

MICROTEC NORD

INNOVATIONEN MEMS-BASIERTER SENSOREN BEI BOSCH

ITZEHOE,
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Innovations

What are Innovations?



Wikipedia:

“[...] innovation takes place through the provision of more-effective products, processes, services, technologies or business models [...]”

Innovations

What are Innovations?



Wikipedia:

“[...] innovation takes place through the provision of more-effective products, processes, services, technologies or business models [...]”

!!!

* Boiling 1 cup (235ml) vs 1 litre

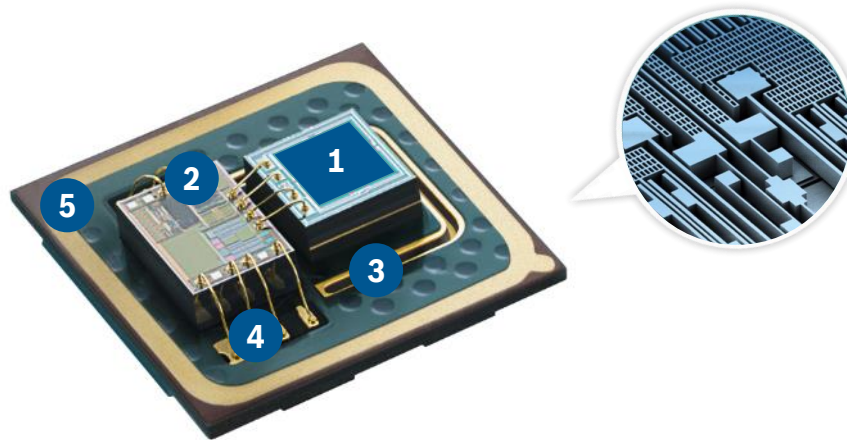
** one cup is equal to 235ml of water

MEMS Sensors

What are MEMS?

Micro-Electro-Mechanical Systems

- MEMS are miniature systems that combine tiny mechanical structures with electronic circuits. Typical individual structures have a size of a few μm .
- The MEMS sensor element is usually packaged together with an ASIC and made into one unit, e.g. into an LGA package.



- 1 MEMS
- 2 ASIC
- 3 Decoupling unit
- 4 Bonding wires
- 5 Printed Circuit Board (PCB)

Market overview

Multitude applications for MEMS sensors



Safety System



Mobile



Imagine



Health & Fitness



Motor Management



Home Application



Industrial & Logistics



Smart Systems

MEMS Sensors

Consumer Applications



► Motion sensing

- Step counting
- Activity monitoring
- Power management
- Free speech profile
- Portrait / landscape



► HMI - User Interface

- Tab / menu control
- Gesture recognition
- Gaming consoles
- Microphones
- AR/VR devices



► PND - Navigation

- Speed and distance estimations
- Altitude detection
- Orientation
- Context awareness
- Location based services



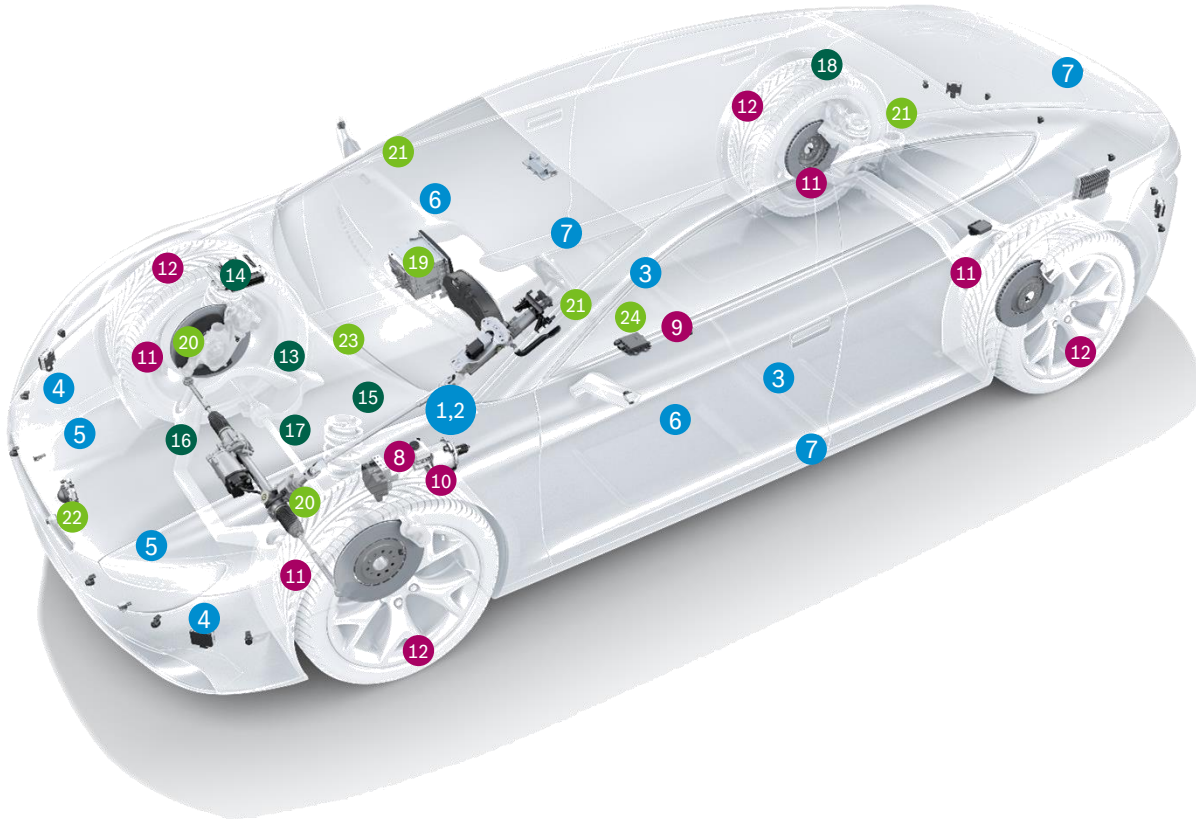
► Environmental sensor

- Gas and air quality
- Beeing recomendations
- Weather forecats
- Smart home
- Humidity
- Temperature



