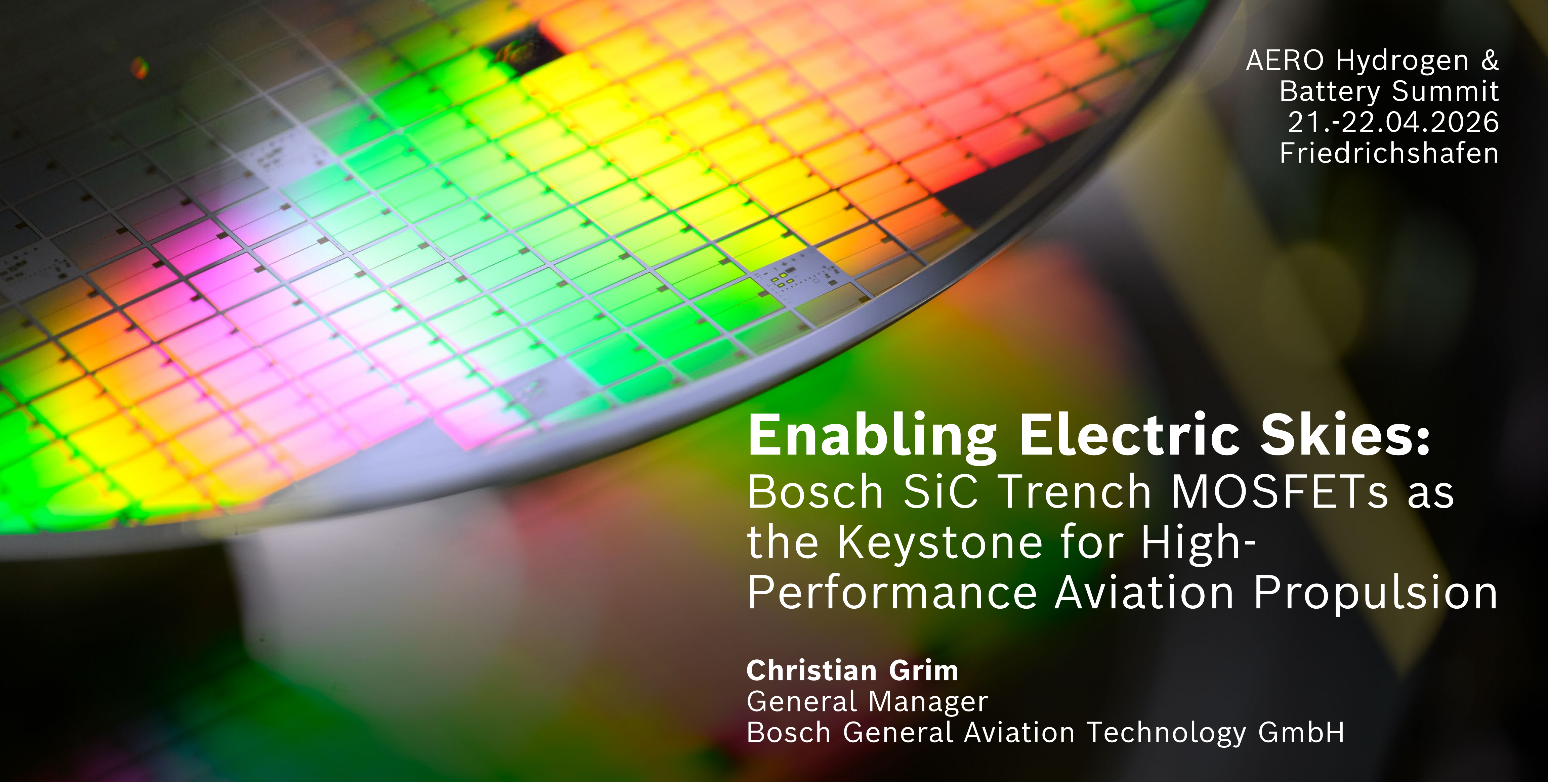


AERO Hydrogen &
Battery Summit
21.-22.04.2026
Friedrichshafen

# Enabling Electric Skies:

## Bosch SiC Trench MOSFETs as the Keystone for High-Performance Aviation Propulsion

**Christian Grim**
General Manager
Bosch General Aviation Technology GmbH

# Who we are
# Bosch business sectors

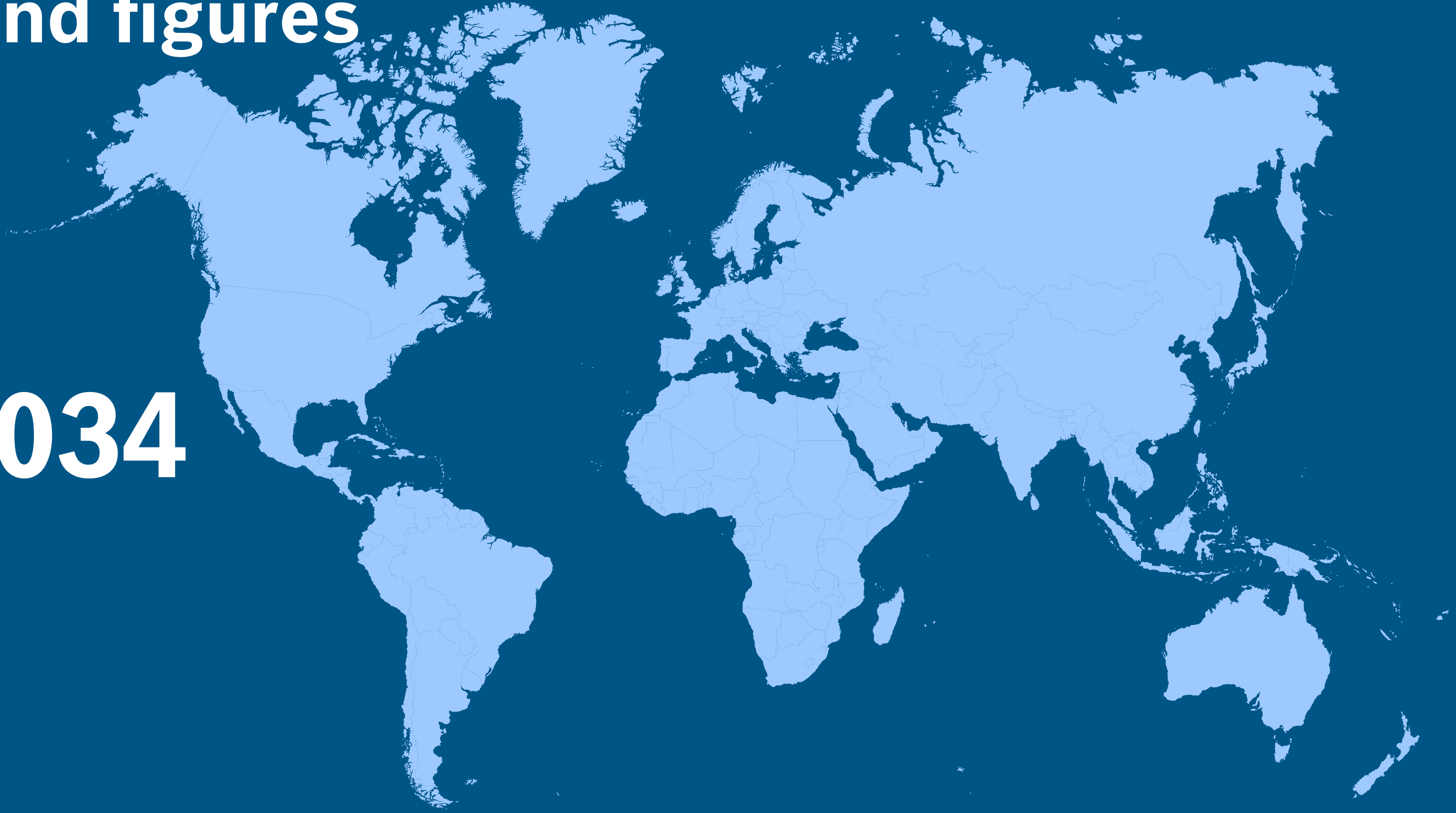
**<u>Mobility</u>**

**Industrial Technology**

**Energy and Building Technology**

**Consumer Goods**

# Who we are
# Bosch Mobility facts and figures



**€55.8bn**

Sales revenue [1]

**231,034**

Associates [1]

**130**

Manufacturing locations [2]

**35**

Research and development locations [2]

Source:
1 Bosch annual report 2024
2 Bosch operating department 2024

# Who we are
# Bosch has a strong, global in-house semiconductor manuf. network

## Frontend

**Reutlingen**

150 mm, 200 mm frontend

Automotive ICs, MEMS, Power S/C, SiC

Electrical wafer sorting, dicing

Nodes: 1 µm … 180 nm

**Dresden**

MEMS starting from 2026 on

300 mm frontend

Automotive ICs, Power S/C

Electrical wafer sorting, dicing

Nodes: 180 … 65 nm

**Roseville**

Starting from 2026 on

200 mm frontend

Power S/C (SiC)

Electrical wafer sorting, dicing

Nodes: 500 nm … 300 nm

## Backend

**Reutlingen**

Final test & wafer level test

Assembly

**Hatvan**

Final test

Assembly

**Suzhou**

Final test

**Penang**

Final test

**Roseville**

Starting from 2026 on

Final test

# Who we are
# Bosch is systematically expanding its SiC manufacturing capacities

Bosch took up **high-volume production** of its first generation of SiC chips in Reutlingen, Germany, **in 2021**.

Bosch is **extending its SiC manufacturing capacities** in both **Reutlingen** and the new wafer fab in **Roseville, California.*** This way, Bosch **makes supply chains more resilient** and **ensures a better supply of the local markets**.

