



Find out what the future of power looks like

Steve Bakos, Sr. Director of Switching Power
17 March 2022



Infineon is your partner for electrification and digitalization



top 10
semiconductor company

~50,280
employees*

Electrification

- › CO₂ saving
- › Energy efficiency
- › Cost savings

Digitalization

- › Productivity
- › Comfort
- › New use cases

9%+ | 19% | 13%
target operating model**

* as of 30 September 2021

** over the cycle: 9%+ revenue growth; 19% Segment Result margin; investment-to-sales ratio of 13%; targets to be approached as Cypress integration progresses

Business growth in the semiconductor market is driven by four areas

Energy efficiency



Mobility



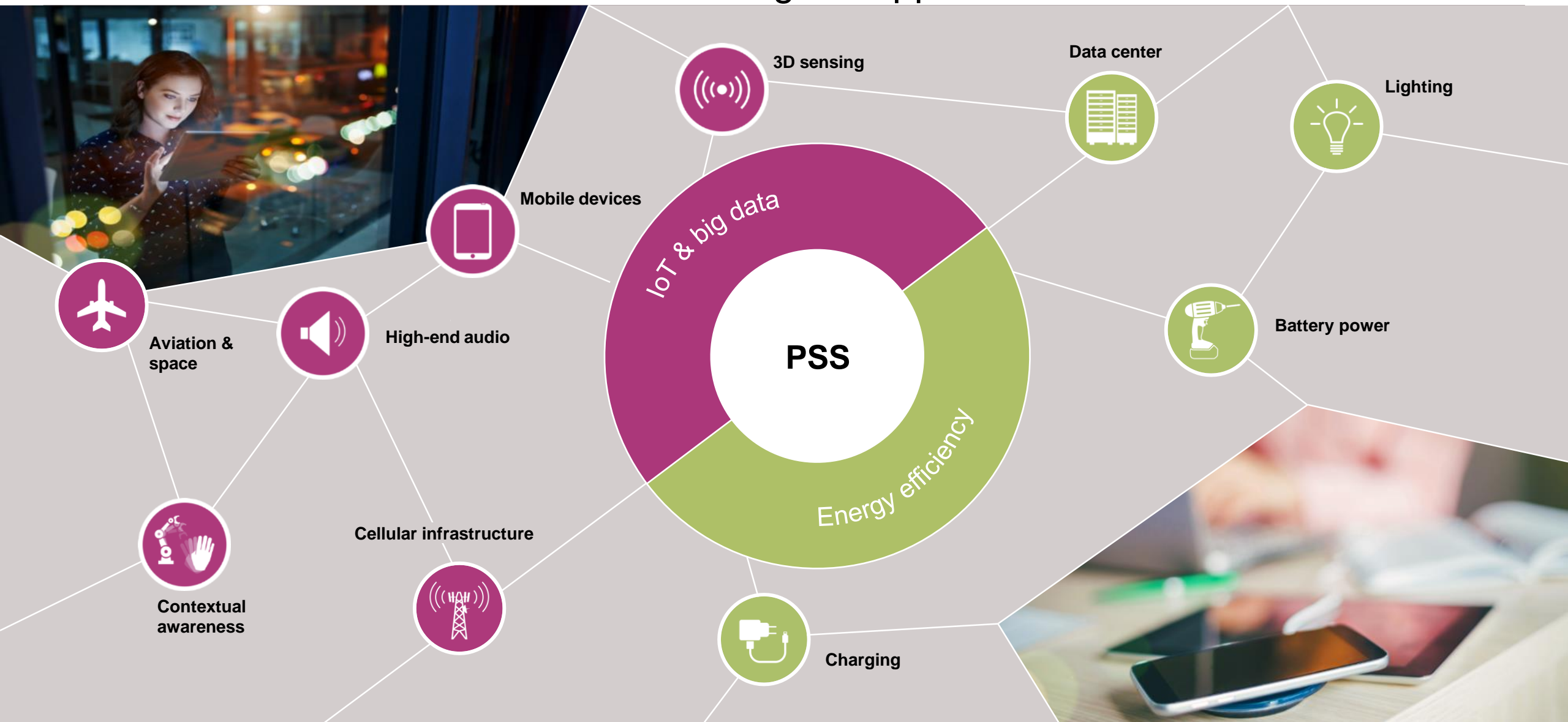
Security



IoT and big data



Focus markets for PSS include a wide range of applications





PSS – Power

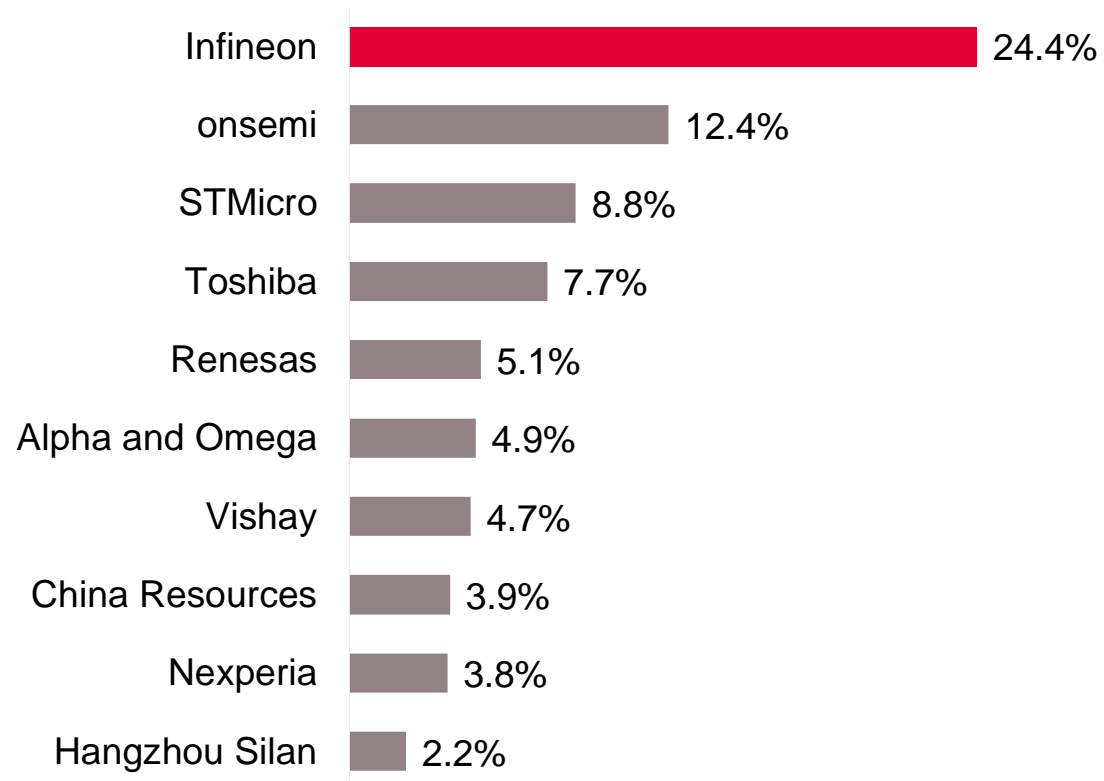