MEMS Sensors

More than 50 MEMS sensors per car



Passive Safety

- 1 High G acceleration sensors for AB-ECU and eCall
- 2 Rollover sensor for Airbag ECU
- 3 Occupant weight sensors or pressure sensors
- 4 PTS - Pedestrian tube sensors
- 5 UFS - Upfront sensors
- 6 PPS - Peripheral pressure sensors
- 7 PAS - Peripheral acceleration sensors

Active Safety

- 8 Inertial sensors für ESP, RSC, RoSe
- 9 MM - Sensor cluster for ESP (accel. & gyro.)
- 10 High pressure sensor for ESP
- 11 Low-g acceleration sensors for active suspension
- 12 TPMS-Tire pressure monitoring system

Power Train

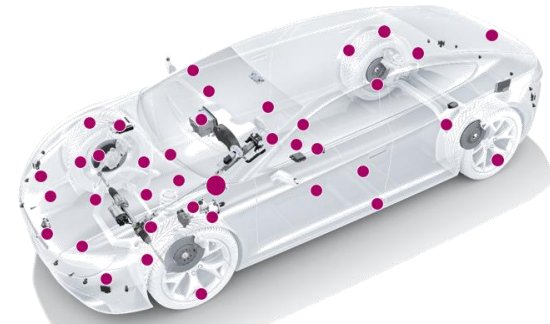
- 13 MAP - Manifold air pressure
- 14 BAP - Barometric air pressure
- 15 Medium Pressure for transmission
- 16 Mass flow sensor
- 17 High pressure sensor for fuel injection
- 18 Tank pressure sensor

Comfort Functions

- 19 Inertial sensor for navigation
- 20 Motor damping / noise cancellation
- 21 Microphones
- 22 Night vision
- 23 Gas / air quality and humidity
- 24 Car alarm

MEMS Sensors

More than 50 MEMS sensors in 1 car



10 Sensors

Engine management

- 1 Mass flow sensor
- 1 Barometric air pressure sensor
- 1 Manifold air pressure sensor
- 1 Oil pressure sensor
- 1 Common rail high pressure sensor
- 1 Tank pressure sensor [Tank pressure]
- 1 Pressure sensor [Start/stop function]
- 2 Accelerometers for active engine mounts
- 1 Pressure sensor for particulate filter

27 Sensors

Active and passive safety

- 2 High-g accelerometers for airbag ECU
- 1 Gyroscope and 1 low-g accelerometer for Roll-over sensing
- 1 Accelerometer for airbag ECU (Structure-borne sound sensor)
- 4 Accelerometers and 2 pressure sensors for peripheral airbag sensors
- 2 Pressure sensors for pedestrian safety
- 1 Gyroscope, 1 low-g accelerometer and 1 high pressure sensor for ESP / ACC
- 1 Gyroscope for active steering
- 1 Accelerometer for eCall
- 4 Tire Pressure sensors and 4 accels
- 1 Pressure sensor for occupant detection

18 Sensors

Comfort

- 2 Pressure sensors for transmission
- 5 Accelerometers for active suspension
- 1 Pressure sensor, 1 humidity sensor for air conditioning
- 2 gas sensors for air quality
- 1 Angular rate sensor and 1 acceleration sensor for navigation systems
- 3 Microphones for speech recognition
- 1 Bolometer Array for night vision
- 1 Accelerometer for car alarm

(Seldom: 16 Pressure sensors (up to 8 pressure sensors per seat))

MEMS Sensors

Automotive Product Portfolio

Acceleration sensors



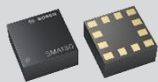
Acceleration sensors
for occupant protection



Low-g acceleration sensors
for VDC, RoSe and active suspension



Low-g acceleration sensor (3-axis)
for navigation / non-safety funct.



Angular rate sensors



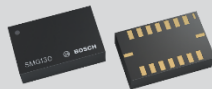
Rollover sensors
for occupant protection



Yaw rate sensors
for VDC



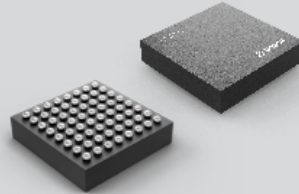
Angular rate sensor (3-axis)
for navigation / non-safety funct.