In the coming years, Bosch will increase its delivery volume more than tenfold compared to today.

---

*The full scope of the planned investment will be heavily dependent on federal funding opportunities.

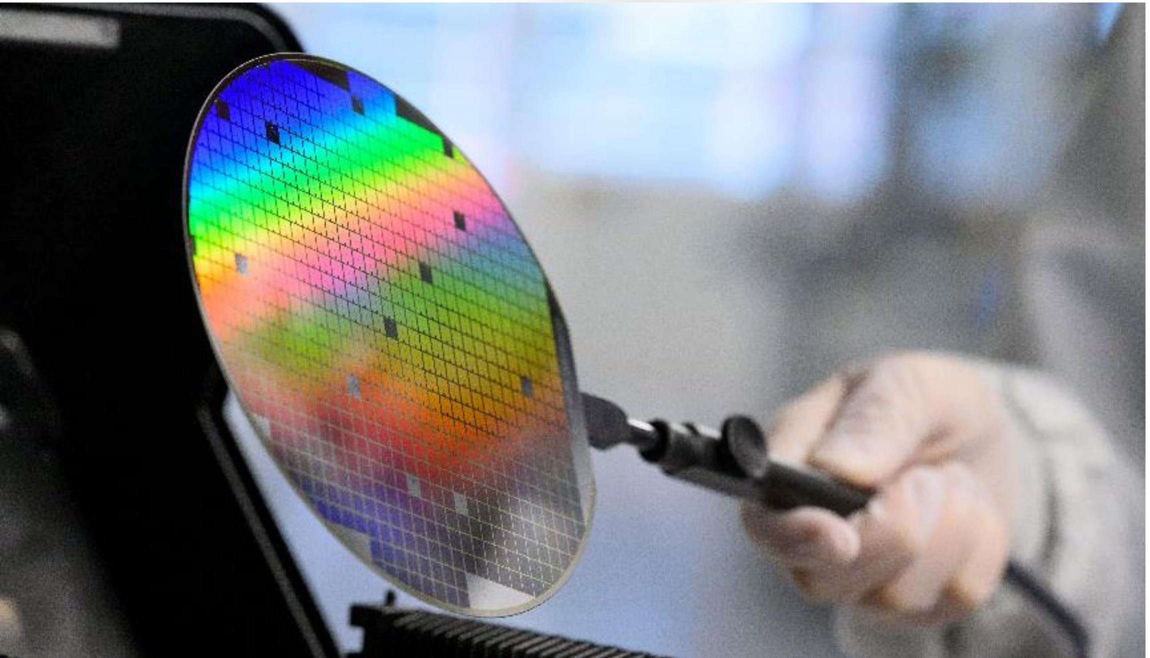
# Shaping a new era of mobility.

# Together.

As a world-leading provider of mobility solutions, we aim to be your partner of choice and a trusted advisor in vehicle systems, software, and hardware.

We empower our partners to successfully compete in changing mobility markets.

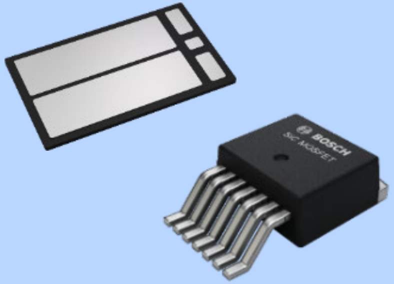
BOSCH



# Bosch is one of the leading semiconductor and sensor suppliers for the mobility industry

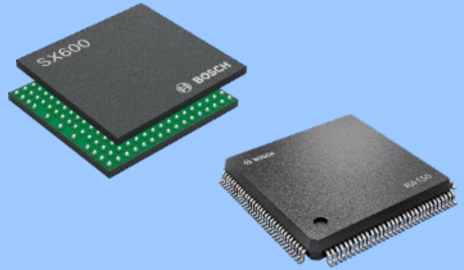
# Portfolio
## Bosch’s semiconductor and sensor portfolio as enabler for aerospace

### Power semiconductors



### MEMS sensors

### Automotive ICs



### Sample applications

High Performance Powertrains

Avionics

Source: Dynon Avionics

Radar sensors

# Portfolio

## Bosch recognized the importance of SiC long before it became relevant for the mobility sector

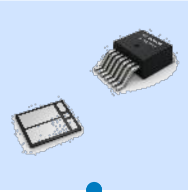
**More than**

**50 mio**

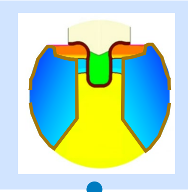
SiC MOSFETs delivered worldwide since 2021

Installation SiC line Reutlingen

SOP 1st Gen
6 ”/150 mm

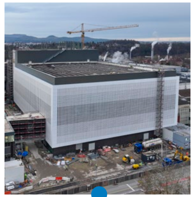


SOP 2nd Gen
6 ”/150 mm



Samples 2nd Gen
8 ”/200 mm

Extension
Reutlingen fab



Samples 3rd Gen
8 ”/200 mm

Samples 2nd Gen
8 “/200 mm

New U.S. fab
in Roseville*

**Dual-fab strategy for reliable supply**

**Roseville (U.S.)**

**Reutlingen (DE)**

**2019** | **2021** | **2023** | **2024** | **2025** | **2026**

*The full scope of the planned investment will be heavily dependent on federal funding opportunities.