Infineon is the clear leader in MOSFETs; growth potential in power ICs



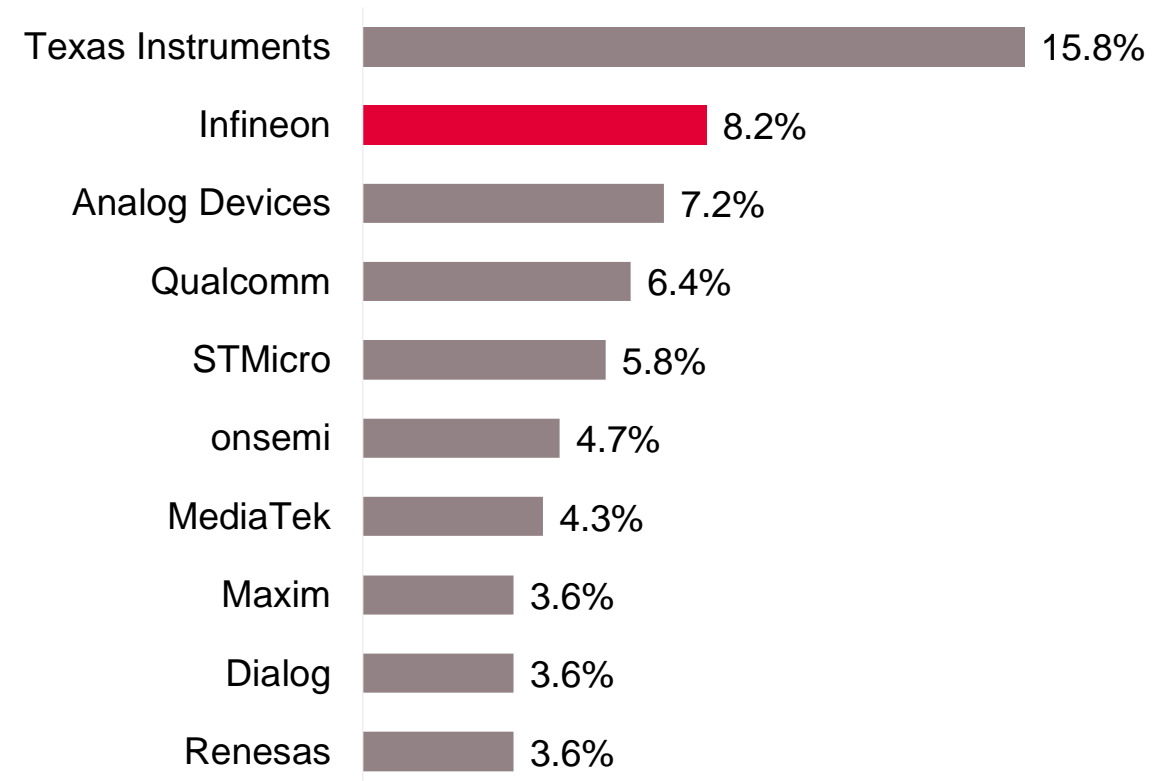
Discrete Power MOSFETs¹

2020 total market: \$8.1bn



Power ICs²

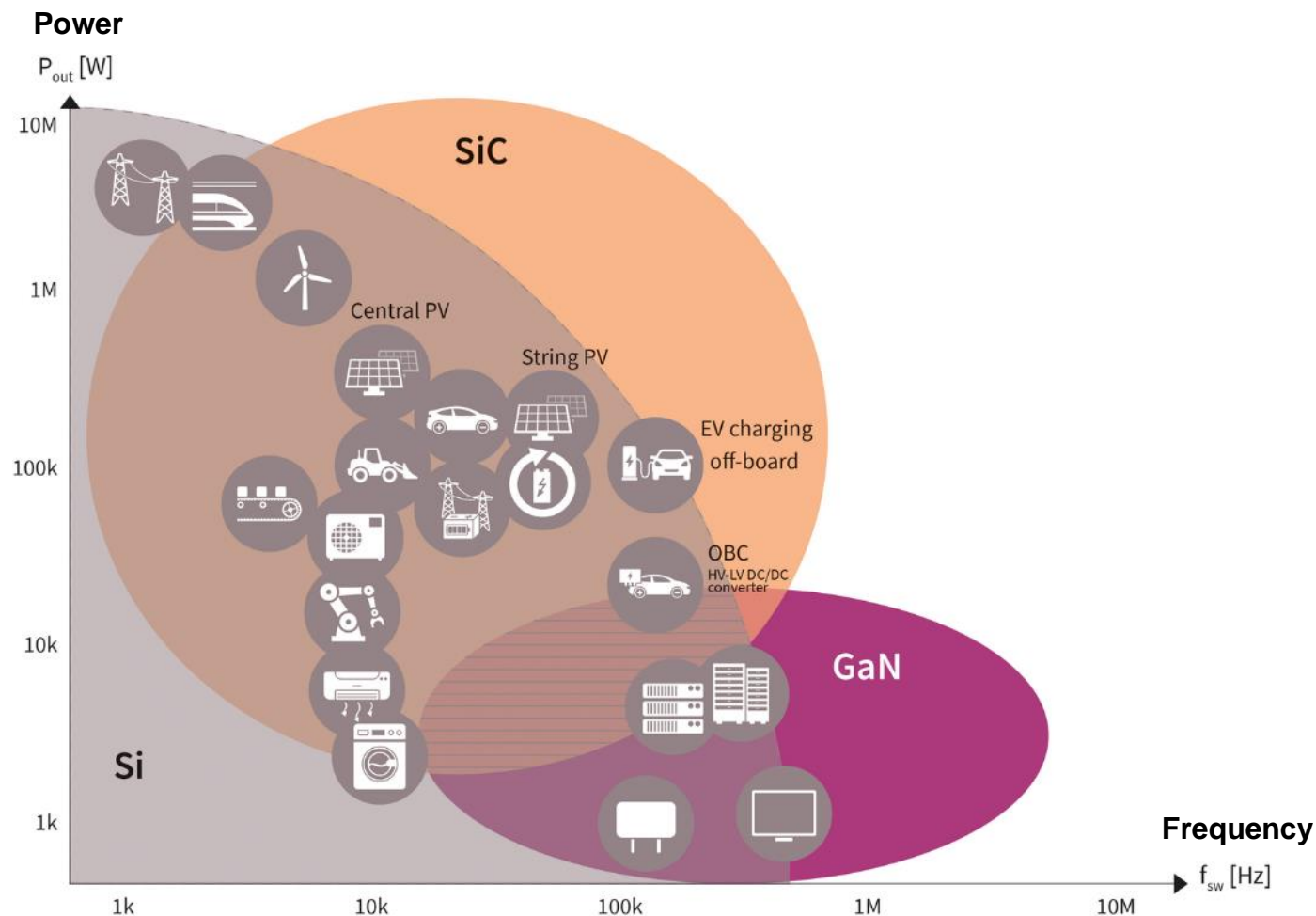
2020 total market: \$24.3bn



¹ Discrete Power MOSFET market includes automotive MOSFETs, protected MOSFETs, SiC MOSFETs and GaN power transistors. | ² Power IC market includes automotive power ICs.
Based on or includes research from Omdia: *Power Semiconductor Market Share Database 2020*. September 2021

Infineon is the Market and Technology Leader in MOSFETs

Comparison of Infineon's technology portfolio



Si

- › Si remains the mainstream technology
- › Targeting 25 V – 6.5 kV
- › Suitable from low to high power

SiC

- › SiC complements Si in many applications and enables new solutions
- › Targeting 650 V – 3.3 kV
- › High power – high switching frequency