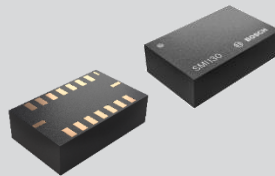
Inertial sensors



Combined inertial sensors
(accelerometer and yaw rate)
for VDC, RSC and RoSe



6 axis combined inertial sensor
(accelerometer and yaw rate)
for navigation and non-safety applications



Pressure sensors



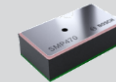
Low pressure sensors
for engine control



Mid-pressure sensors
for transmission control



Pressure sensors
for occupant protection

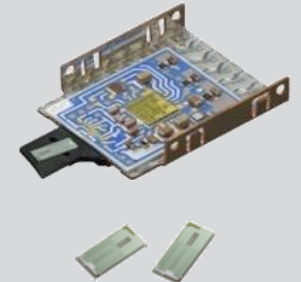


High pressure sensors
for engine and brake systems



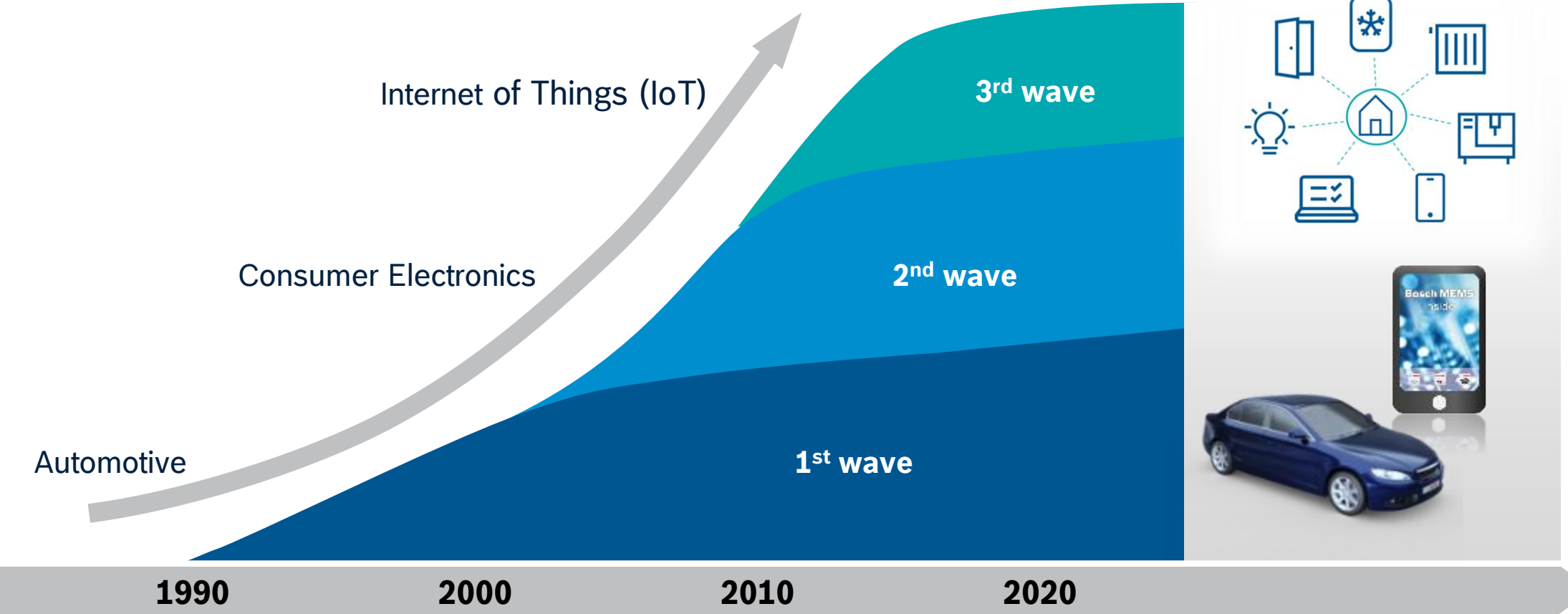
