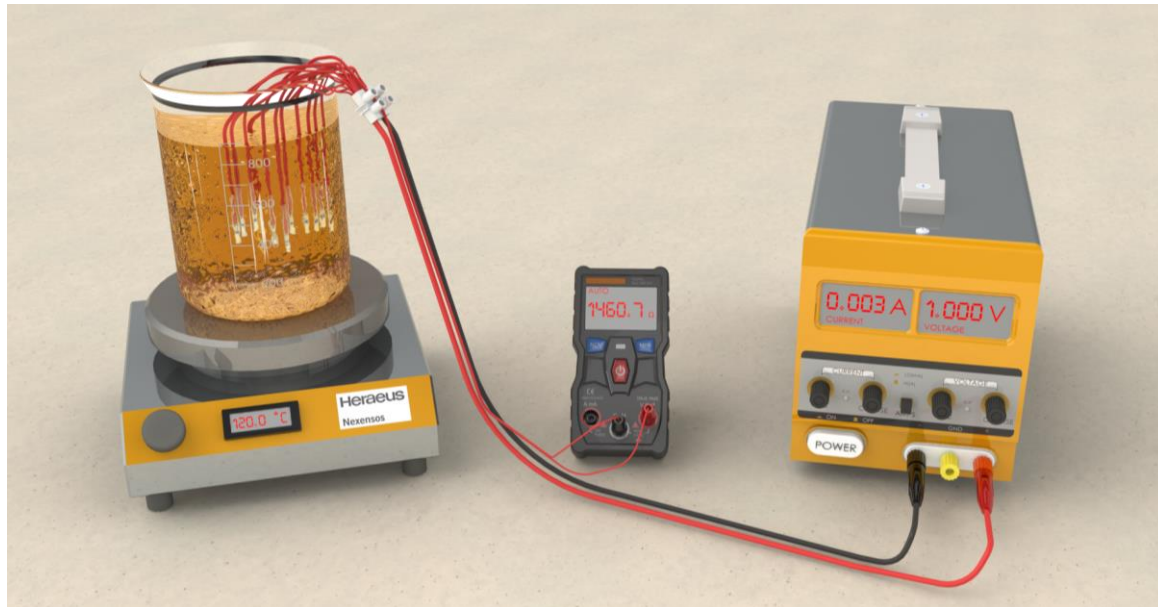
### Experimental setup:

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?