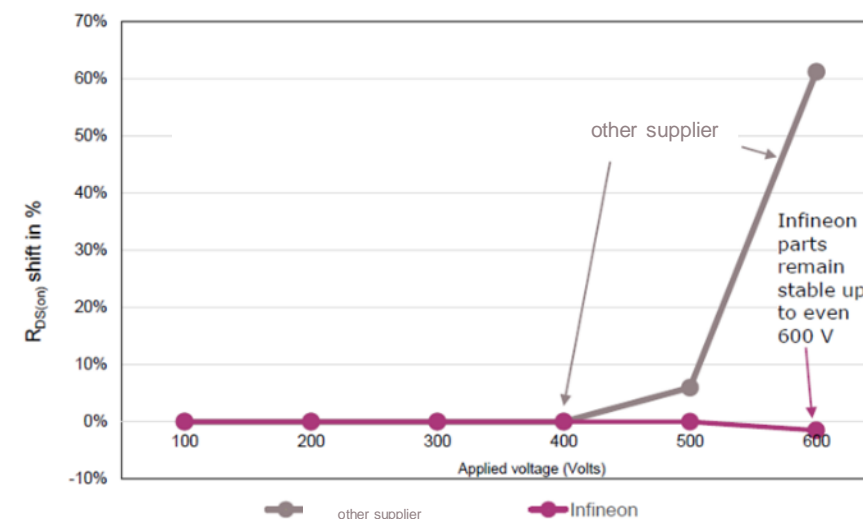
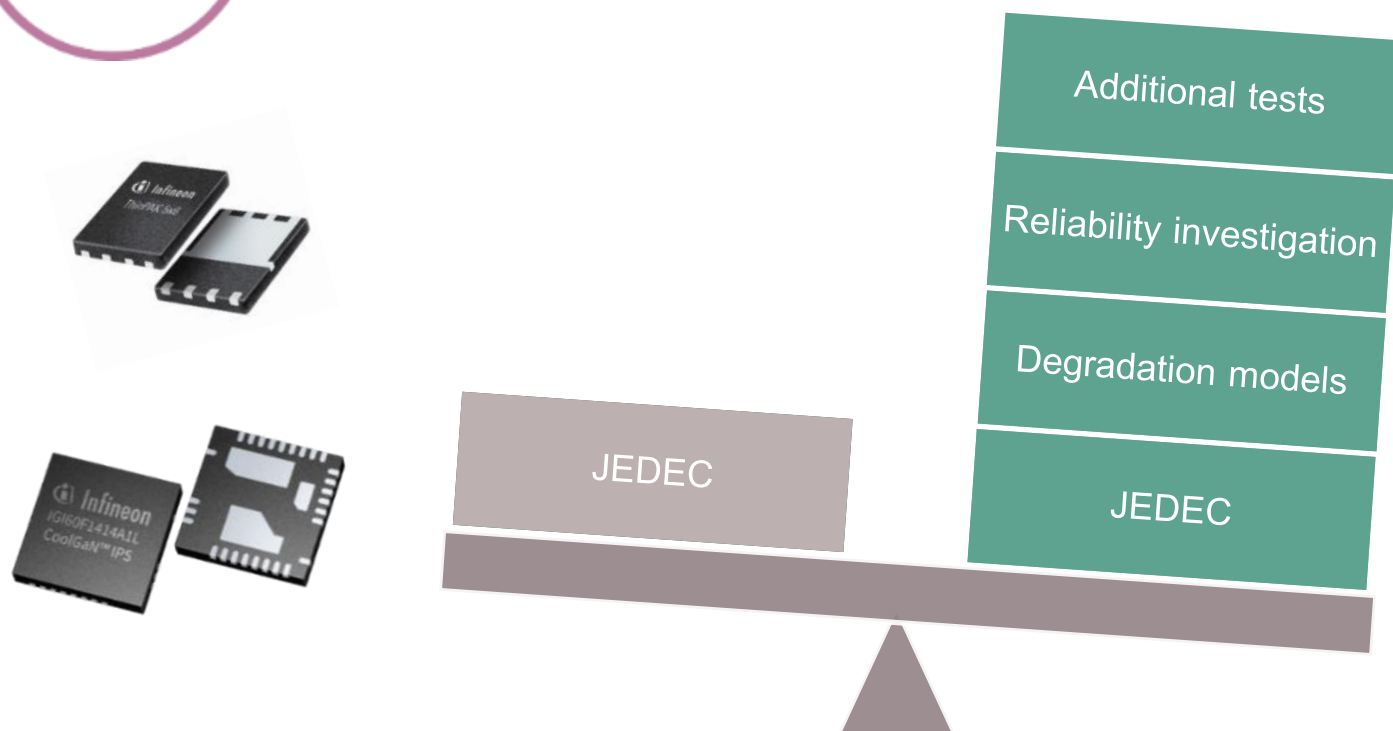
GaN

- › GaN enables new horizons in power supply applications and audio fidelity
- › Targeting 80 V – 600 V
- › Medium power – highest switching frequency

Infineon's GaN qualification approach is leading in the industry

CoolGaN™

Most reliable GaN HEMTs in the industry



Infineon applies **stringent qualification plans**, including failure models to predict lifetime and in-field failure rates

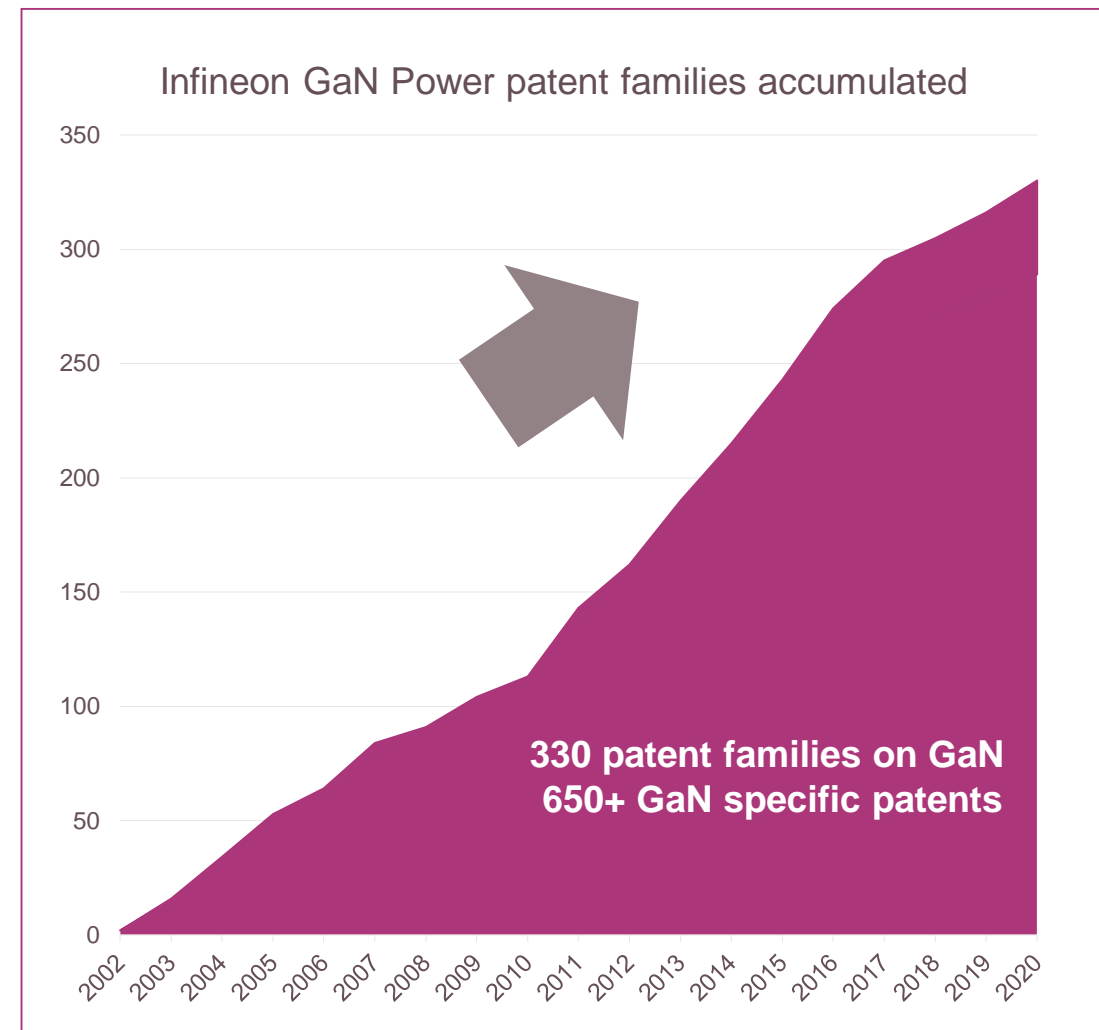
Infineon is #1 GaN IP leader: we dare to innovate for the best solutions