Mass flow sensors

Mass flow sensors
for engine management



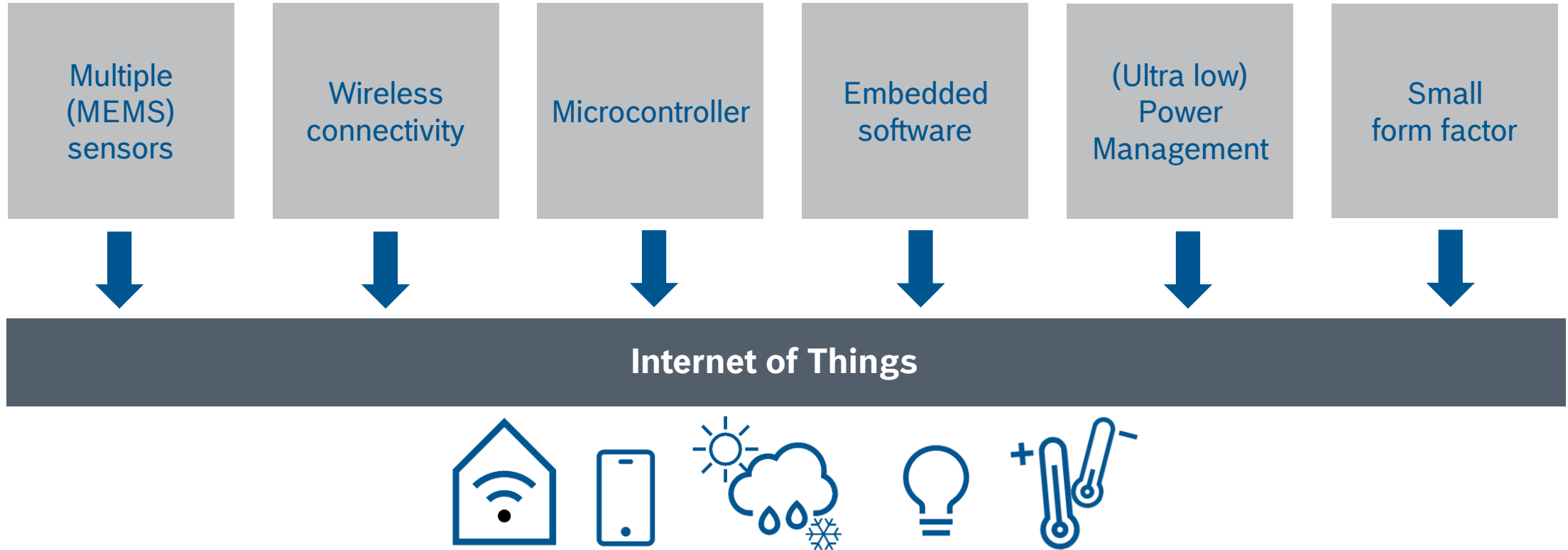
MEMS – a success story

From first cars to an indispensable element in our lives



Market overview

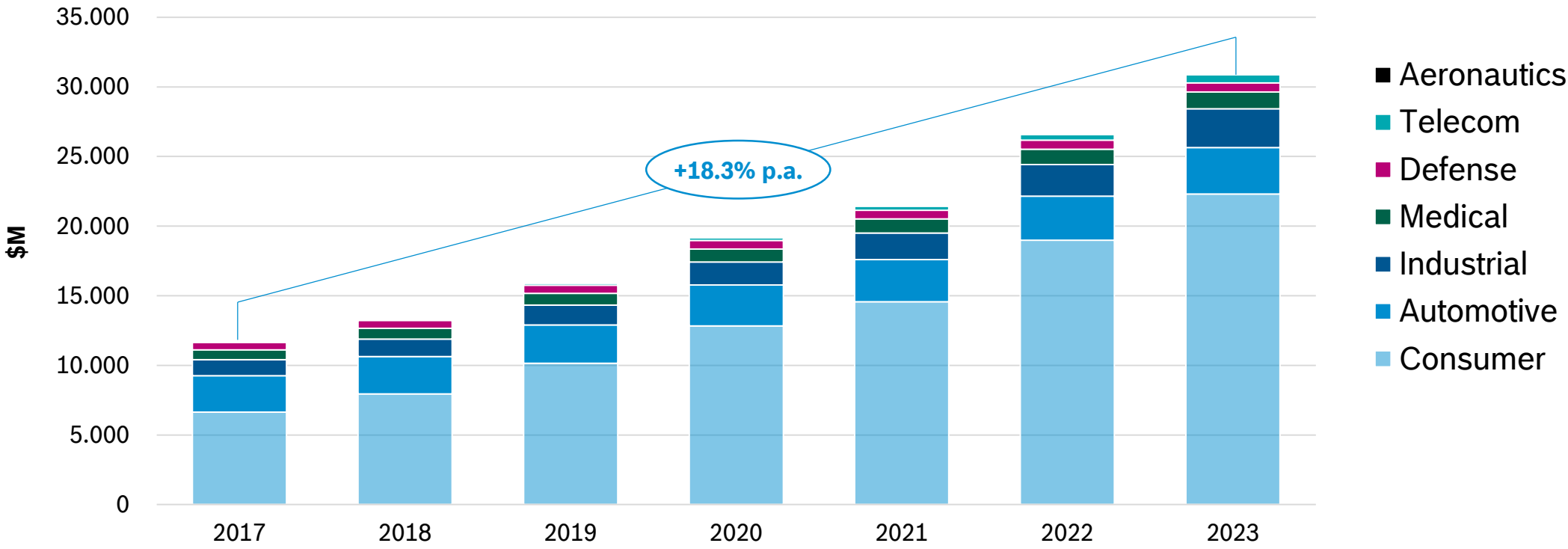
Internet of Things – Connected smart systems and sensors



Wireless connected smart sensors and actuators - Enabler for the IoT

Market overview

Total MEMS market

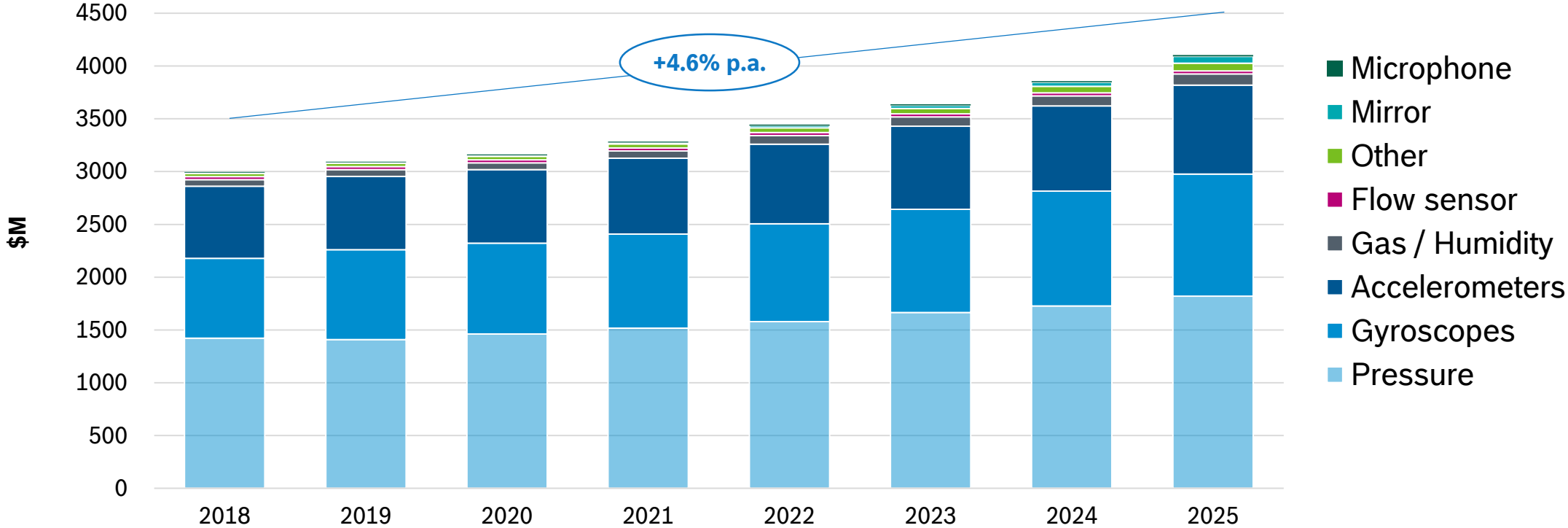


Source: Yole, Status of the MEMS Industry 2018

MEMS is a rapidly growing market - driven mainly by CE and Automotive applications