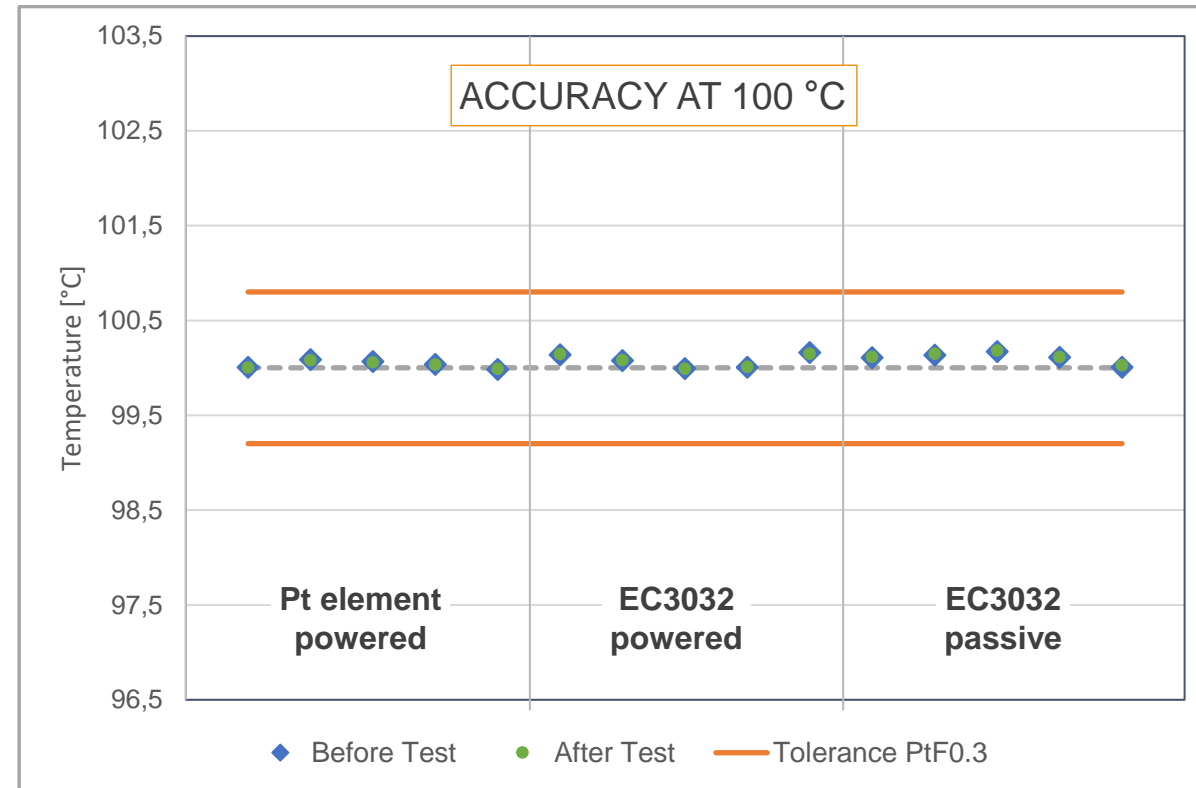


### Experimental setup:

- 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

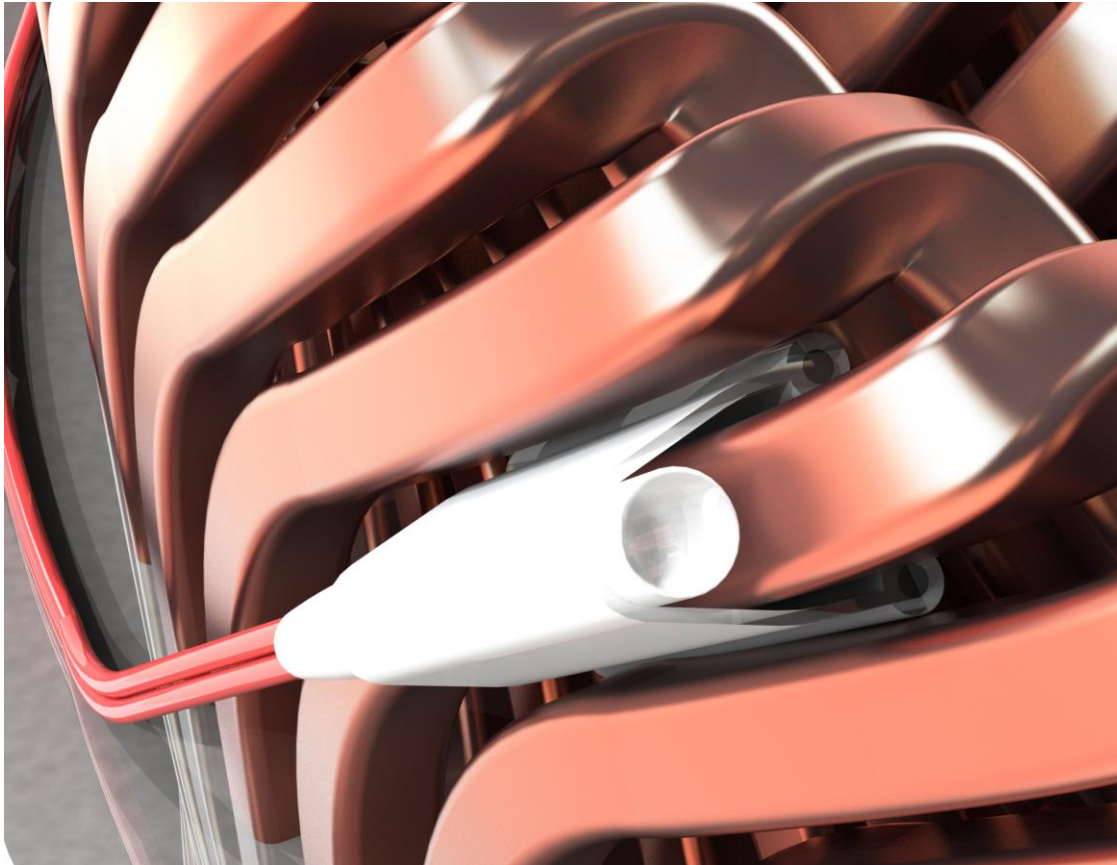


A detailed close-up photograph of a copper heat exchanger. The image shows multiple rows of copper tubes with a wavy, corrugated design, typical of micro-channel heat exchangers. A white plastic connector or fitting is visible, attached to one of the tubes. The lighting is dramatic, highlighting the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