650+

GaN specific patents covering the whole value chain from epiwafers to devices

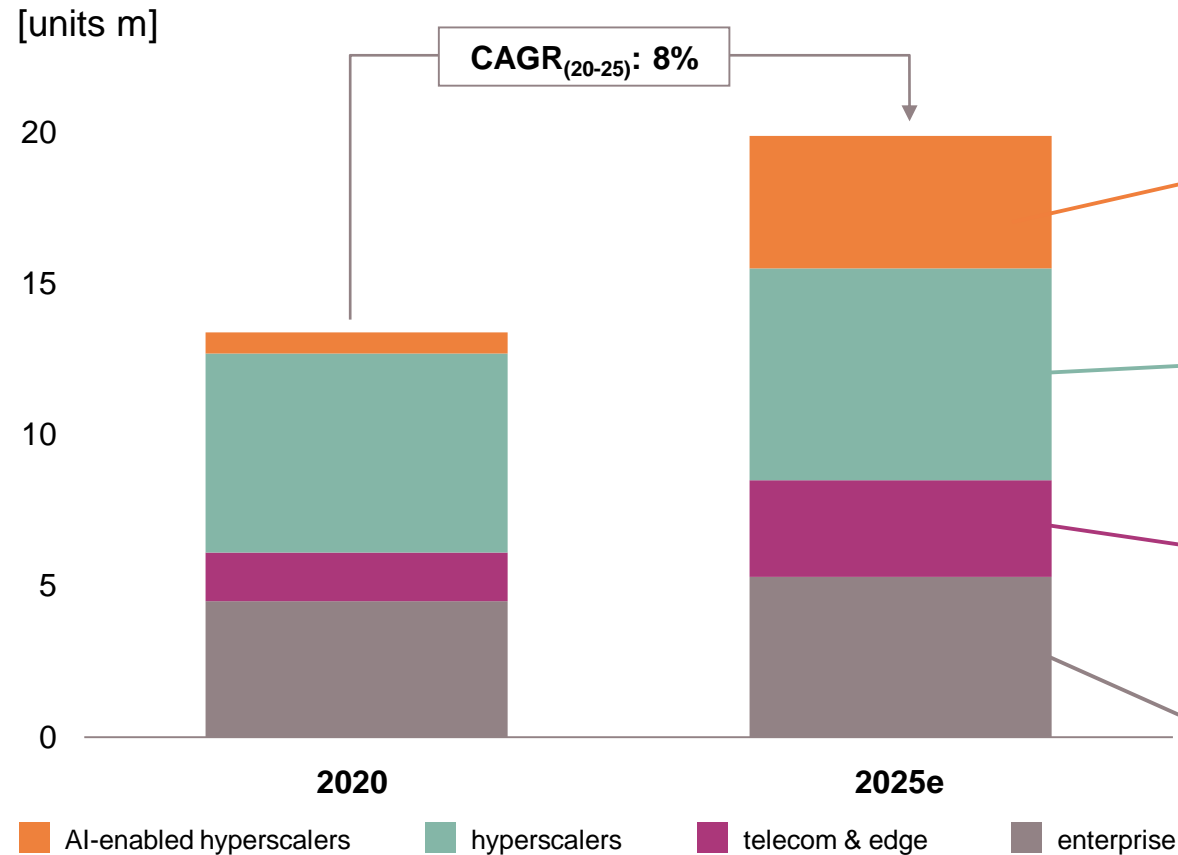
- › Infineon is the #1 in power with **19+ years** of innovation in GaN.
- › **650+ GaN specific patents** and many more related patents.
- › **Innovation is part of our DNA.**
- › Infineon's leading GaN IP position allows to **limit the freedom-to-operate of competitors** developing GaN technology.



Source: Power GaN Patent Landscape Analysis, KnowMade, Report 2019

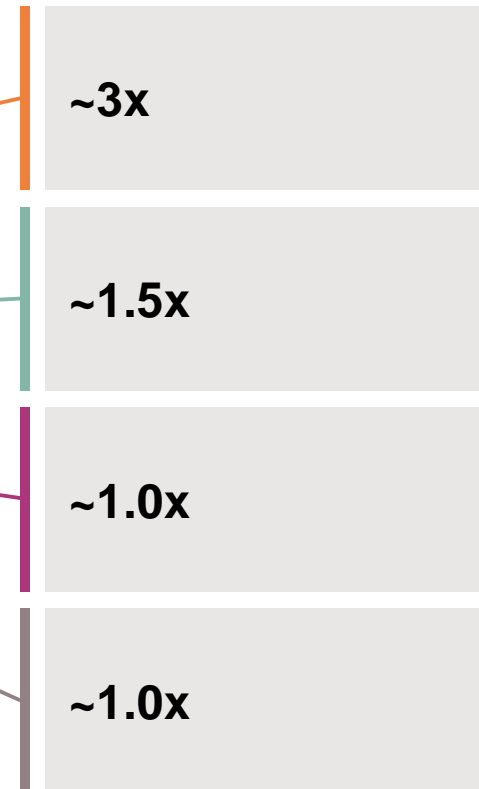
Data center – AI hyperscaler and telecom/edge computing are driving the growth

Server growth



Power requirement per server

Power¹:



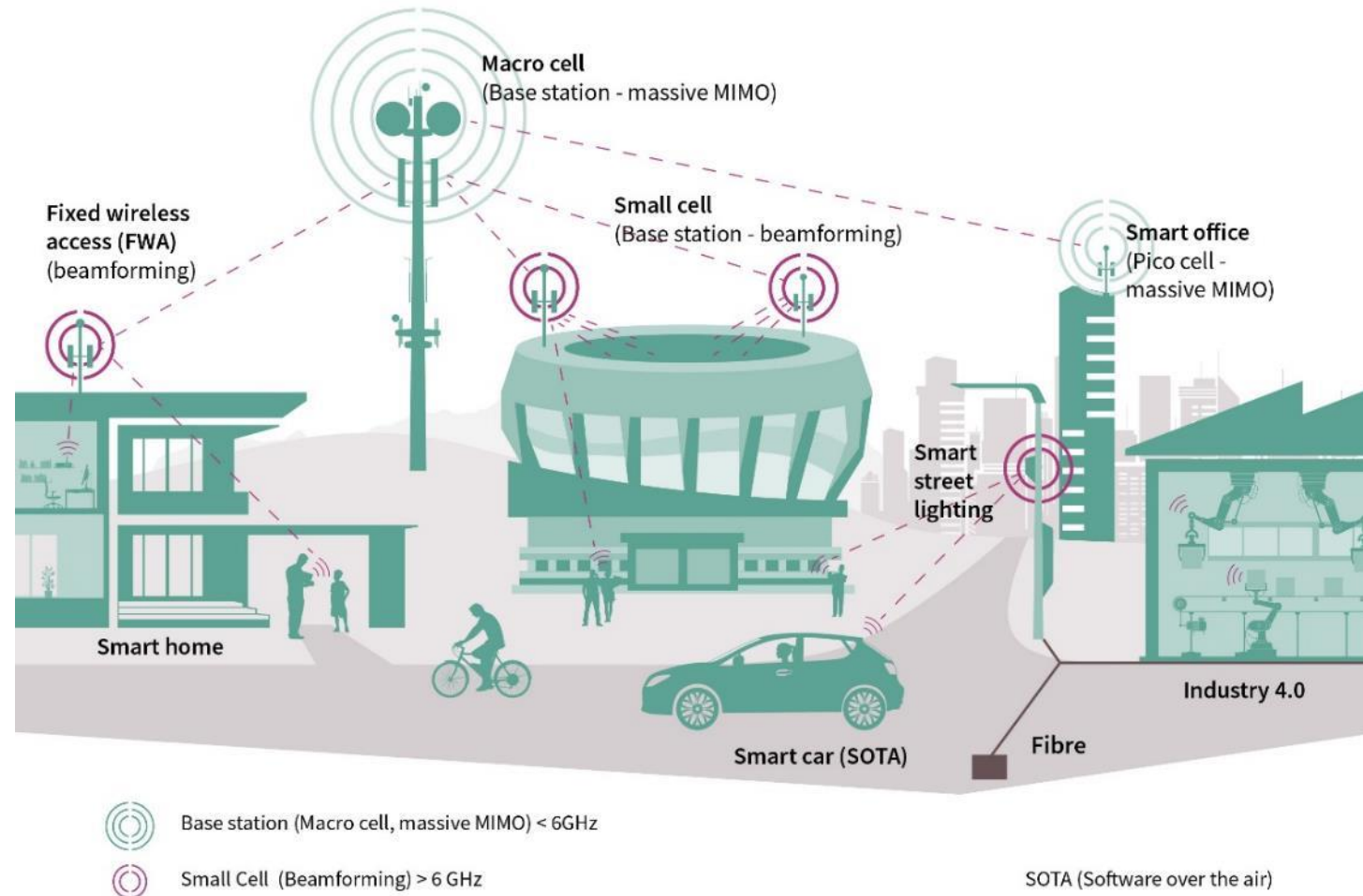
Exponential increase in **AI Training & Networking** (ASIC/SoC/FPGA/CPU/GPU) power level requires cutting-edge innovation in Device & Packaging technologies to solve power efficiency and density challenges

→ The bill of material is outpacing unit growth by a factor of ~1.3x.

