

Wie ultrakleine MEMS Sensoren den Alltag erleichtern und Leben retten

Dr. Gerhard Lammel, Director System Architecture, Bosch Sensortec

Sensoren und Messsysteme 2026, Nürnberg
09. Juni 2026



Agenda

1. Wie klein können Sensoren werden?
2. Optische Partikelsensoren und Waldbrände
3. Hochgenaue Drucksensoren und Notruf
4. Robotik
5. Zusammenfassung



Who we are Invented for life

Robert Bosch GmbH Four business sectors

Mobility Solutions, Industrial Technology, Energy & Building Technology, Consumer Goods



Mobility Electronics The electronic heart of Bosch

Electronic Control Units & Semiconductor components



Bosch Sensortec Sensing solutions for consumer electronics

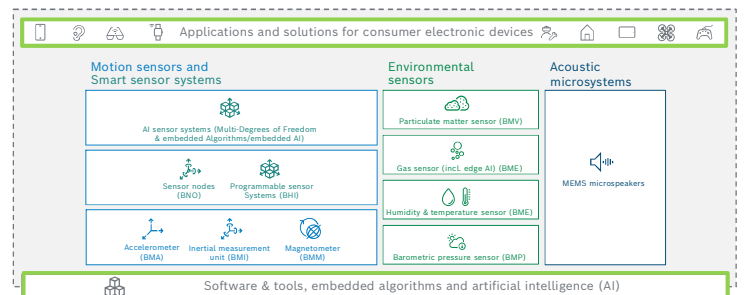
Motion & environmental sensors, smart sensor systems, optical microsystems, acoustic microsystems



3 Internal | Bosch Sensortec | BISTEAPI BISTEAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.



The large spectrum of MEMS devices And their combinations



4 Internal | Bosch Sensortec | BISTEAPI BISTEAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

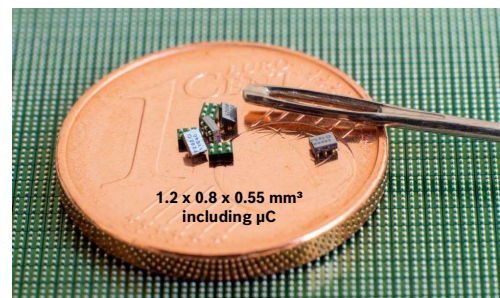


1

Wie klein können Sensoren werden?



The world's smallest Accelerometers BMA580/BMA530 in Wafer Level Chip Scale Package (WLCSPP)

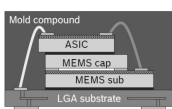


5 Internal | Bosch Sensortec | BISTEAPI BISTEAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

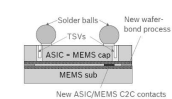


Size matters: The world's smallest CE accelerometer Enabled by our cutting-edge ASICap technology

Classical LGA
4 mm²
Accelerometer



ASICap
Chip Scale Package
1 mm²
Accelerometer



Footprint 1 mm² and height 0.55 mm:
The smallest Bosch product ever

Main features

- No mold compound
- No bond wires
- No substrates

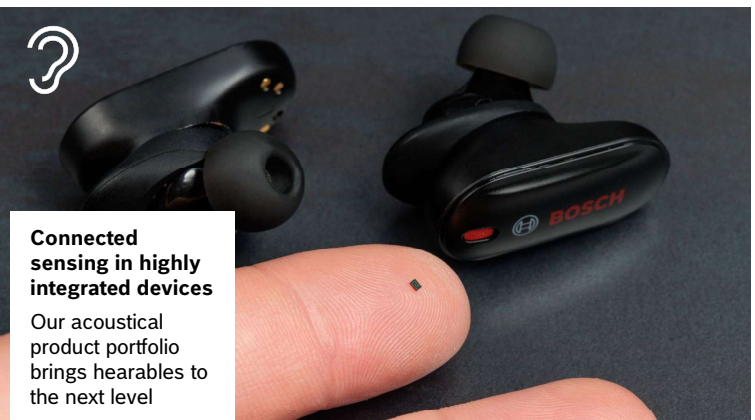
Main technology milestones

- ASIC TSVs
- ASIC/MEMS wafer bonding



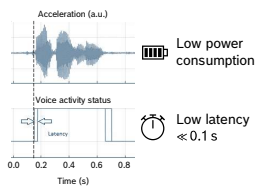
Enabler for the Internet of Things:
µController, ASIC, and MEMS in a single tiny package.