# Industry Challenges
# Challenges for High-Performance Aviation Propulsion

**Battery Energy Density**

Batteries store far **less energy per kilogram than jet fuel**, which drastically **limits the range and payload** capacity of electric aircraft, confining them to short-haul missions.

**Thermal Management**

**High-power electric systems generate** intense **heat** that must be managed to prevent component failure or battery fires. **Dissipating this heat within a lightweight aircraft structure is a major engineering problem.**

**Certification & Regulatory Frameworks**

Existing aviation safety standards are starting to be designed for high-voltage electric propulsion. **Regulators must develop and approve entirely new rules to certify these novel aircraft**, a slow and complex process.

**System Weight and Integration**

The **combined weight of batteries, motors, and cooling systems is a significant penalty compared to conventional engines.** This excess mass directly compromises the aircraft's overall performance and efficiency.

# Use Cases
# Silicon Carbide Trench MOSFET potential applications

Microchips made of silicon carbide **switch high currents with lower losses,** and thus **make e-mobility more efficient.**

**Smaller battery**

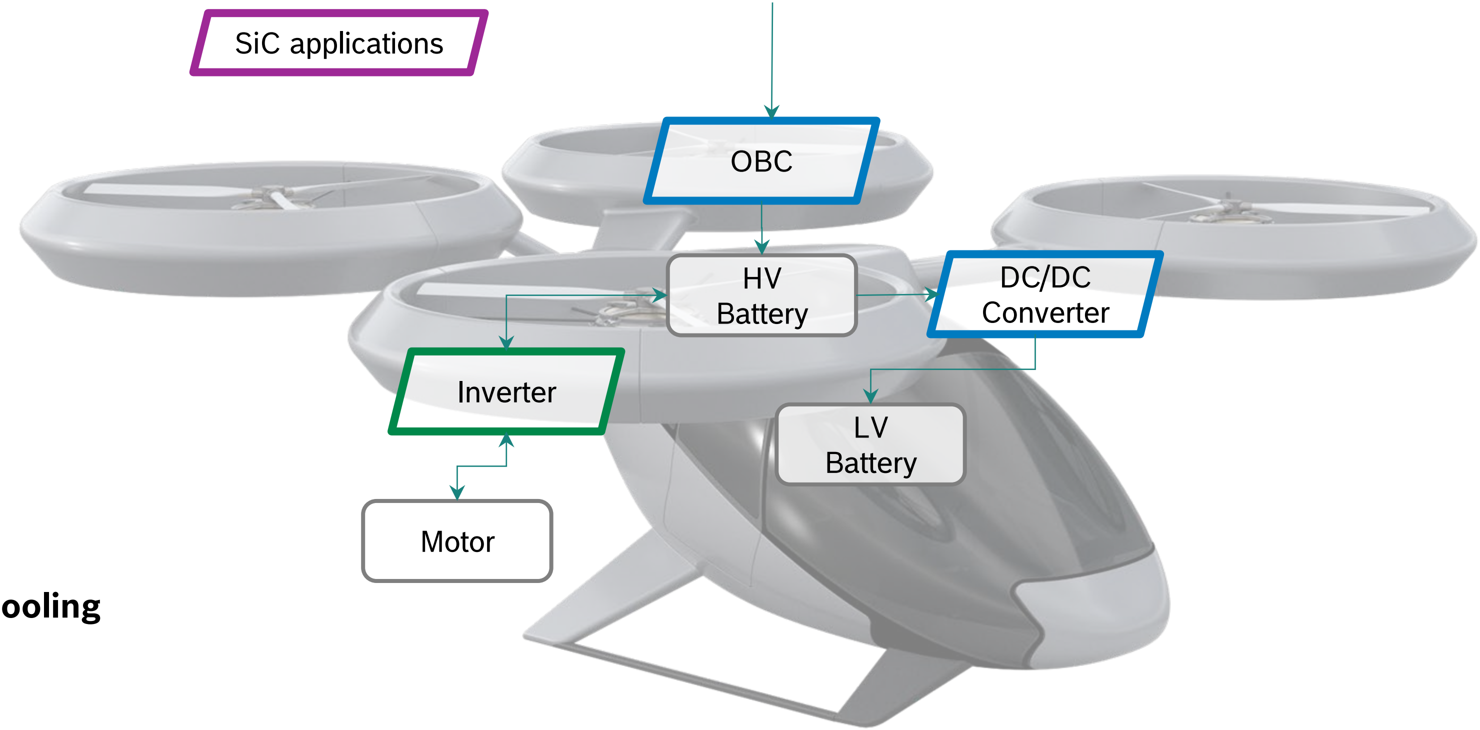
**Longer range**

**Higher efficiency**

**Minimize cooling system**

**Meet regulation requirements**

**Emission reduction**

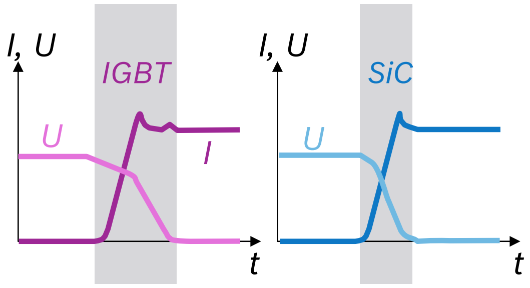


SiC ... Silicon Carbid
OBC ... On Board Charger
HV ... High Voltage

LV ... Low Voltage
DC ... Direct Current
AC ... Alternating Current

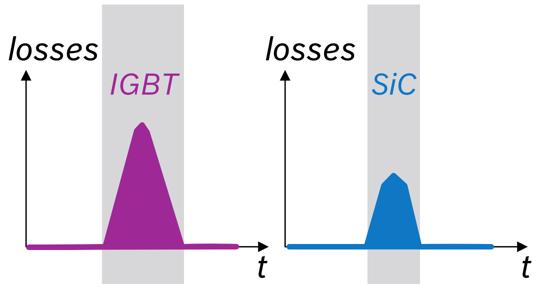
# Technology insights
# **Benefits of SiC technology for e.g. traction converter**

## Faster switching



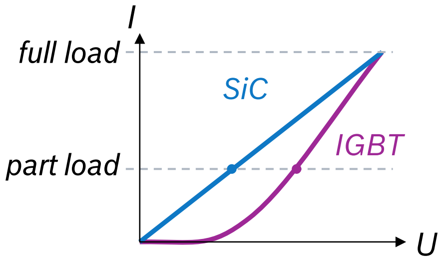
Smaller, lighter passive components,
lower e-machine losses