¹ Normalized overall power requirement per server board for x-comparison
Based on or includes research from Omdia: *Data Center Server Equipment Market Tracker – 2Q21 Database*. September 2021

Transition from 3G/4G to 5G drives demand in power semis for antennas and power supplies

Smart and connected - the communication of tomorrow with 5G



- > **driver #1:** massive growth of data and computing power
- > **driver #2:** higher number of base stations due to dense network
- > **driver #3:** ~4x higher power semi content per radio board: from ~\$25 for MIMO antenna to ~\$100 for massive MIMO antenna array
- > **driver #4:** fog computing data center as a completely new market

Our announcements – Infineon OptiMOS™ 5 25 V and 30 V solutions (1/4)



2/28/22: Infineon OptiMOS™ 5 25 V and 30 V solutions in PQFN 2x2 set new form factor, on-state resistance and switching performance standards

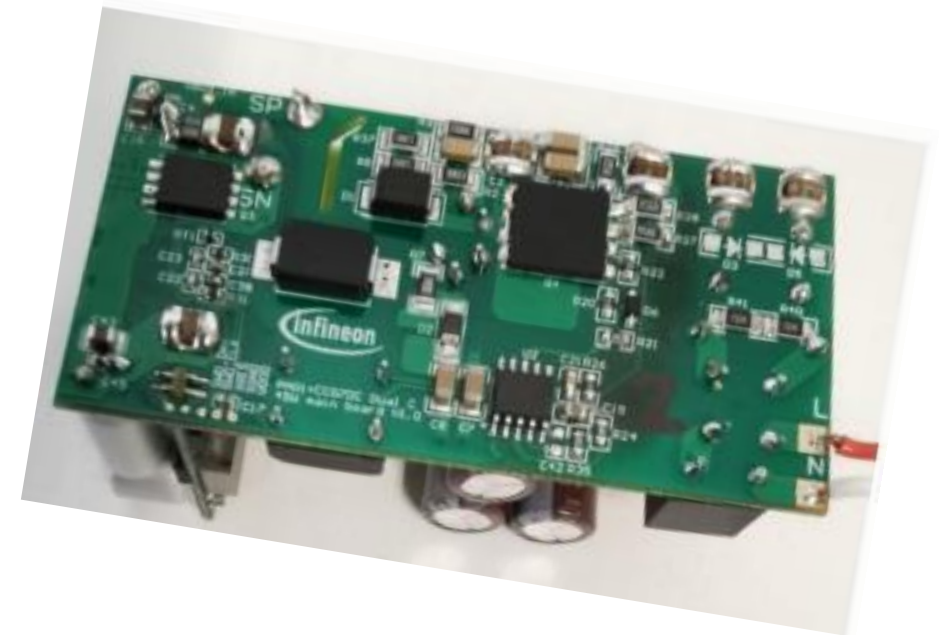
- **Sets new technology standards** in discrete power MOSFET technologies
- **Combines thin wafer technology and packaging innovation**; significant performance benefits in extremely small form factor
- Optimized for synchronous rectification in **SMPS (Switched Mode Power Supply)** for servers, telecom bricks, portable chargers and wireless charging
- Designed for **electronic speed controls (ESC)** for small brushless motors in drones



Our announcements – New EZ-PD™ USB-C products for consumer applications (2/4)

3/16/22: Infineon expands family of EZ-PD™ USB-C products for consumer applications with CCG7DC, includes dual-port USB type-C PD and buck-boost controller for DC-to-DC applications

- **Infineon EZ-PD™ CCG7DC, dual-port USB type C**
- Highly integrated and programmable (Arm™ Cortex™ A0) dual-port USB type-C Power Delivery (PD) solution with integrated buck-boost controller
- **Complies to the latest USB Type-C and PD specifications**
- Targeted for **multi-port consumer charging applications**
- Supports a **wide input voltage range (4V-24V with 40V tolerance)** and programmable switching frequency (150 kHz-600 kHz) in an integrated PD solution



Our announcements – Optimized CoolSiC™ 650 V SiC MOSFETs (3/4)

3/20/22: Optimized CoolSiC™ MOSFETs 650 V in D²PAK for the lowest losses in the application and highest reliability in operation

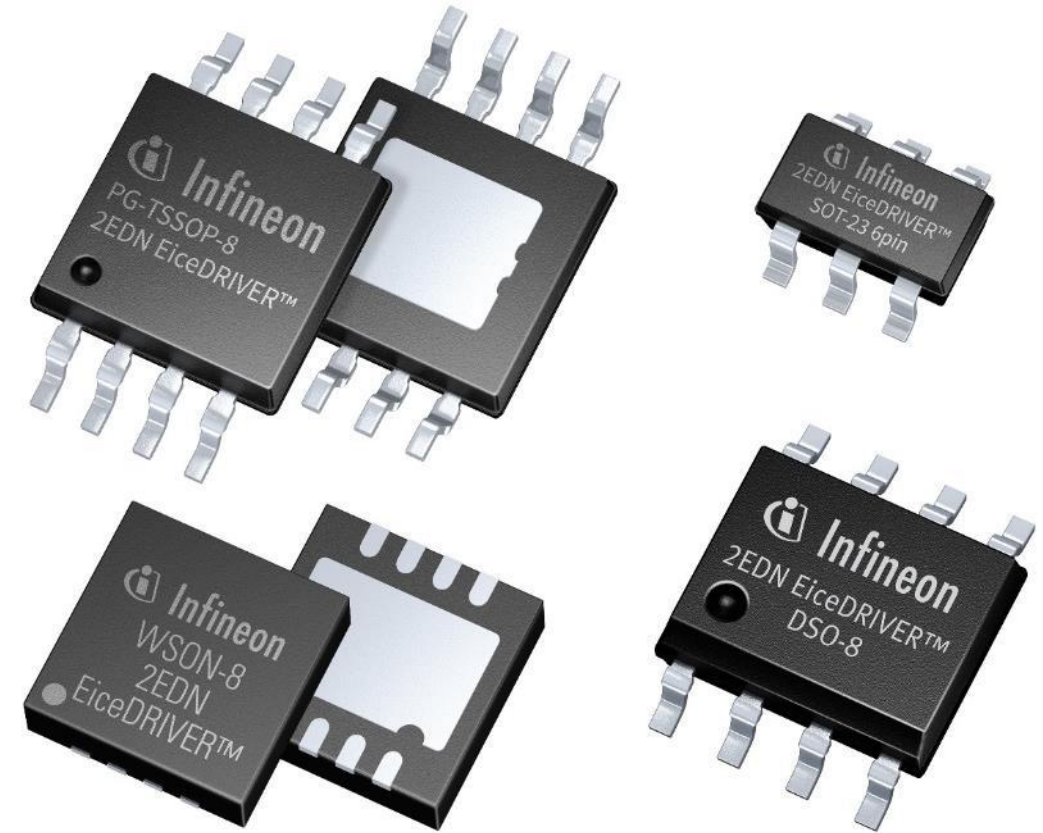
- **CoolSiC™ 650 V silicon carbide (SiC) MOSFETs are cost optimized and delivers reliability and high performance and are easy-to-use**
- Built on Infineon's **state-of-the-art SiC trench technology** and come in a compact D²PAK SMD 7-pin package
- Targets high-power applications including **servers, telecom, industrial SMPS, fast EV charging, motor drives, solar energy systems, energy storage, and battery formation**



Our announcements – Next-generation EiceDRIVER™ 2EDN gate driver ICs (4/4)

3/21/22: Next-generation EiceDRIVER™ 2EDN gate driver ICs set a new benchmark for form-factor, faster UVLO reaction and active output clamping

- EiceDRIVER™ 2EDN product family targets space-constrained applications
- Complement the existing 2EDN driver ICs with higher system-level efficiencies, excellent power density, and consistent system robustness, and fewer external components
- Drives power switch device performance in applications such as **servers, telecom, DC-DC converters, industrial SMPS, EV charging stations, motor control, low-speed light electric vehicles, power tools, LED lighting, and solar energy systems**
- **14 new devices with broad range of packages**