# MOUNTING OPTIONS

Replaceable and permanent solutions

## MOUNTING SOLUTION



### Requirement:

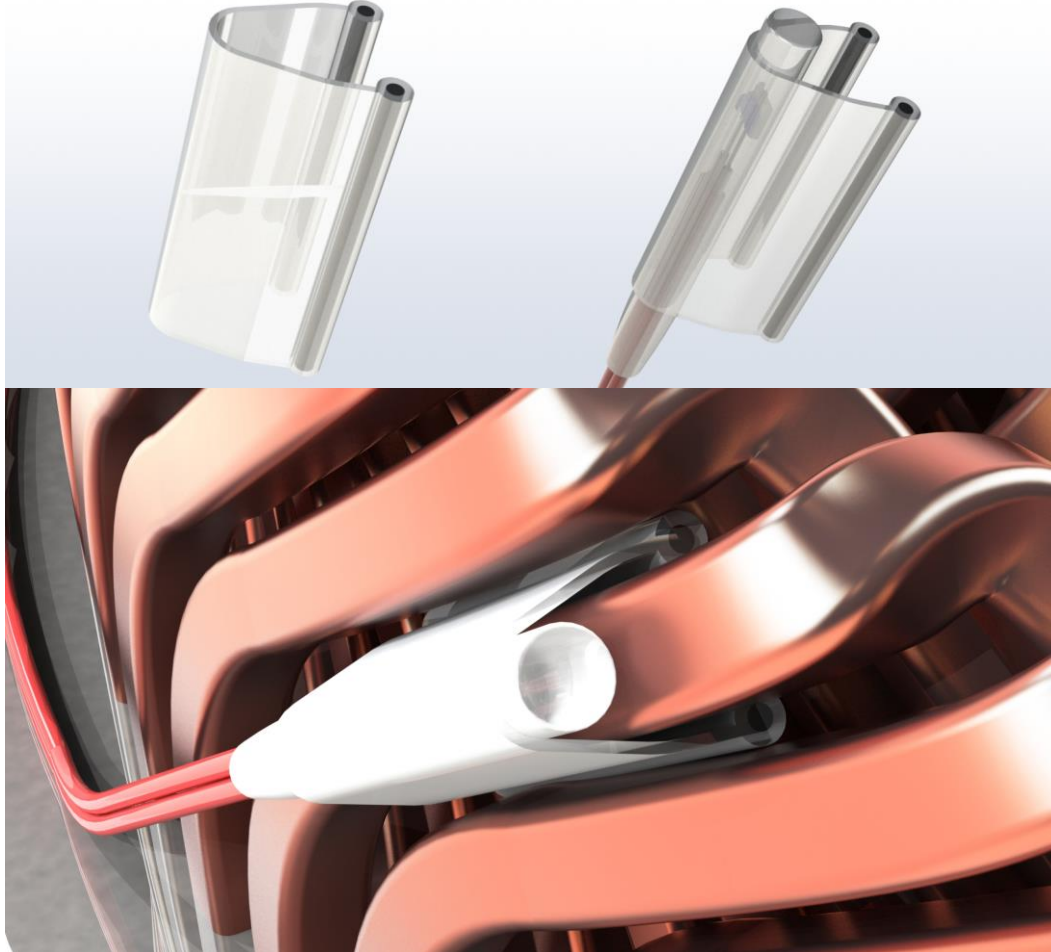
Solutions for hairpin designs needed for **replaceable** or **permanent** mounting of sensors