## Lower switching losses



Less cooling effort,
smaller size

## Lower conduction losses



Lower inverter losses in partial load,
higher energy efficiency

**+200%**
**Inverter power density**

↔

**–6%**
**Battery cost at equal operating range**

IGBT ... Insulated Gate Bipolar Transistor

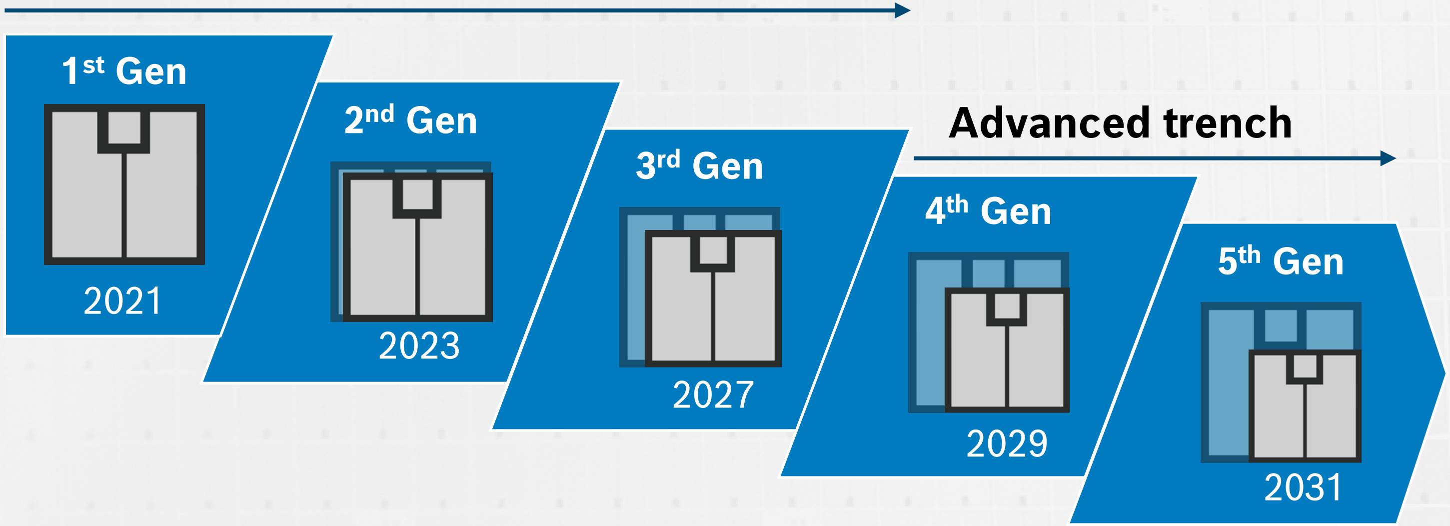
SiC ... Silicon Carbide

# Technology insights
# Innovation roadmap to keep SiC cost/performance leadership

Fast **innovation roadmap** to maintain SiC performance **leadership** and enable **cost benefit**

**Dual-channel trench**

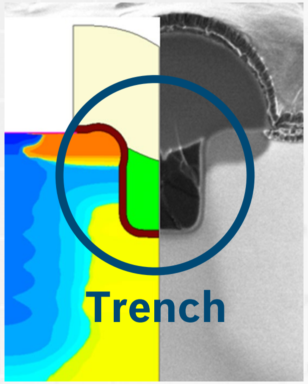
**Advanced trench**



Higher Power Density = **Less Cost per Power**

**SiC dual-channel trench technology**

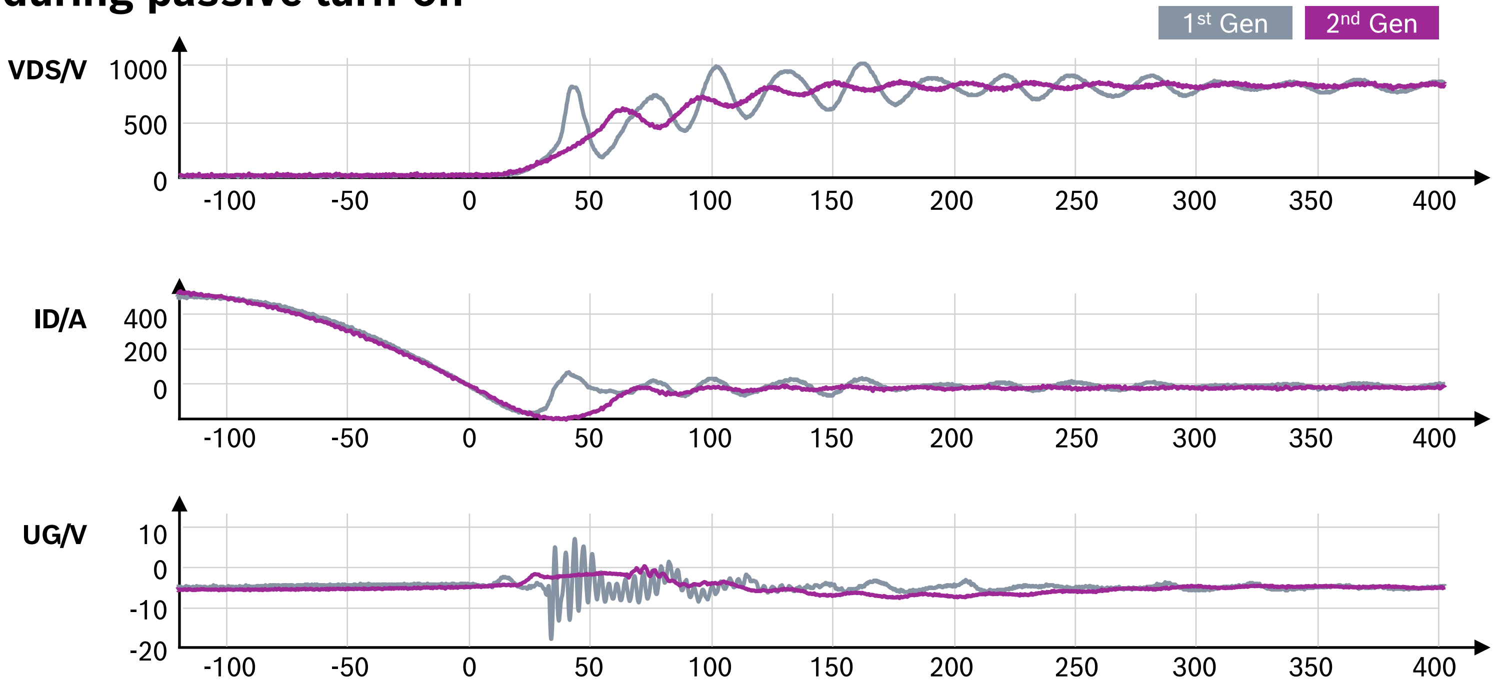
- ✓ Bosch-owned technology
- ✓ Designed for automotive applications
- ✓ Enabler for future **advanced trench** and **superjunction** architectures