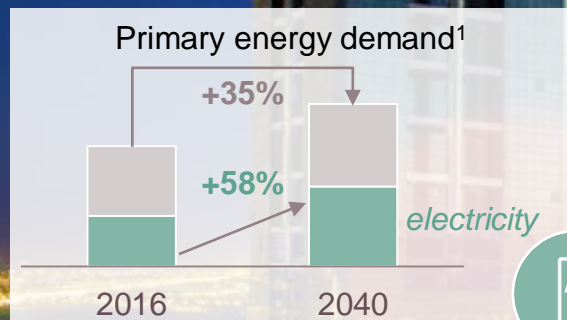


Industrial Power Control: The Future of Power

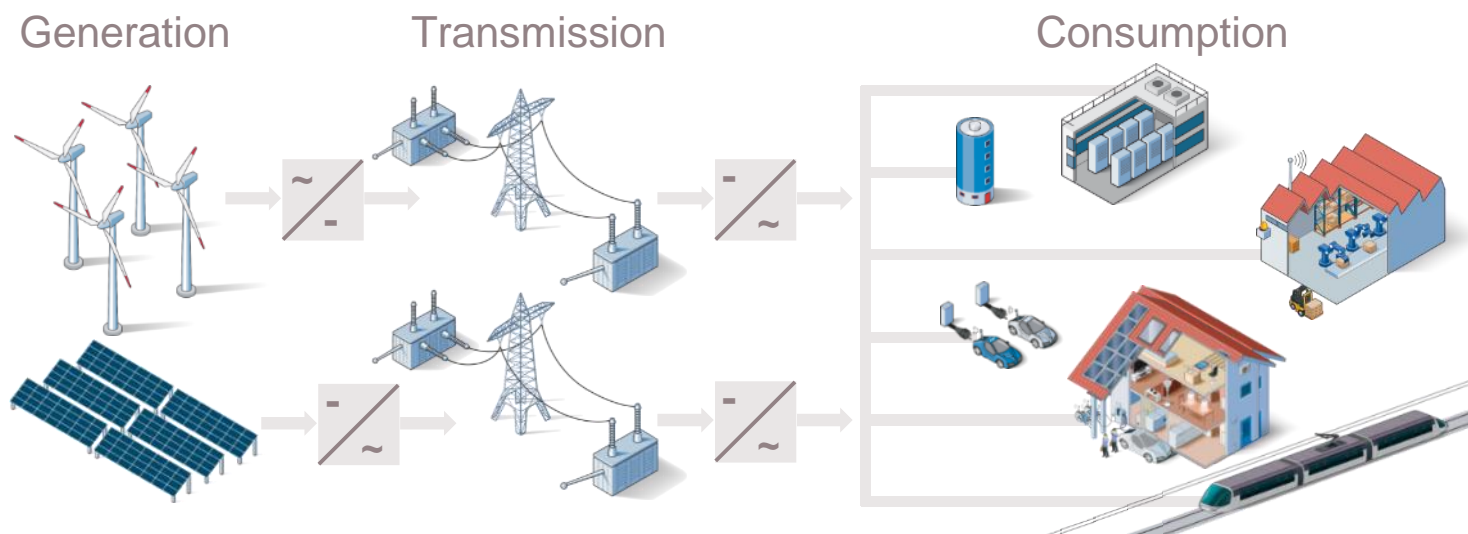
Roland Stele, Vice President and General Manager, IPC
17 March 2022



Increasing demand for electrical energy is driving business of IPC



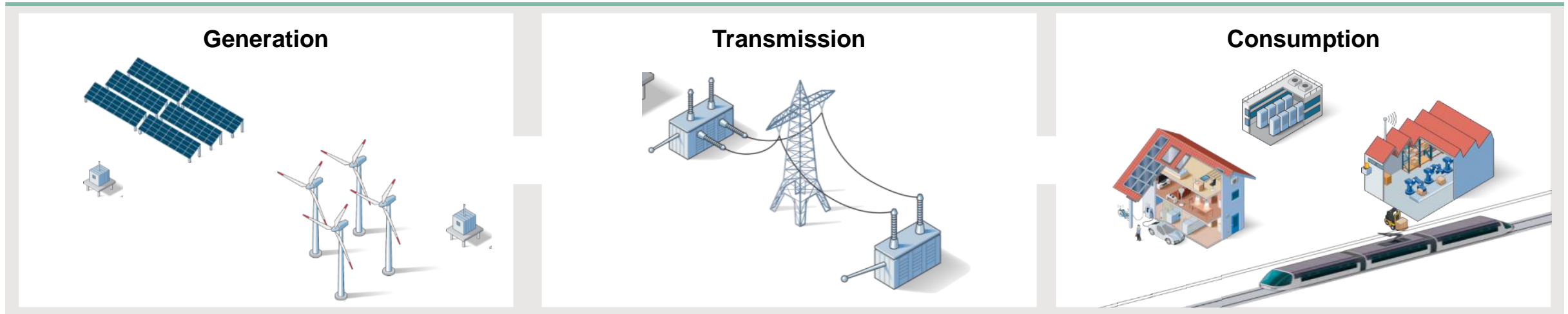
Shaping the electrical energy chain



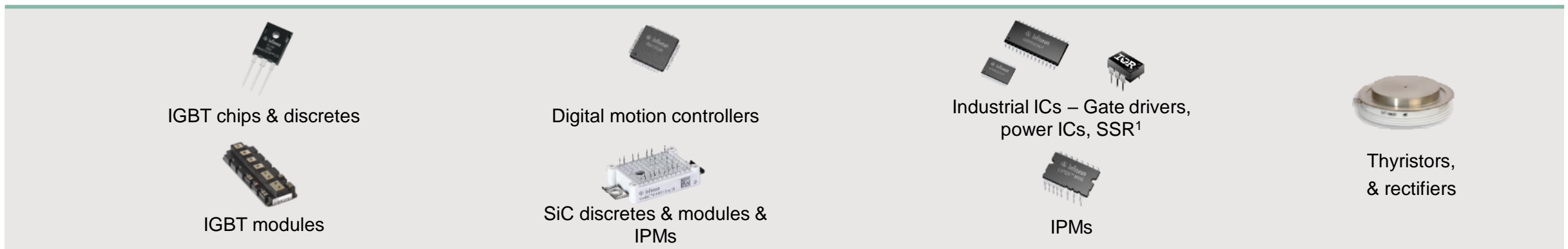
1) Source: BP 2018 Energy Outlook

IPC delivers leading semiconductor solutions for smart and efficient energy generation, transmission and consumption

Infineon present along entire energy supply chain

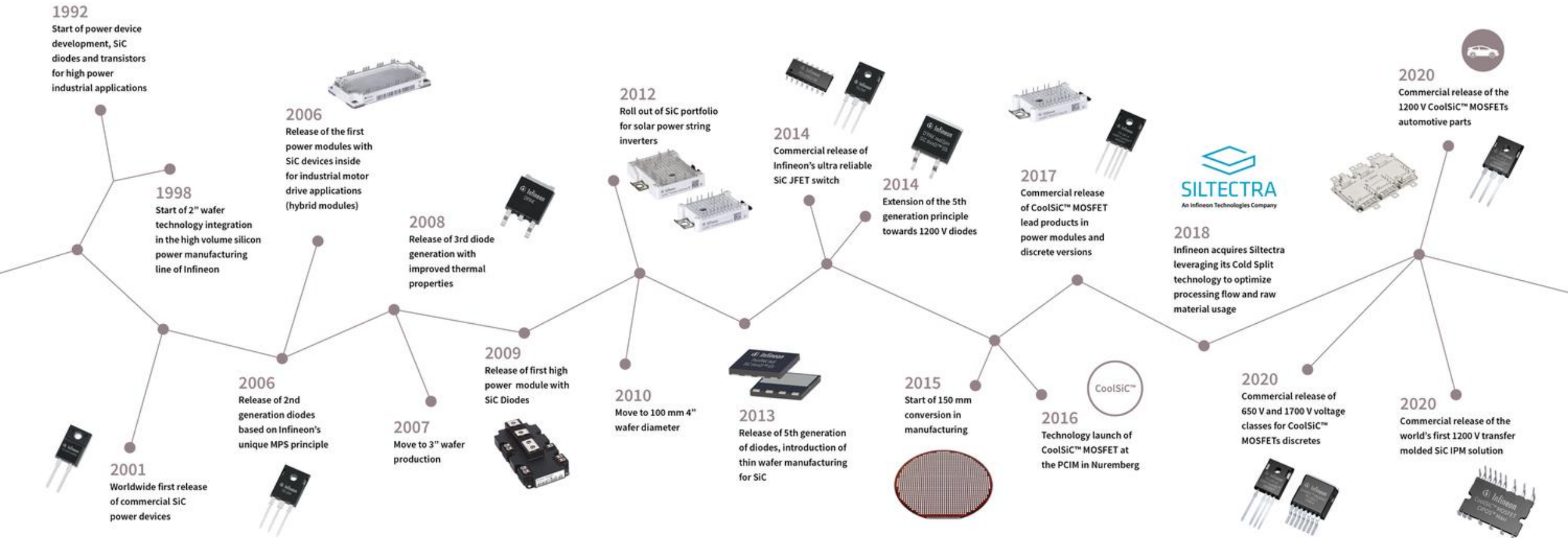


IPC product overview



Note: 1) SSR = solid state relay

Infineon has 20 years of field experience with SiC



Solar string inverters are strongly benefitting from the advantages that CoolSiC™ MOSFETs provide



Advantages of SiC

- › With CoolSiC™ MOSFETs, the **power of a string inverter can be doubled at the same inverter weight**
- › Furthermore, the efficiency reduction at high operating temperatures is significantly lower compared to a Si solution. You can achieve a **maximum efficiency of over 99%** by using CoolSiC™ MOSFET solutions from Infineon



CoolSiC™ allows a power density increase by a factor of 2.5, e.g. from 50 kW (Si) to 125 kW (SiC) at a weight of less than 80 kg, so it can be lifted by two installers.