### 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

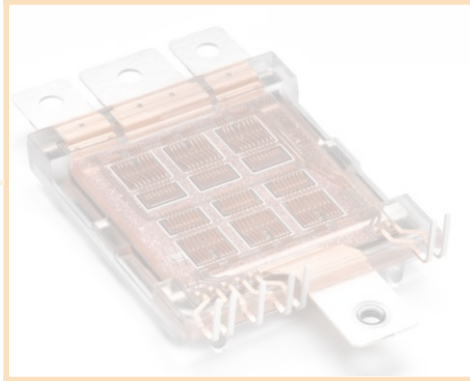


- Materials with well-known properties
- Flexible choice of materials and dimensions



Ready for series processing

## E-MOBILITY TRENDS



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[image: Danfoss]



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# FROM TRENDS TO SENSOR SOLUTIONS: CHARGING



## CHARGING EQUIPMENT

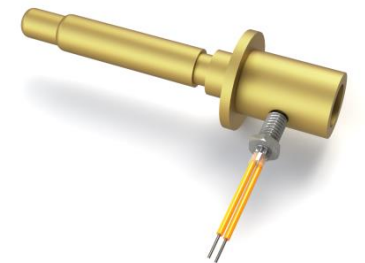
- Higher charging powers
- Increased safety requirements

## 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

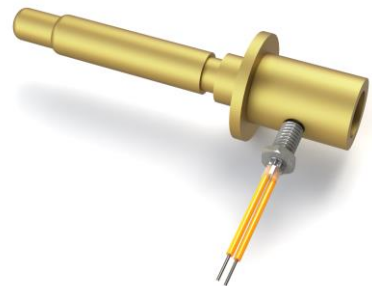
## OUR TEMPERATURE SENSOR SOLUTION

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



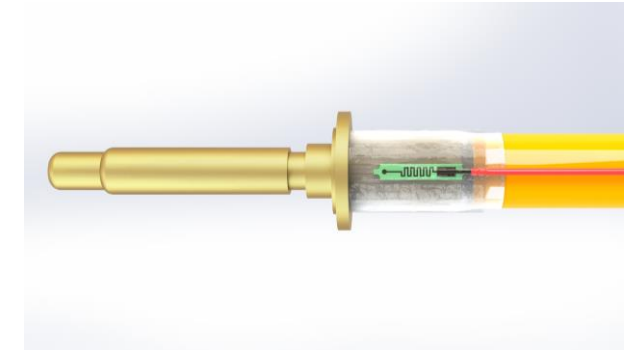
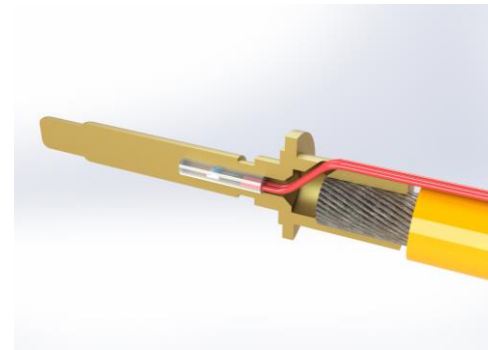
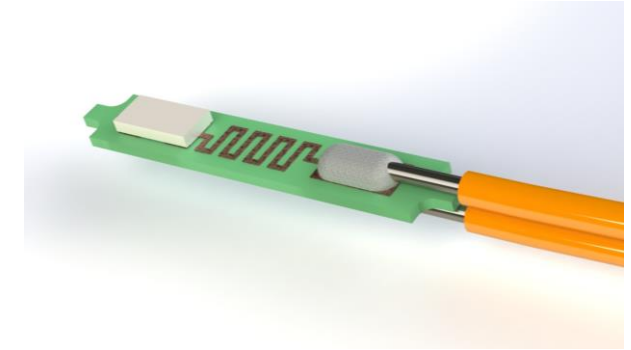
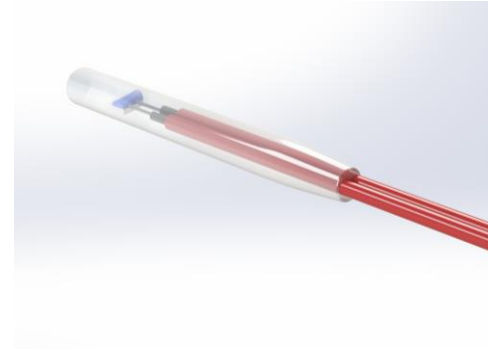
# PORTFOLIO & CONCEPTS FOR CHARGING PIN APPLICATIONS