6 Internal | Bosch Sensortec | BISTEAPI BISTEAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.



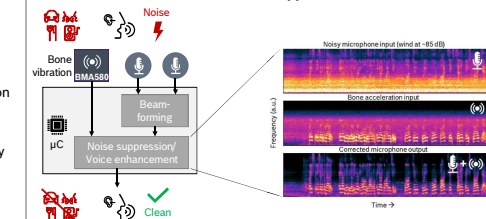
High-bandwidth accelerometer Enabling many voice enhancing functions

Integrated μ Controller:
On-sensor **voice wake-up** feature



Highly integrated sensor:
MEMS, ASIC, and μ Controller

Not sensitive to acoustic noise: **Noise suppression!**



Integrated μ Controller makes
configuration & customization
highly flexible

Enabler of new use cases to
make life more convenient

9 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.

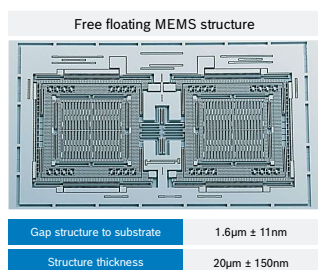


By the way: we are on Mars, too.

The BIM160 takes flight stability to new spheres.



MEMS sensing solutions Highest precision in MEMS processing



11 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.



2

Optische Partikelsensoren und Waldbrände



Every 5 seconds
one human being
is killed by fine dust.



Source: World Health Organization, <https://www.who.int/news/photo/2017/1/candle>

14 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.



Particulate Matter Common Sources of Air Pollution and 'Fine Dust'

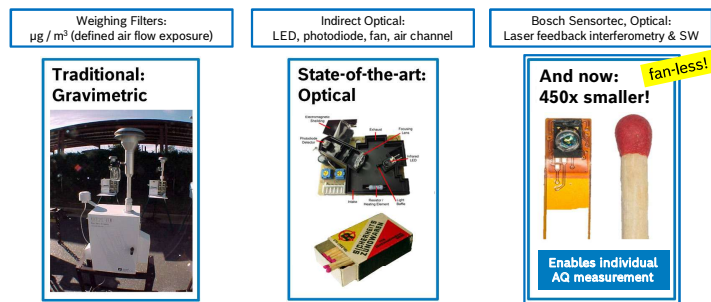


Awareness to air quality continues to increase => Particulate Matter seen as the proxy indicator

14 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.



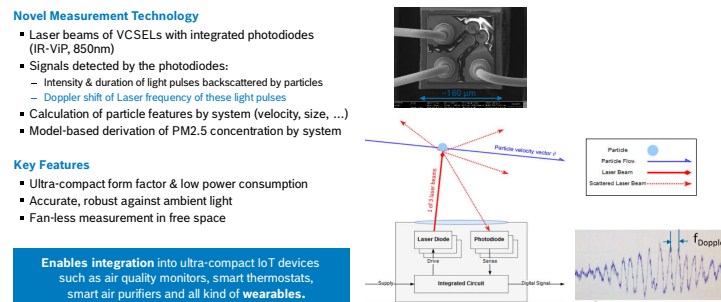
Particulate Matter Sensor Fine Dust Measuring Devices



2 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.



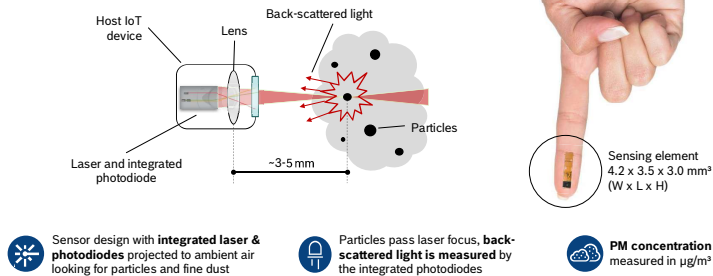
Particulate Matter Sensor BMV080 Working principle



5 Internal | Bosch Sensortec | BSE2AP1 BISTP1 P1 | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any patents, registrations, trademarks, and/or other intellectual property rights.



BMV080 uses the Doppler effect with back-scattered light from moving particles.