**SiC trench = highest power density**

# Technology insights
# **Design for optimum switching**

## Comparison 1st generation to 2nd generation switching during passive turn-off



**Parasitic turn-on immunity**
High immunity against parasitic turn-on by tuning of Miller ratio

**Diode**
Soft recovery over complete temperature range

**Switching control**
Very good controllability of maximum dv/dt

**Clean switching**
Low ringing ensured from 2nd Gen on

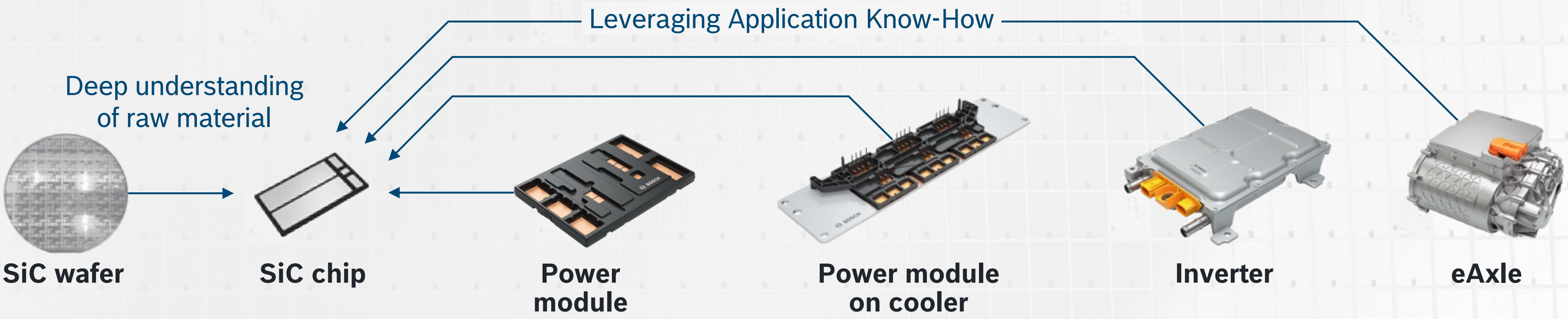
**3rd generation with further optimized switching behavior for inverter**

BOSCH

# Technology insights

## Leveraging application expertise for the best SiC

**Bosch SiC MOSFETs:**
developed by **application + chip + material** experts



Leveraging Application Know-How

Deep understanding
of raw material

**SiC wafer**

**SiC chip**

**Power module**

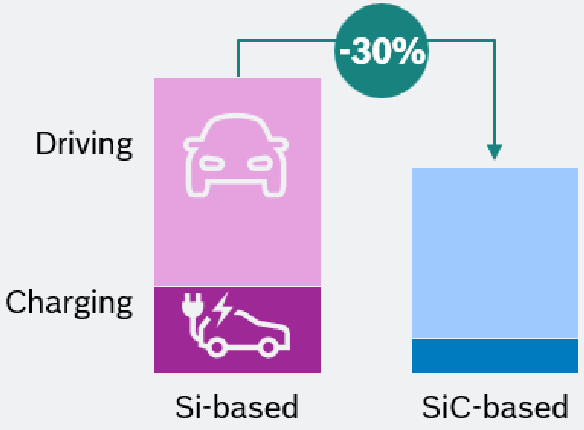
**Power module on cooler**

**Inverter**

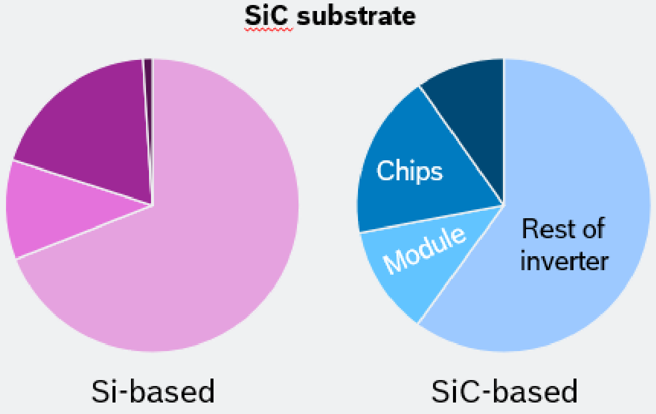
**eAxle**

# Technology insights
# **The substrate impact**

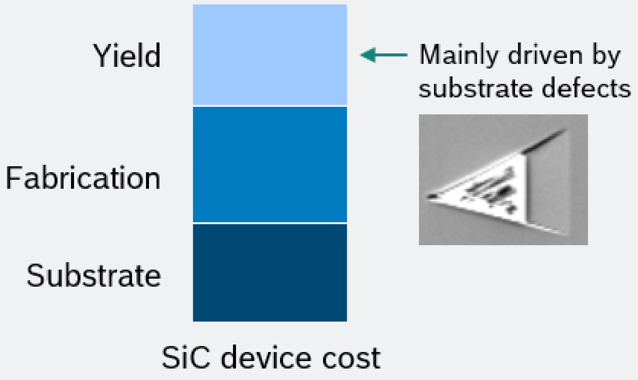
### Impact of **SiC** on **tank-to-wheel** losses



### **Direct** impact of substrate on inverter cost



### **Indirect** impact of substrate quality on cost

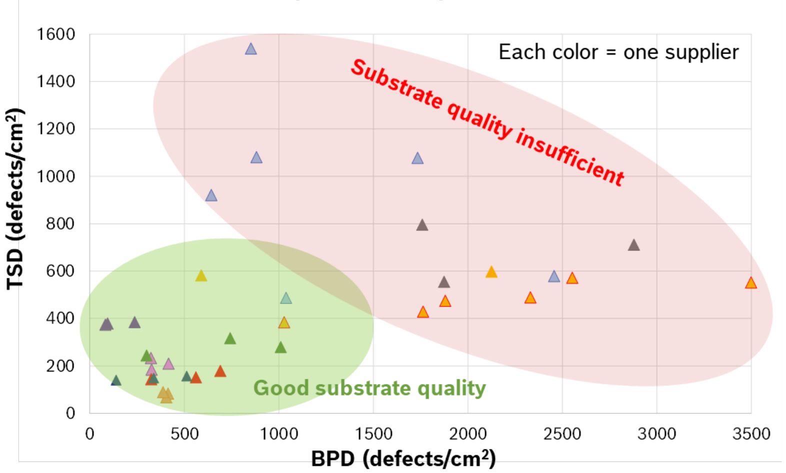


**Understanding of substrates is crucial for realizing cost-effective chips that unlock peak efficiency of EVs**

# Manufacturing insights

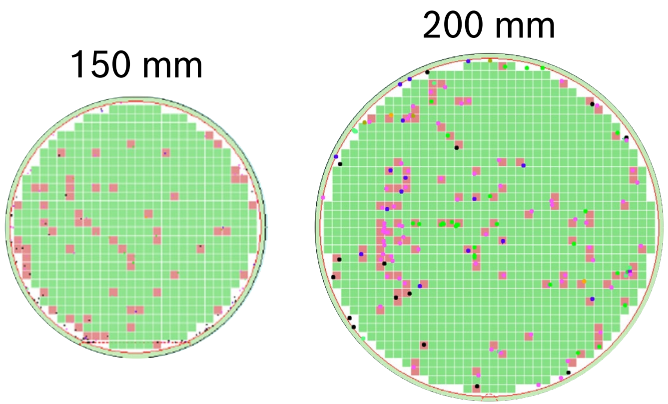
# Technology transfer 150 to 200 mm: substrates and yield