## SCREW TYPE SENSOR ASSEMBLIES



Screw diameters: M4 / M5 / M6

## PCB MOUNTED SENSOR SOLUTIONS

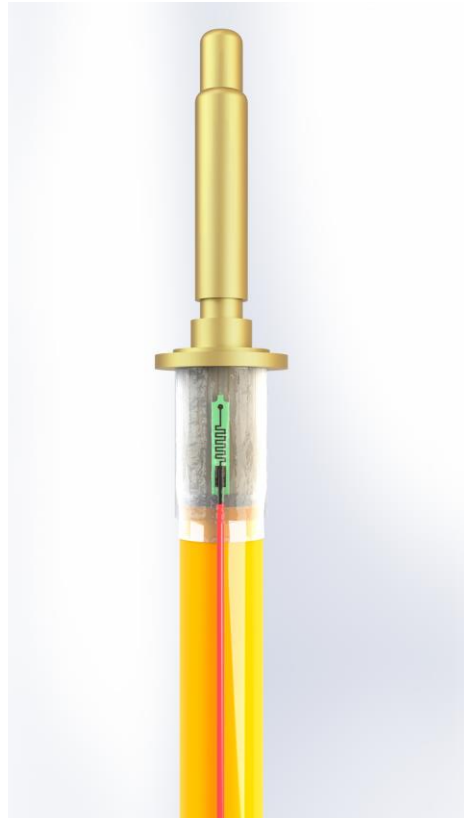


We develop and produce sensor elements and assemblies with highest quality standards to