Article: [pv magazine top innovation](#), 14 Nov 2018

CoolSiC™ helps to cut charging time for electric vehicles by 50%



Advantages of SiC

- › CoolSiC™ MOSFET cuts charging time in half at the same charging station and footprint
- › One 1200V CoolSiC™ MOSFET is sufficient to support a DC-link voltage of 800V
- › Due to 50% lower conduction and switching losses from lower C_{oss} the overall efficiency can be increased which lowers the cooling effort
- › CoolSiC™ performance maximized by the matching EiceDRIVER™ gate driver solution



Doubling the power density allows part count reduction of a comparable Si solution by 50% thanks to doubled voltage in the switch positions.

Our announcement – EiceDRIVER™ F3 Enhanced (1/2)

2/22/22: Versatile short-circuit protection for power electronics systems: Infineon presents EiceDRIVER™ F3 Enhanced gate drivers

- Modern power electronics require higher power densities to prevent short-circuit events from occurring
- Infineon's isolated EiceDRIVER™ Enhanced gate drivers with the F3 Enhanced delivers reliable and versatile protection to prevent destructive short-circuit events
- Allows conventional power switches, such as IGBTs, as well as CoolSiC™ wide-bandgap devices to be protected
- Designed for industrial drives, solar systems, electric vehicle charging, energy storage systems, commercial air conditioning and other applications



Our announcement – Enhanced IPOSIM platform with automatic lifetime estimation (2/2)

3/11/22: Enhanced IPOSIM platform with automatic lifetime estimation simplifies selection of suitable semiconductor components

- *The challenge: Industrial customers want to estimate the lifetime of power modules in the early design stage of power electronics systems*
- Infineon Power Simulation platform (IPOSIM) is used for calculating losses and thermal behavior of the company's power modules, discretes and disc devices
- Easy access for single working points and user-defined load profiles
- Automated service allows easy estimation of lifetime components according to usage and the application requirements.
- Customers can access:
 - Infineon's power electronics expertise online 24/7, anytime during the design process
 - Tools to digitally estimate the lifetime of modules in user applications

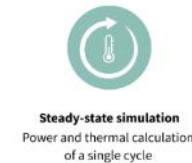
IPOSIM is Infineon's online simulation platform for loss & thermal calculations of Infineon power modules, discretes and disk devices.

IPOSIM helps you to select the most suitable Infineon's high power product according to the needs of your application.

Main Features

- › User-friendly flow, designed to guide you step by step in simulating with power devices
- › Fast online simulation powered by PLECS®
- › 19 topologies for discs and modules available, clustered by power conversion type
- › Multi-selection of up to 5 Infineon products for performance comparison
- › Save and Share designs within your team using deep-link.

2 types of simulation offered:



IPC demos at APEC 2022

Active demos

- › **6ED2742S01Q** - New 160 V three phase gate driver for battery powered applications
- › Key facts of the new 160 V three phase gate driver **6ED2742S01Q** evaluation board
 - 12 V to 120 V input capable motor drive power stage board
 - Incl. a iMotion's IMC101T-based MADK control board
 - runs a vacuum cleaner / blower at a 24 V input
 - can be tuned to work for 12 V to 120 V battery applications.

Static demos

- › **1: Eval-M7-HVIGBT**
 - Evaluate 600 V RC-D2 together with the driver IMD110
- › **2: EVAL-2ED2748_Forklifts_Evaluation KIT**
 - 3.5 kW high-power motor drive demo for forklift and industrial robotics (New 160 V half bridge gate driver 2ED2748)
- › **3: REF-DAB11KIZSICSYS**
 - 11 kW SiC bi-directional DC-DC converter board for EV Charging and ESS applications
- › **4: EVAL-1ED3321MC12N**
 - Versatile short-circuit protection with EiceDRIVER™ F3 Enhanced
- › **5: EVAL-6ED2230S12TM1**
 - 6ED2230 inverter board with Easy SiC 45 mΩ module (FS45MR12W1M1_B11)
- › **6: REF-22K-GPD-INV-EASY3B**
 - This reference design REF-22K-GPD-INV-EASY3B is an industrial motor drive for three-phase 400 V AC grids and has a nominal power of 22 kW



Infineon and the future of SiC power devices: A story of success and growth

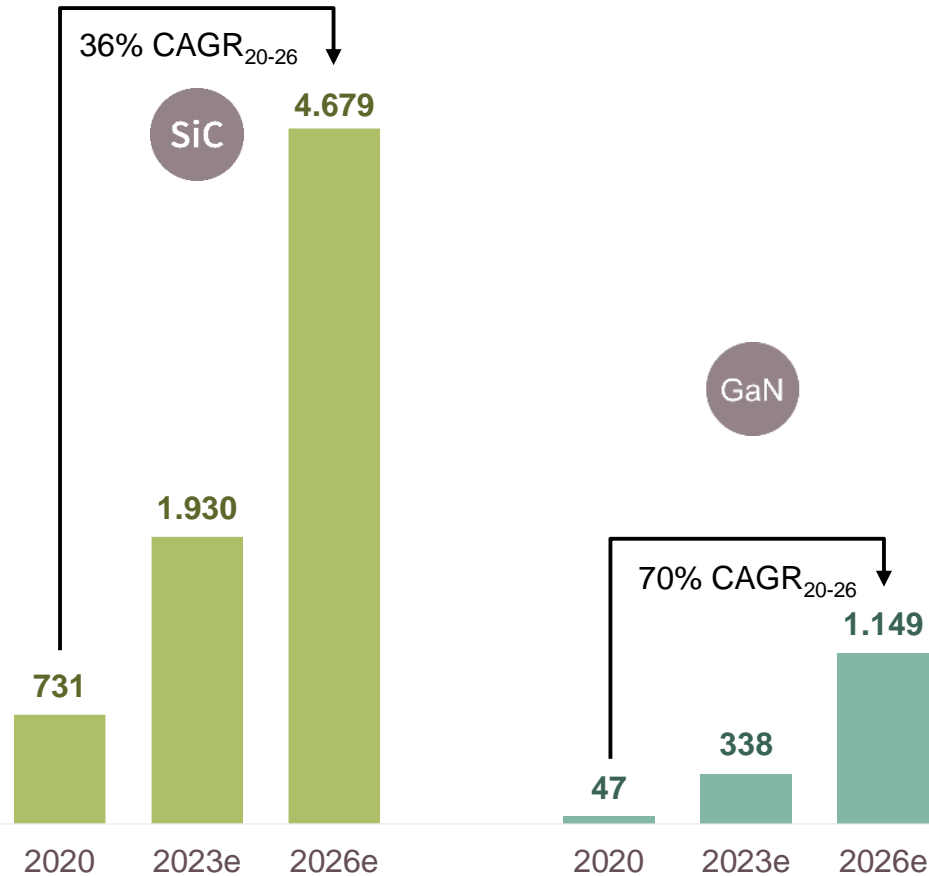
Dr. Peter Friedrichs, Vice President Silicon Carbide
17 March 2022



Infiniteon is excellently positioned to provide added value from WBG to its customers

WBG market development

Total market [in million USD]



Source: Yole Développement (Yole): Compound Semiconductor Quarterly Market Monitor. Q4 2021



Electromobility

- › Leverage huge IGBT customer base with broadest portfolio and full system solution
- › Seamless and cost-effective upgrade path across entire power range



Renewable energy

- › Doubling PV inverter power at same weight and size
- › CoolSiC™ allows a power density increase by a factor of 2.5



Chargers & adapters

- › Combine leading-edge system and application understanding with additional strengths
- › Broad GaN IP portfolio, large R&D force and best-in-class manufacturing landscape