Market overview

Automotive MEMS market

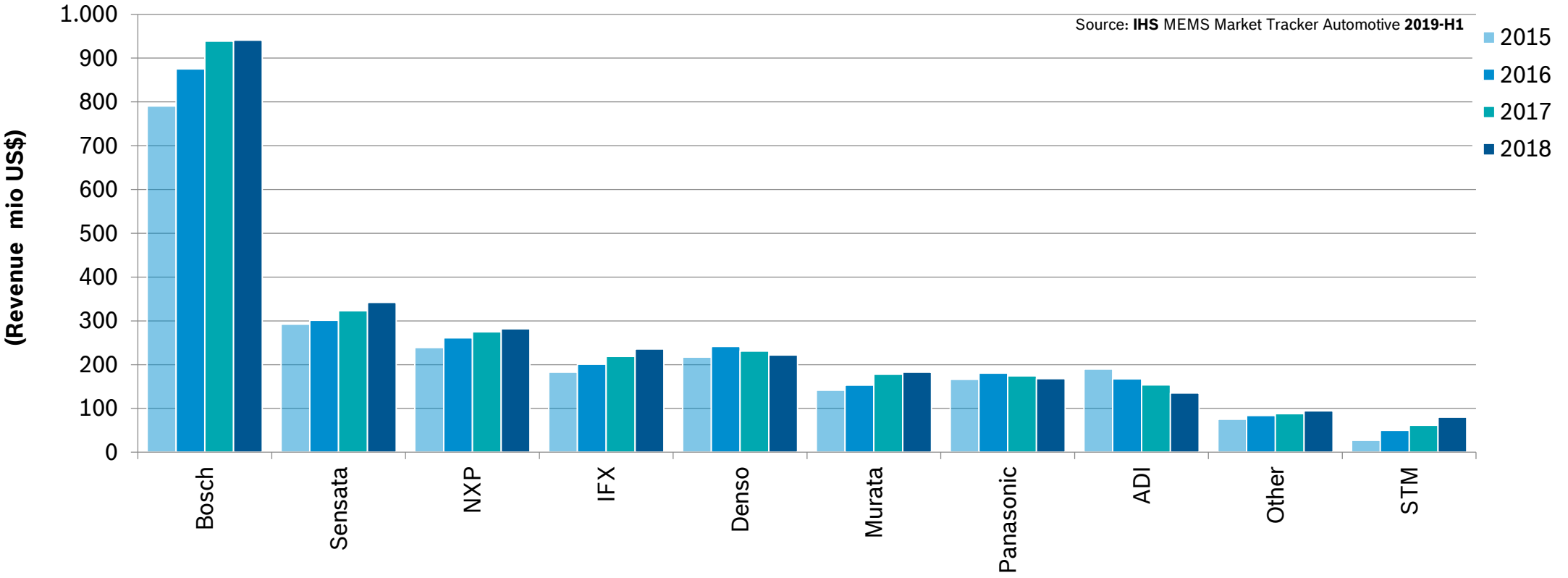


Source: IHS – Automotive MEMS market tracker – H1 2019

MEMS Sensors for automotive are a > 3 billion US\$ market

Market overview

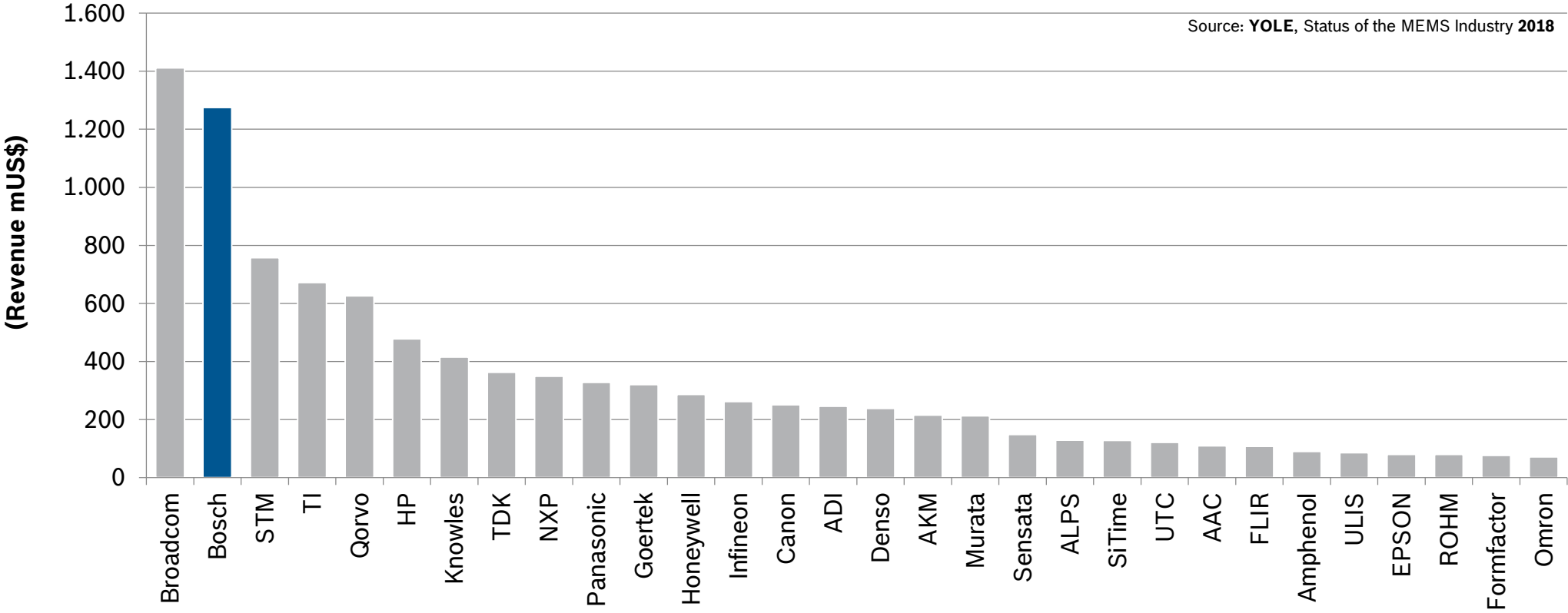
TOP 10 MEMS automotive suppliers



Bosch is world's largest MEMS supplier for automotive applications

Market overview

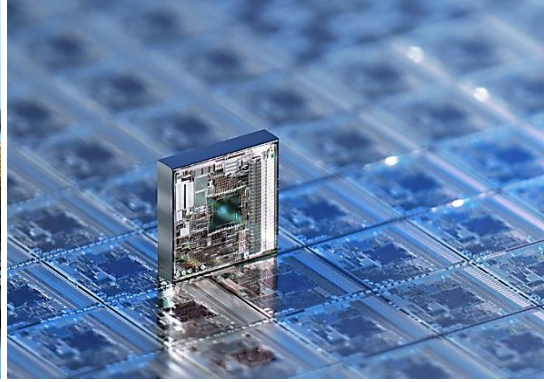
TOP MEMS suppliers by revenue 2017



Bosch is world's largest MEMS sensor supplier

MEMS @ Bosch

Bosch – The MEMS pioneer



- Start of MEMS production in 1995
- More than 10 billion MEMS sensors produced
- More than 1000 MEMS patents
- 100% in-house – from MEMS design to MEMS manufacturing

Bosch - Decades of expertise in MEMS development and MEMS mass production

MEMS Sensors

Three pillars of MEMS

Automotive Electronics - AE



► MEMS for automotive applications

- Accelerometers, Gyroscopes, Inertial sensors, Mass flow, and Pressure sensors

Bosch Sensortec - BST



► MEMS for consumer applications

- Accelerometers, Gyroscopes, Inertial, Magnetic, Pressure and Environmental sensors

Bosch Connected Devices and Solutions - BCDS



► MEMS-based IoT sensor solutions