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

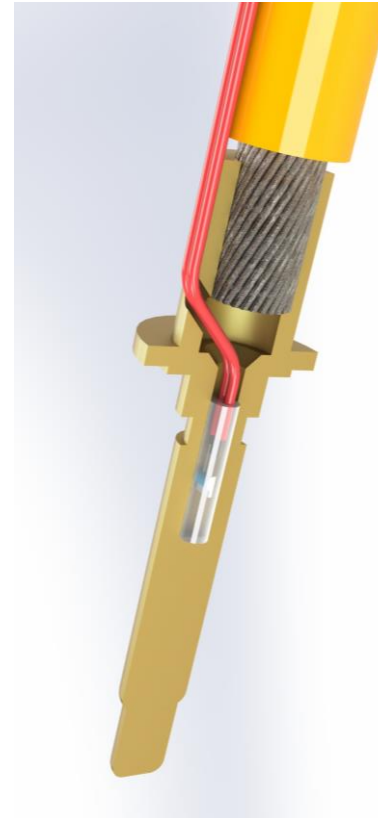


# ADVANCED SENSOR DESIGNS FOR CHARGER PIN APPLICATIONS



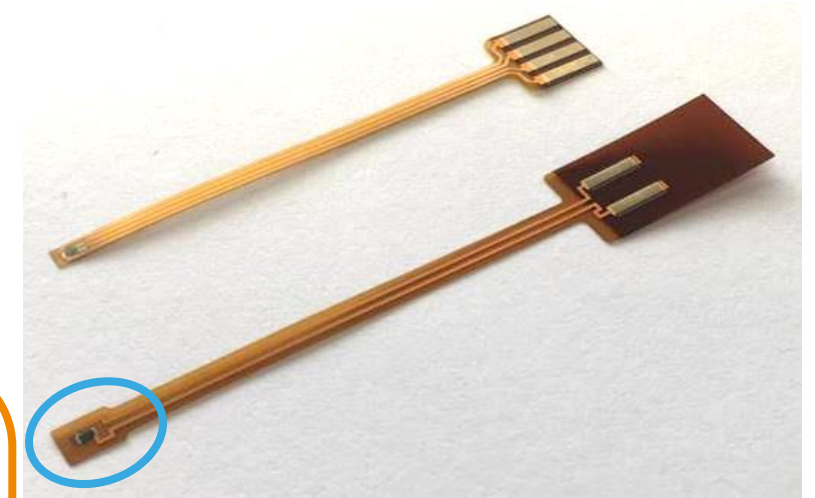
## Application support

- 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

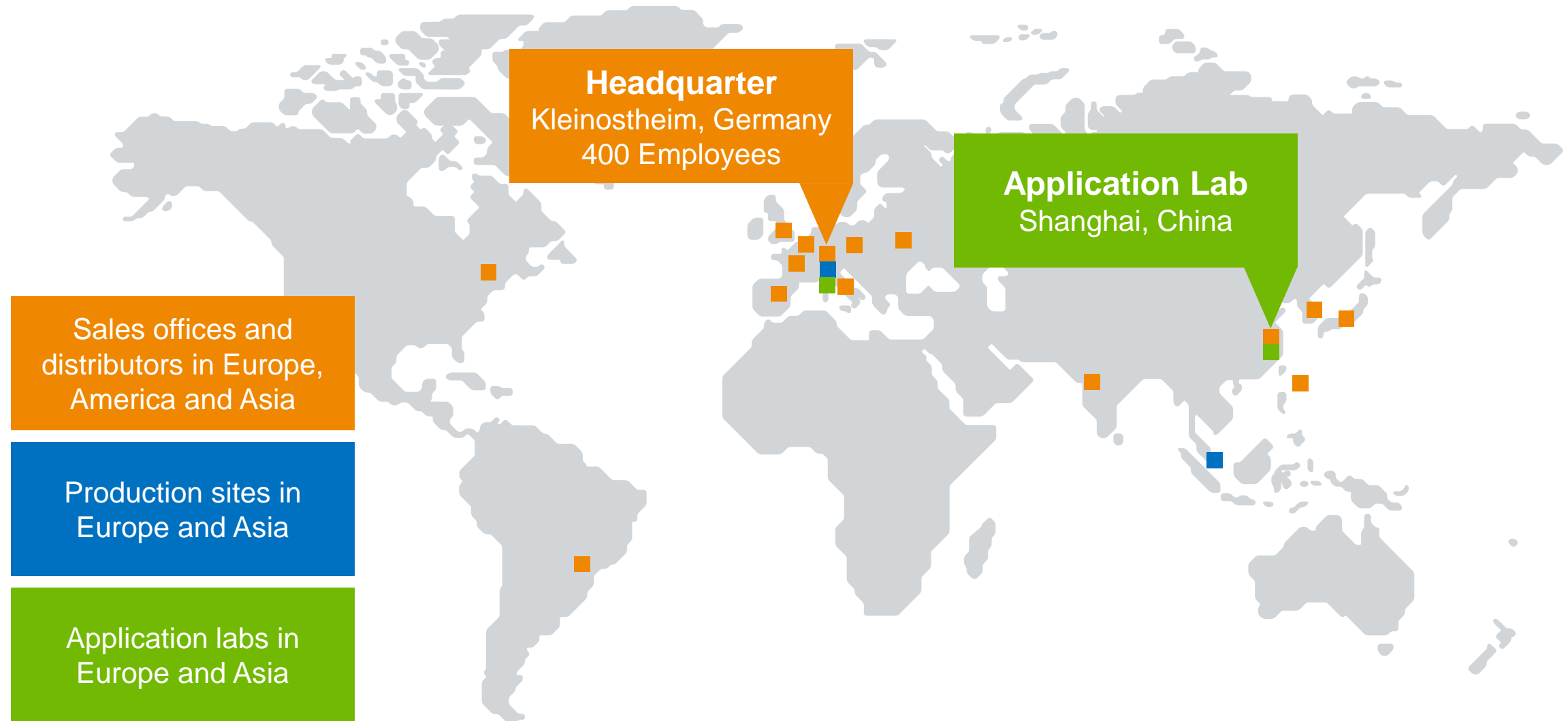
## INNOVATION POWER: GETTING EVEN CLOSER TO THE CRITICAL SPOTS



**Sensor innovation:**  
Nexensos microRTD with footprint down to  $0.6 \times 0.3$  mm and low profile of  $\sim 40$   $\mu$ 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