## Substrate quality 200 mm: choosing the right suppliers



Wafer maps show same level of yield for 150 mm and 200 mm epitaxy

## Substrate quality is crucial for device yield



**Bosch substrate strategy: Minimizing supply risks**

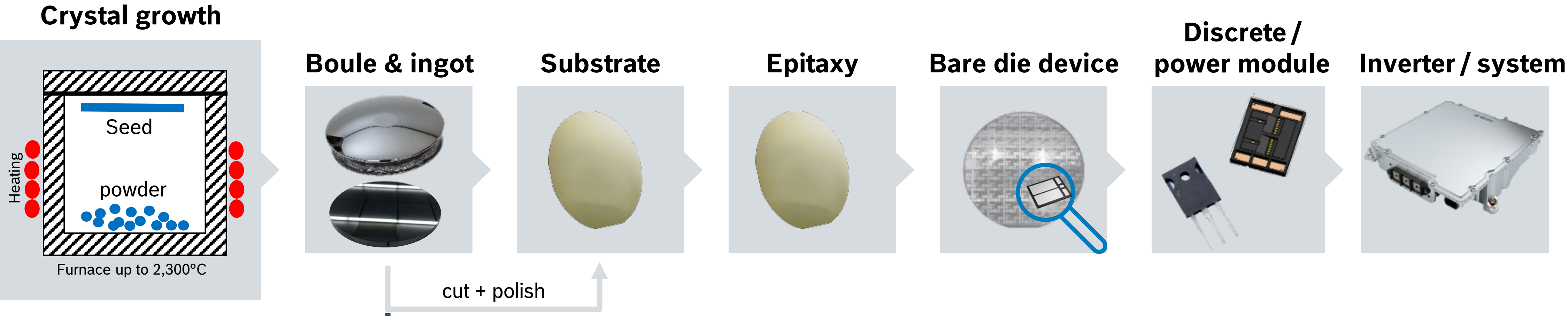
**1** Multi-source substrate supply with regional diversification

**2** In-depth technical monitoring and quality control

**Substrate quality monitoring is key to ensure 200 mm manufacturing with yield above industry standard**

TSC ... Threading Screw Dislocation BPD ... Basal Plane Dislocation

# Manufacturing insights
# Value chain steps from SiC crystal to power module



**Crystal growth** → **Boule & ingot** → **Substrate** → **Epitaxy** → **Bare die device** → **Discrete / power module** → **Inverter / system**

cut + polish

## Bosch value chain

| | Boule & ingot | Substrate | Epitaxy | Bare die device | Discrete / power module | Inverter / system |
|---|---|---|---|---|---|---|
| | **Supplier** | **Bosch** | | | | |
| BOSCH | Strategic supply via partnership | In-house wafering + long term contracts | In-house + suppliers | in-house[1] | In-house + OSAT | In-house |

**Understanding and managing the SiC supply chain is key to stay successful!**

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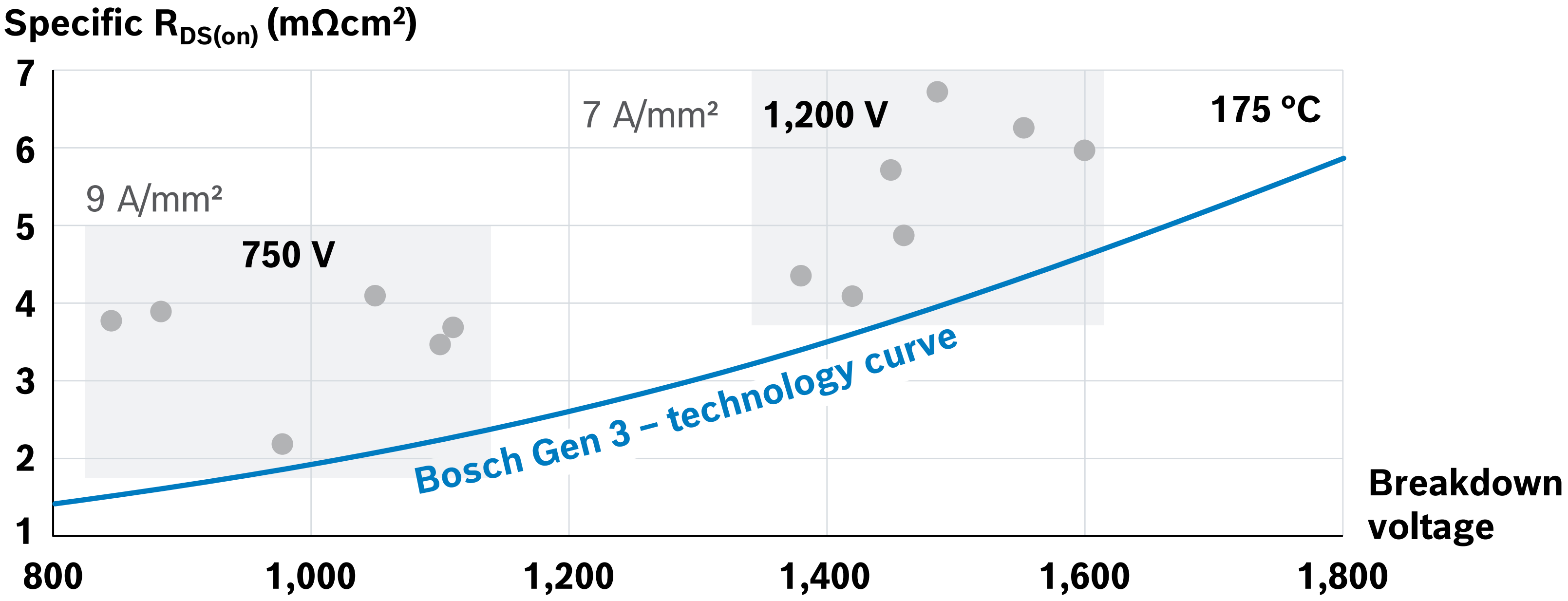
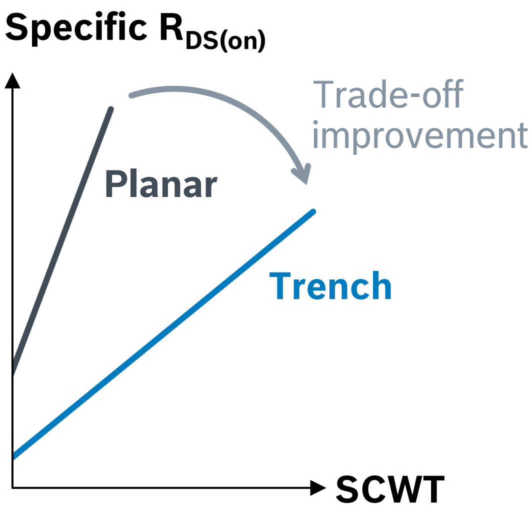
1) For system business also external sources available