- Wireless Sensor solutions for Telematics, Data logging, and Industrial IoT applications

Bosch - a global supplier of MEMS sensors for automotive, consumer and IoT markets

MEMS @ Bosch

From automotive to the internet of things



1995

First internal automotive MEMS business

1st high volume pressure sensor for power train application

1999

External automotive MEMS business

Distribution of Sensor via Product Team Sensors PT-S



2005

Foundation of CE Bosch Sensortec

Development and distribution of MEMS sensors for consumer markets

2009

Acquisition of Akustica

MEMS microphones for consumer markets



2013

Foundation of BCDS

Bosch Connected Devices and Solutions GmbH
MEMS products for I4.0 / Internet of Things

MEMS @ Bosch

Wafer fabs in Reutlingen



Employees

3674



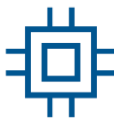
Production area

34 300 sqm



Minifactories

Frontend: ASIC und Sensor
Waferfab
Backend: Wafer Test, Sensor
Montage (Assembly)



Products

IC, power S/C (chip and
packaged), sensors
(packaged, customer
specific mold package)

150 mm module

- 4 100 sqm
- 1 500 wafer starts/day
- Technologies:
 - BCD1, 2, 3, 3s, 4, 4s
 - CMOS, Bipolar, PSC bipolar, MOS
 - Pressure sensors
 - Inertial sensors
 - Process: $\geq 0.5 \mu\text{m}$