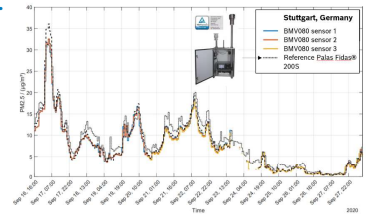
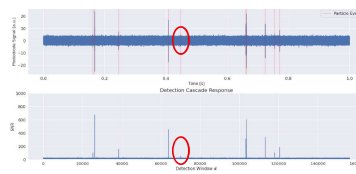


17 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Particulate Matter Sensor BMV080
Find the needle in the haystack...

Signal for typical particle size distribution @ 300 µg/m³
(Duration: 1s, sampling rate: 10 MHz)



- Test location: Outdoor (Stuttgart Feuerbach)
- Test duration: 11 days
- Reference Equipment: Palas Fidas® 2005 - optical PM reference equipment used by the German state of Baden-Württemberg

7 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

BOSCH



BOSCH

Wildfires
Arcachon, France

- This once was a restaurant.

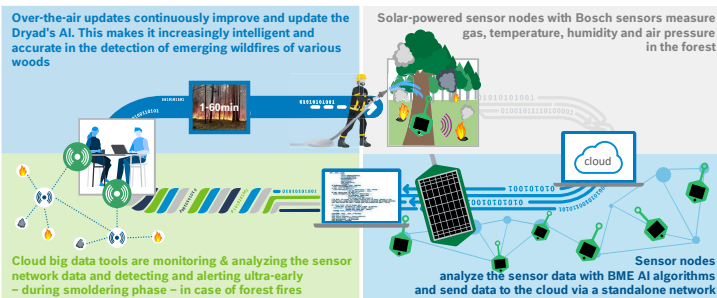


photo: Gerhard Lattner

20 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Environmental sensing
Detecting wildfires before they spread



21 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Wildfire detection
Unauthorized Wildfire in detected in 30 Minutes

- Dryad's ultra-early wildfire detection system, detected a small illegal fire swiftly, allowing for prompt response measures.
- The sensor network detected a change in air composition through the Bosch BME688 gas sensor, triggering an alert through the mesh to the customer.
- Pilot deployment since January 2023 with 91 sensors covering 78-hectare area in the forest adjacent to Deir Mar Moussa.



source: <https://www.dryad.net/post/dryad-silvanet-detects-unauthorized-wildfire-in-lebanon>

22 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

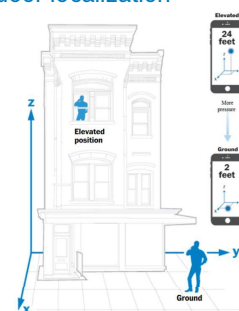
BOSCH

3

Hochgenaue Drucksensoren
und Notruf

BOSCH

Pressure Sensor Use cases
Indoor localization



Current situation

- Increasing usage of wireless phones for emergency calls, particularly from indoors where traditional localization technologies don't work efficiently or fail completely (e.g. GPS)

Initiative

- FCC (Federal Communications Commission) issued E911 rule in the US: The location of the 911 caller will automatically be transmitted to responder

Challenge

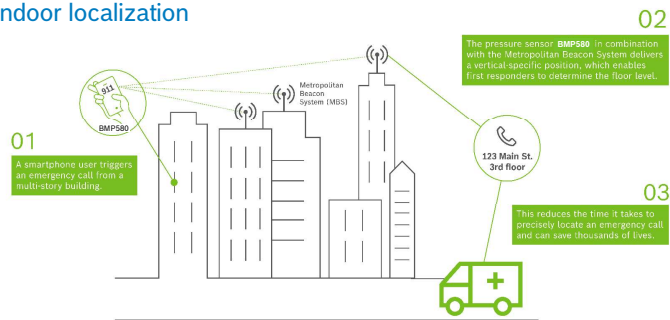
- Development of new technology to implement this feature as a standard in future wireless phone generations in the US is finished now.



24 Internal | Bosch Sensortec | BSE0AP1 BSE0PU PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, modification, distribution, as well as in the event of applications for industrial property rights.

BOSCH

E911 emergency call initiative Indoor localization



25 Internal | Bosch Sensortec | BSEDAPI | BSEDAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



Barometric pressure sensor Indoor localization



Solution

- FCC requires wireless providers in the US to adopt a z-axis location accuracy metric of ± 3 meters relative to the handset for 80 percent of indoor wireless 911 calls.
- Bosch and NextNav LLC, a 3D geolocation service provider, have created a solution that provides highly accurate z-axis capabilities indoors.
- Combining barometric pressure sensors inside smartphones with NextNav's Metropolitan Beacon System (MBS) z-axis service determines three-dimensional location and positioning for enhanced emergency calls (E911).