OSAT ... Outsourced Semiconductor Assembly and Test

# Technology insights
# Gen 3 SiC from Bosch: pushing performance



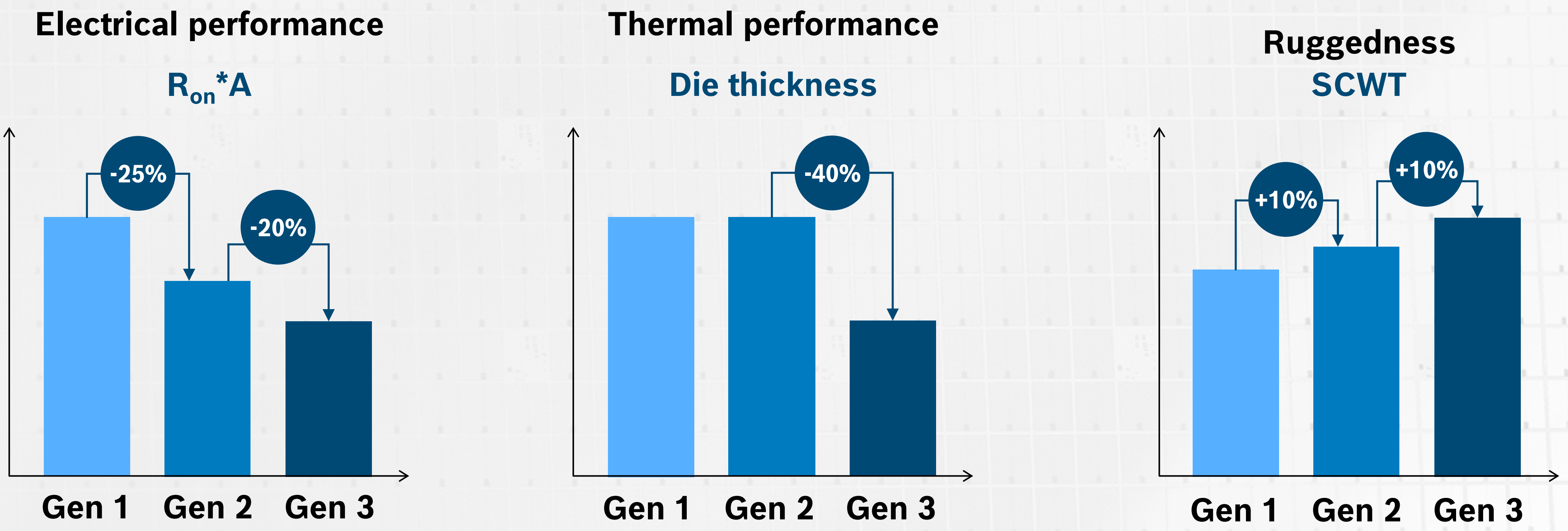


**1) Bosch SiC is one of the top technologies regarding performance across all voltage classes**

**2) Trench devices outperform planar devices and offer additional robustness advantages**

SCWT ... Short-Circuit Withstand Time

# Technology insights
# Gen 3: high performance meets high quality

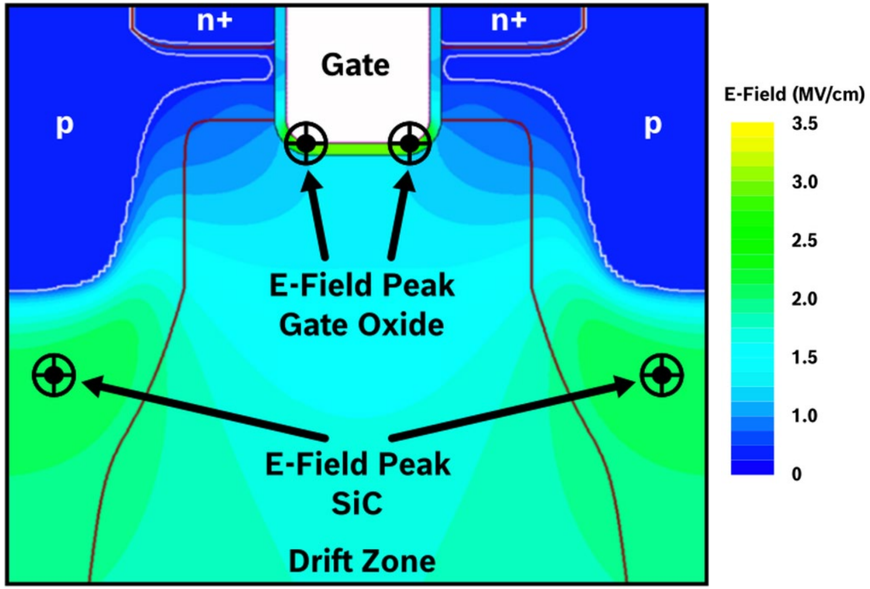


**Bosch Gen 3 SiC delivers high performance and high ruggedness**

SCWT ... Short-Circuit Withstand Time

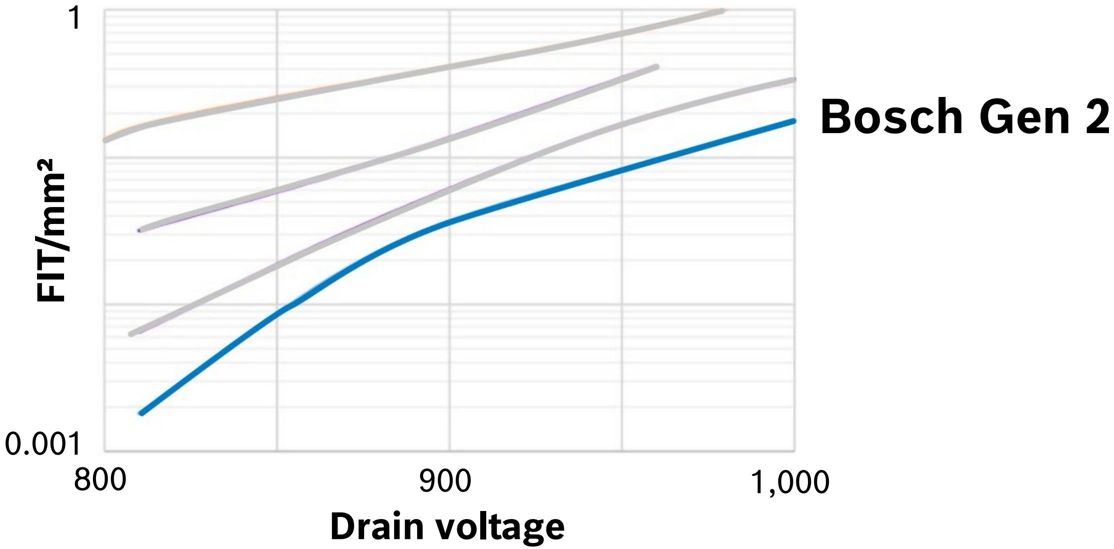
# Quality and reliability insights
# **Failures caused by cosmic ray**

### Off-state E-field in Gen 2 Bosch SiC MOSFET



→ Regions with **high off-state e-field** most susceptible to **single-event burn-out**