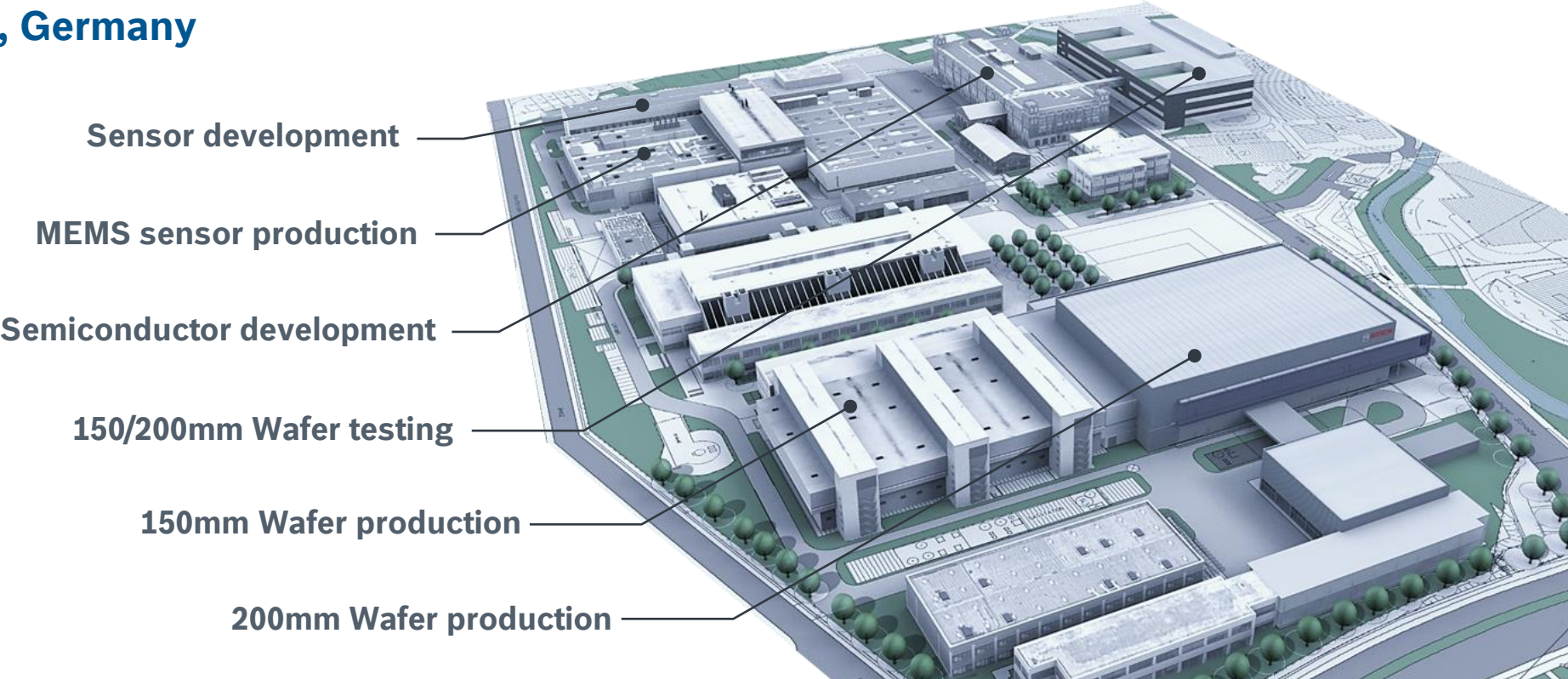
200 mm module

- 4 600 sqm
- 1000 wafer starts/day
- Technologies:
 - BCD4, 4s, 6, 6sCu
 - Advanced CMOS, HVCMOS
 - Pressure sensors
 - Inertial sensors
 - Process $\geq 0.18 \mu\text{m}$