The FCC estimates that the additional vertical information has the potential to save up to **10,000** lives per year just in the USA alone.*

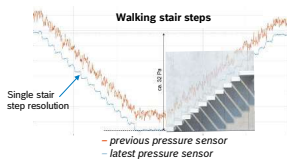
*Source: <https://docs.fcc.gov/public/attachments/DOC-340516A1.pdf>

26 Internal | Bosch Sensortec | BSEDAPI | BSEDAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



Hidden high-tech in consumer sensor What does accuracy of 17.5cm mean?

Walking the stairs or measurement to the extreme



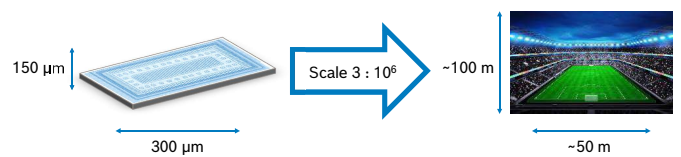
Equivalent of

	~17.5 cm step height, Air column 13000.000 m vs. 13000.175 m
	~2.1 Pa pressure difference 101302 vs 101300 Pa
	/ 300 ~7.6 µg weight change of air on membrane
	/ 1000000 ~12.6 aF capacitance change

27 Internal | Bosch Sensortec | BSEDAPI | BSEDAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



Hidden high-tech in consumer sensors Deflection of pressure sensor membrane



- Size of membrane 300x150 µm²
- Deflection change for one step height (17.5cm): 5.9 pm

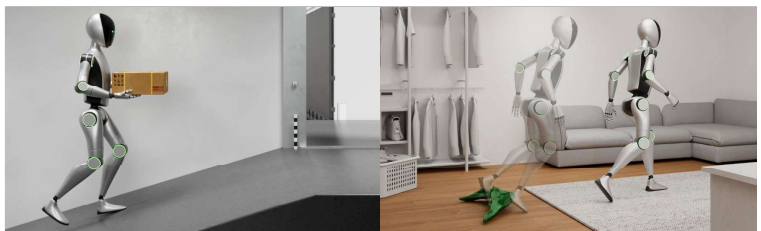
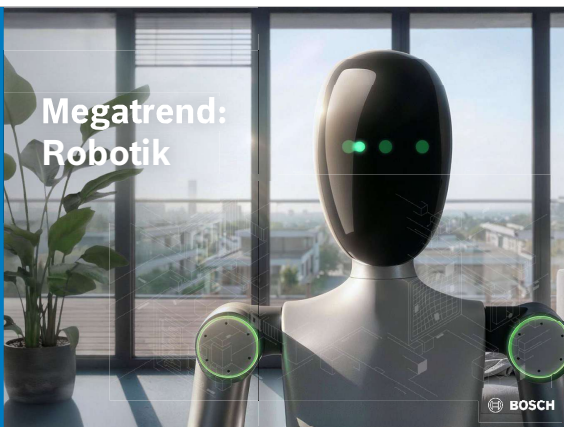
- Size of soccer field ~ 100x50m²
- deflection change at the center: 2 µm

28 Internal | Bosch Sensortec | BSEDAPI | BSEDAPI PE | 2026-06-09
© Bosch Sensortec GmbH 2026. All rights reserved. Also regarding any disposal, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



4

Megatrend: Robotik



Motion control and balancing

Maintaining balance, body orientation, and precise limb control is essential for humanoid and social robots. Bosch MEMS sensors enable the robot to continuously sense and correct its posture and motion.



Dynamic motion control and balancing

The robot detects when it is falling or changing height and reacts to stay safe thanks to Bosch's MEMS sensors. IMUs and accelerometers capture real-time dynamic motion such as falling, slipping, or other unwanted accelerations or displacements. Pressure sensors precisely measure barometric air pressure to monitor subtle height changes. Together, they give the robot a sense of movement and orientation in space.