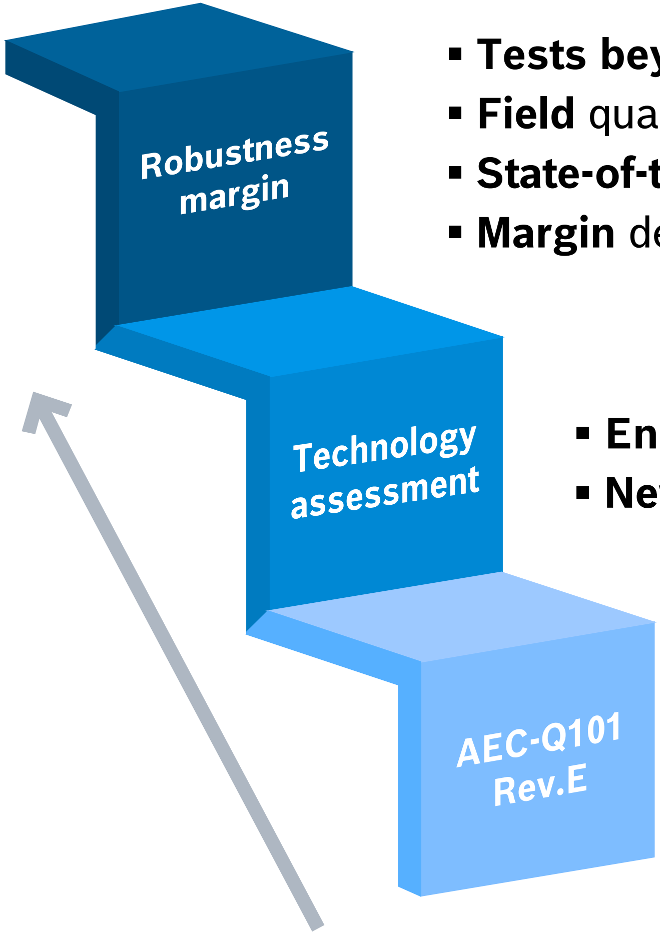
### Area-specific FIT rate



→ Regions with **high off-state e-field** most susceptible to **single-event burn-out**

**Ensuring cosmic ray robustness is key for achieving high robustness in power devices**

# Quality and reliability insights
# **Fast innovations with quality beyond standard**



- **Tests beyond duration of AEC-Q101**
- **Field** quality **monitoring** established
- **State-of-the-art analysis** applied
- **Margin** defined for relevant parameters to consider drift

- **End-of-life modelling** addressed with determination of acceleration factors
- **New tests** implemented

- **AEC-Q101 as starting point and reference** concerning methods
- Deep insight on application conditions thanks to vertical integration

# Industry Challenges
## Why Bosch's silicon carbide (SiC) is a Keystone for Electric Aviation

**Battery Energy Density**

**Highly efficient SiC based inverters ( >99%) reduce energy wasted as heat.** This **maximizes the usable range** extracted from the battery pack, effectively **extending flight endurance.**

**Thermal Management**

**SiC components generate significantly less waste heat** due to lower electrical losses. This **allows for smaller, lighter cooling systems**, directly reducing a major source of weight and complexity.

**Certification & Regulatory Frameworks**

**BOSCH provides extensive reliability and performance data** from its automotive-grade SiC production. This proven track record gives regulators a strong technical foundation **to accelerate the creation of new aerospace safety standards**.

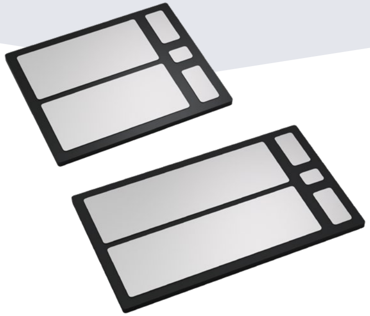
**System Weight and Integration**

The high efficiency and thermal performance of SiC enable much more compact and lightweight inverters, converters, and cooling systems. **This increases the powertrain's power-to-weight ratio, directly reducing overall aircraft mass.**

# Key applications
# SiC power semiconductors and power modules

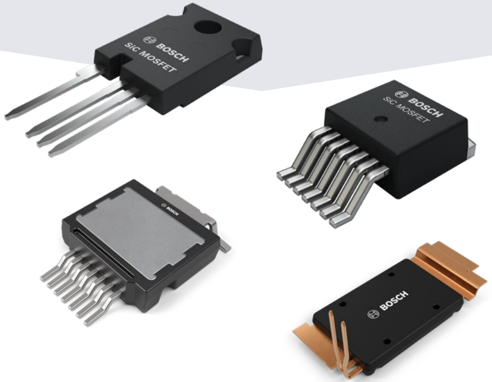
## SiC bare dies

The bare die versions are designed for high power applications like inverter modules.



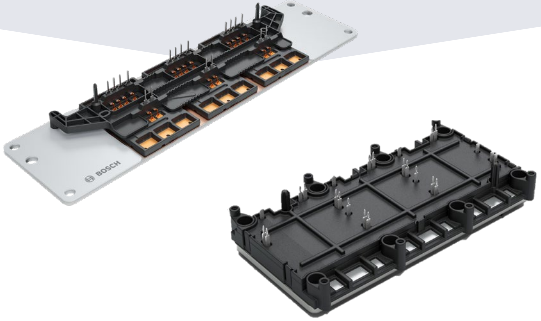
## SiC discretes

The packaged versions are designed for high power applications like on-board chargers, DC/DC converters and inverters.



## SiC power modules on cooler

The CSL (Compact Silicon Carbide Line) and PM6 power modules cover all major requirements of EV mass market.



# Bosch Aviation Technology
# … is the key partner to tackle the major industry challenges

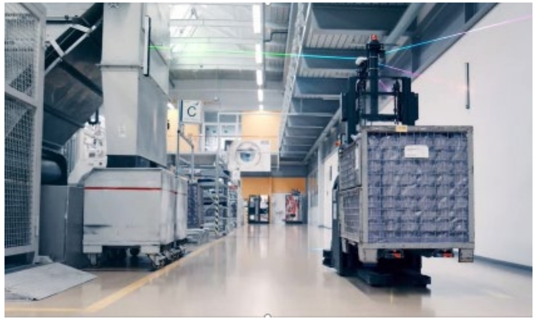
**Prototype Components for Proof of Concept**

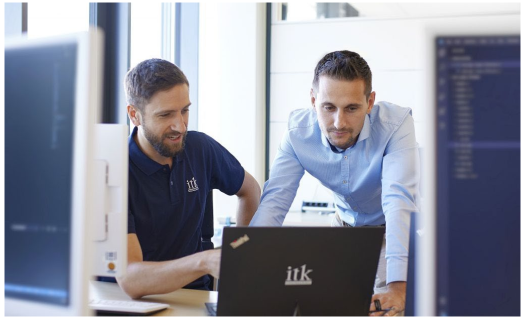
**Managing Innovation and latest Technology Standards**

**Highest Product Quality in Series**

**(for COTS* products and manufacturing services)**

**Providing Engineering Method Expertise**





*… Commercial off the shelf

AERO Hydrogen &
Battery Summit
21.-22.04.2026
Friedrichshafen

# THANK YOU FOR YOUR ATTENTION!

**Christian Grim**
General Manager
Bosch General Aviation Technology GmbH