MEMS @ Bosch

Development and production at one location

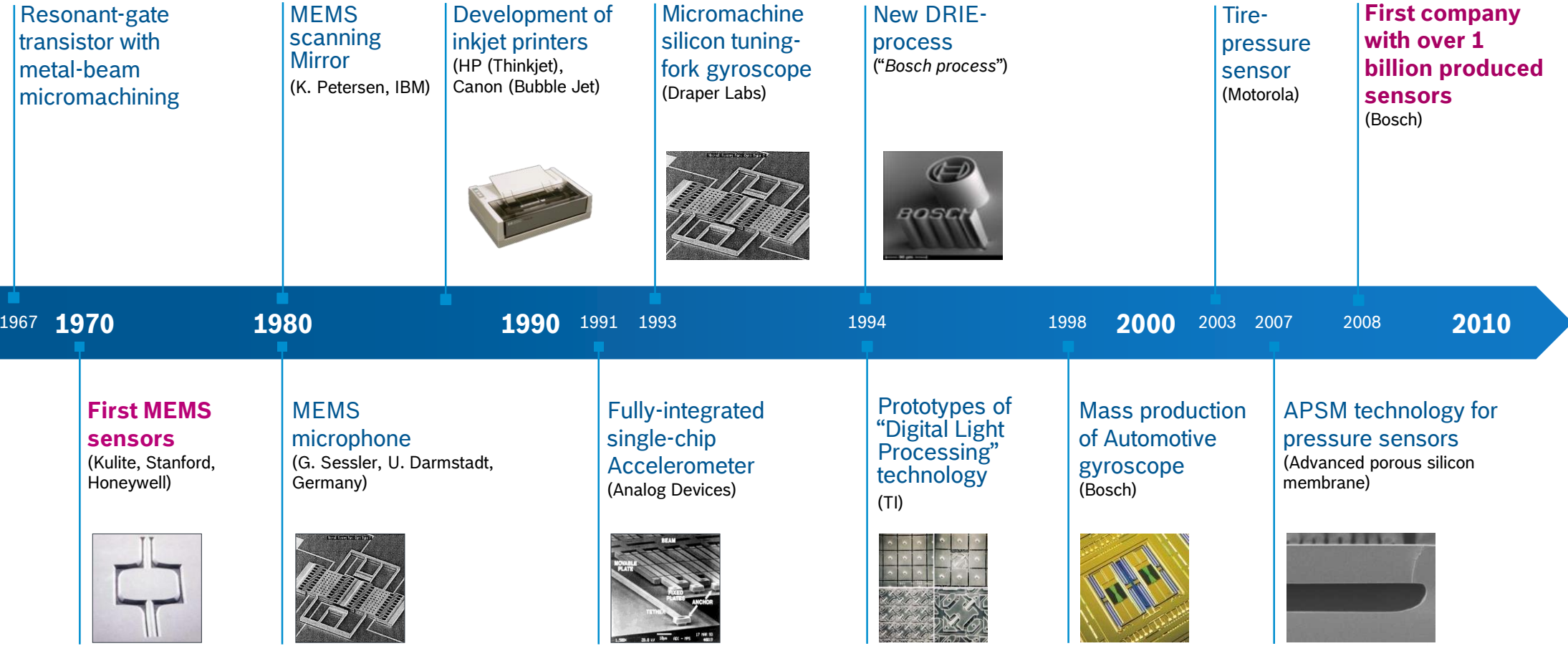
Reutlingen site, Germany



MEMS and semiconductor development, production and testing on one site

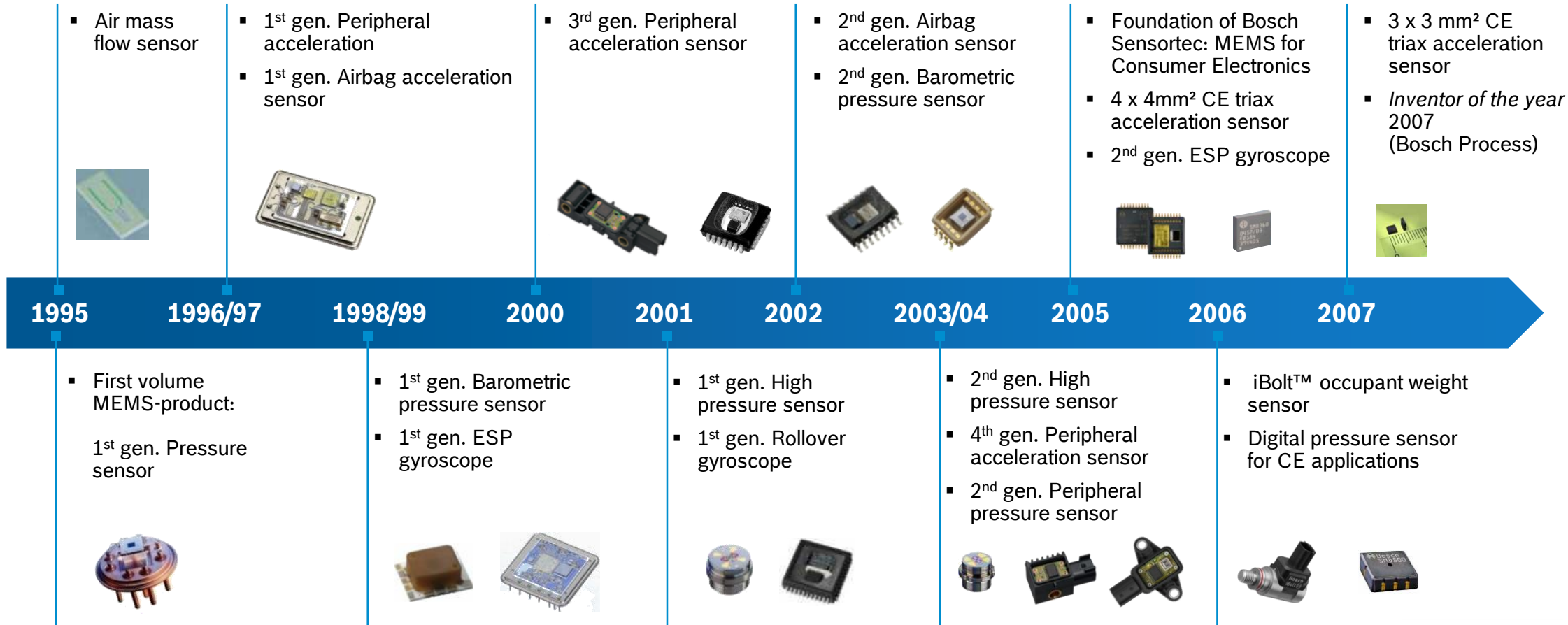
MEMS market overview

From laboratory to mass production



MEMS market overview

Milestones MEMS sensors at Bosch (1/2)



MEMS market overview

Milestones MEMS sensors at Bosch (2/2)

- 5th gen. Peripheral acceleration sensor
- *Deutscher Zukunftspreis* 2008 for Smart Sensors
- 1st gen. ESPi sensor



- 1st inertial sensor in mold package
- 1st 2 x 2mm² CE triax
- 1st gen. mid pressure sensor for transmissions
- 3rd gen. high pressure sensors



- 1st CE gyroscope
- 1st CE inertial sensor
- 2nd gen. ESPi sensor
- 1st multi-chip MEMS microphone



- 5bn MEMS sensors
- 1st ESP inertial sensor in BGA package
- Next gen. high pressure sensors
- 1st CE inertial sensor sub 1mA in 2.5 x 3 mm²



- World's smallest AUT triax accel. (2 x 2mm²)



2008

2009

2010

2011

2012

2013

2014

2015

2016

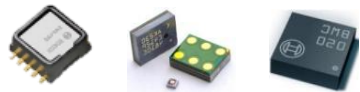
2017

2018

- 2nd gen. Peripheral pressure sensor
- 2nd gen. Rollover gyroscope
- Acquisition of Akustica Inc.



- 1st digital barometric pressure sensor for AUT
- Smallest integrated digital MEMS microphone
- 1st digital CE compass with "FlipCore" technology



- 2nd gen. CE compass
- Smallest CE 3-axis MEMS sensor
- 1st CE 9-axis sensor



- 1st CE smart sensor hubs
- 6th gen. Peripheral acceleration sensors
- World's 1st indoor air quality sensor



- 3rd gen. ESPi sensor
- 2nd gen mid pressure sensor



THANK YOU!