Sensor	Type	Purpose
BMP581	Ultra-low noise pressure sensor	Height tracking, navigation enhancement
BMP585	Gel-filled pressure sensor	Height tracking, surface pressure detection, navigation enhancement
BM1088	6-axis IMU	Platform stabilization and basic motion control, navigation and SLAM, orientation tracking
BM1423	Standard IMU	Basic motion control, stabilization, orientation tracking
BM1563	High performance IMU	Platform stabilization and basic motion control, navigation & SLAM, orientation tracking



Limb positioning

Encoders are a key technology for precise limb positioning in robots. IMUs provide additional motion data to enhance positioning and motion control. Smart IMUs integrated into body parts such as arms, legs, and the waist monitor and control movements even under dynamic conditions. Magnetometers add absolute heading information, ensuring stable and accurate orientation tracking. Combined with motor control and joint angle measurements from encoders, robots can detect unintended motions such as slippage and adapt to dynamic situations.

Sensor	Type	Purpose
BM1563	High performance IMU	Platform stabilization, real-time motion and orientation tracking
BH1360	Programmable smart IMU	Context recognition, programmability, built-in algorithms for orientation tracking
BM1350	Magnetometer	Absolute heading and orientation immediately on start-up, supporting drift compensation when used with IMU



Environmental sensing

To act intelligently, robots must sense more than just motion or visuals. Environmental sensors from Bosch, such as air quality and humidity sensors, enable context-aware behavior. Humanoid robots can detect poor air quality, smoke, and gases, suggest ventilation, and provide real-time feedback to users as ambient-aware companions.

PM sensor Gas sensor Pressure sensor

Sensor	Type	Purpose
BME690	Gas, humidity, temperature, pressure sensor	Monitors environmental comfort, indoor air quality, and specific gases with fast response time
BMV080	Particulate matter sensor	Detects dust, smoke, and fine particles in real-time
BMP581	Ultra-low noise pressure sensor	Altitude tracking and weather conditions
BMP585	Gel-filled pressure sensor	Media robust, track water pressure, altitude and weather conditions

BOSCH

Tactile Sensing

The robot uses gel-filled air pressure sensors and integrated IMUs in its hands and fingers to detect pressure intensity, distribution, contact force, and 3D hand orientation in real time. This high-resolution tactile sensing enables dexterous manipulation and basic motion control—such as grasping, releasing, and grip adjustment—even without continuous visual input. Vibration and acceleration patterns further support slippage detection.

Pressure sensor Magnetometer IMU

Sensor	Type	Purpose
BMIO88	High performance IMU	Basic motion control, bias stability, vibration robustness
BMIA23	Standard IMU	Basic motion control, stabilization, orientation tracking
BMIS63	Next gen high performance IMU	Platform stabilization and basic motion control, navigation & SLAM, orientation tracking
BMM350	Geomagnetic, high accuracy sensor	3D hand orientation, absolute orientation tracking
BMP581, BMP585	Pressure sensors	Fine surface pressure detection for touch-sensitive control and gripping

BOSCH

Tactile sensing is a major driver for humanoid robots.
What does a tactile sensor look like?

Pressure sensors have been designed to measure fluid pressure but are excellent tactile sensors.

Deformation → Pressure increase

Elastomer Pressure Sensor Press

BOSCH

Mechanical robustness of CE sensors
Life (of a sensor) can be harsh...

Sensors are exposed to various kinds of mechanical stress...

...yet, they must sense extremely small movements!

BOSCH

From use-cases to requirements to tests
Characterization & qualification in BST test center

Characterization	Temporarily applied stress	Stress over lifetime
Characterization tests (performance at t=0) - Offset - Sensitivity - Noise - Accuracy - Current consumption	Sensor specific tests (performance in specific stress situations) - Bending - Short-term Temperature stability - Vibration robustness - Pressure Stability - Installation robustness	Qualification tests (performance over lifetime) - Environmental (temperature, humidity,...) - Mechanical (shocks, drops) - Chemical (chemicals, water,...) - Electrical (ESD, solderability)

BOSCH

5

Zusammenfassung

BOSCH

Sense #LikeABosch
Conclusions

1. Engineers can save lives (when working on the right product)
2. MEMS sensors can contribute significantly to sustainability.
3. Interdisciplinary teamwork is the key to success.

BOSCH

Thank You!

IPCEI Microelectronics and Communication Technologies



The IPCEI ME/CT project is supported by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Parliament, by the Ministry for Economic Affairs, Labor and Tourism of Baden-Württemberg based on a decision of the State Parliament of Baden-Württemberg, the Free State of Saxony on the basis of the budget adopted by the Saxon State Parliament, the Bavarian State Ministry for Economic Affairs, Regional Development and Energy and financed by the European Union - NextGenerationEU.

BOSCH