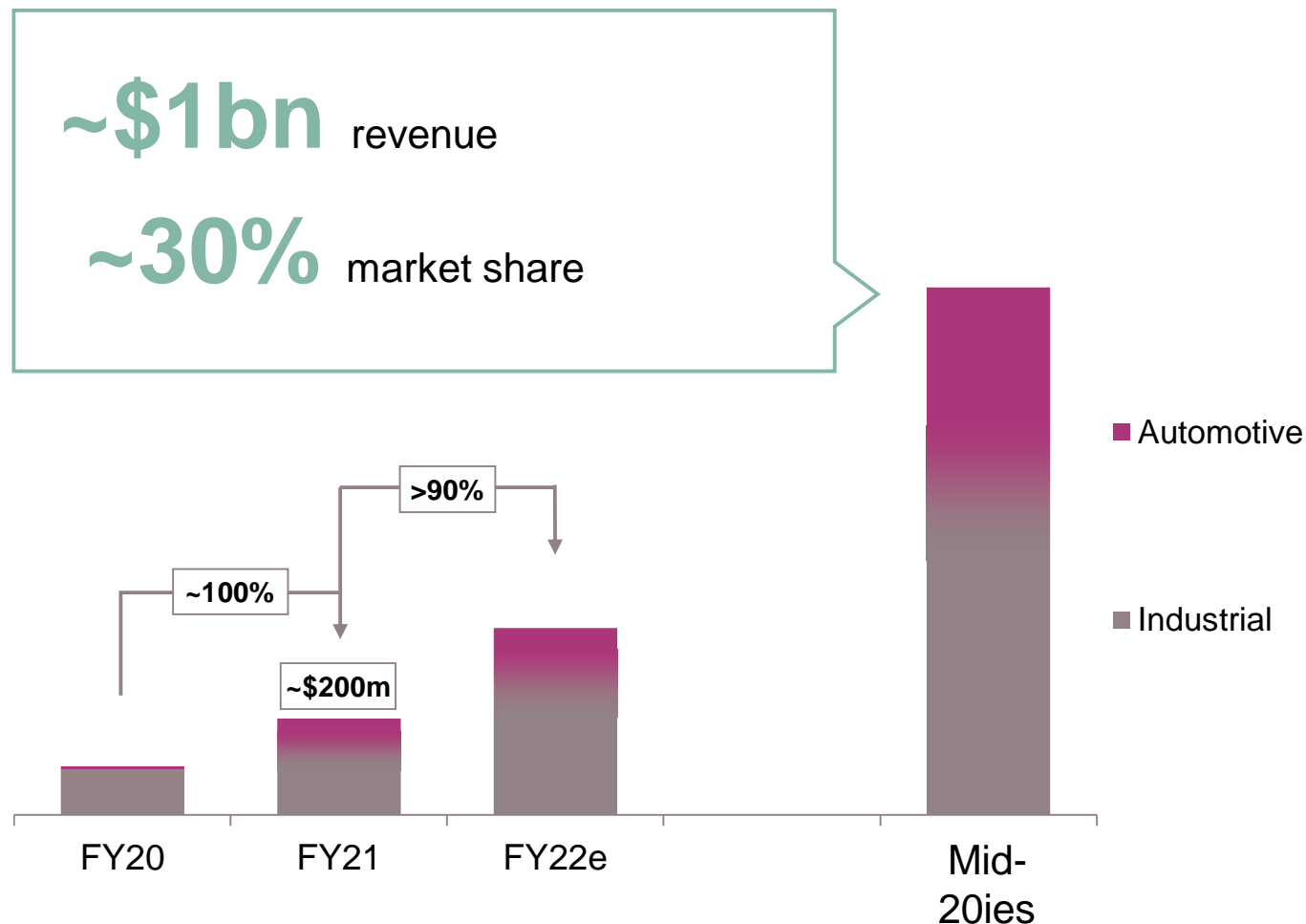


Data centers

- › Enabling advanced SMPS topologies with highest efficiency >97.5%
- › Offering complete solutions based on the full portfolio of switches, drivers and controllers

SiC – US\$ 1 billion revenue in sight

SiC revenue development for Infineon

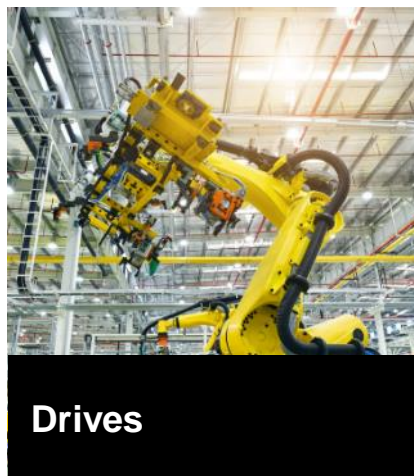
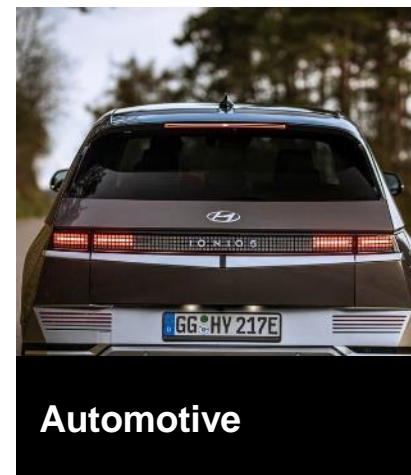
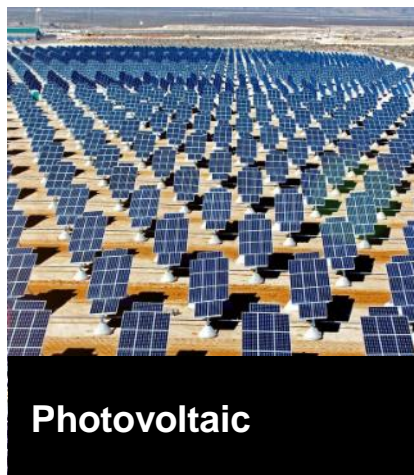


Infineon's success factors

- › Best in class Trench MOSFET on the market
- › 2nd Gen. CoolSiC™ Trench MOSFET will be launched in FY22
- › Broadest portfolio fits customers' individual needs
- › Scalable portfolio allows for easy and seamless upgrade from IGBT to SiC-based inverters
- › Strong module capabilities
- › System expertise and customer access

SiC – Infineon is serving all relevant applications

Focus applications



Infineon serves
> 3,000
 customers directly or via
 distribution

Customers



Let's take a look back on our customers' voices



Solar

"SiC helps us build **compact, powerful and reliable** inverters. The CoolSiC modules almost double our Sunny Highpower PEAK3 inverter's output from 0.97 to 1.76 kW/kg. Due to the compact design, the inverters **are much easier to transport** and much faster to install."



"....We are accelerating our steps to fulfill the corporate mission of 'Clean power for all'"

"To make this possible, the new SG350HX redefines the super-high power string inverter and helps Sungrow's customers **to reduce the cost of energy.**"



Industrial power supply

Lite-on is very keen on introducing the silicon carbide-based SMPS to the market, which exceeds the requirement of 96 percent **efficiency** for the Titanium certification.



Automotive

"By using traction inverters based on Infineon's CoolSiC power module, we were able to **increase the range** of the vehicle by more than five percent."



EV charging

„We found that at high temperatures, Infineon devices have the **most reliability**. It's not just one characteristic, it's a range of characteristics: RDSon and high threshold voltages, the oxide layer stability is a key component."



"With Infineon's CoolSiC EasyPACK modules in combination with a perfect matching driver IC, we were able to significantly **improve the efficiency** of our new hypercharger"



Strong CoolSiC™ portfolio expansion: by packages and by voltages, in addition customized solutions for EASY module family

Broadest and best-in-class SiC portfolio

| | | Industrial | | | | | Automotive grade | | | |
|-----------------------------|----------------|-----------------|--------|-----------------|-----|--------|------------------|-----------------|-----------------|--------|
| package options voltages | CoolSiC™ Diode | CoolSiC™ Hybrid | | CoolSiC™ MOSFET | | | CoolSiC™ Diode | CoolSiC™ Hybrid | CoolSiC™ MOSFET | |
| | Discrete | Discrete | Module | Discrete | IPM | Module | Discrete | Discrete | Discrete | Module |
| | | | | | | | | | | |
| 600 V | | | | | | | | | | |
| 650 V | | | | | | | | | | |
| 1200 V | | | | | | | | | | |
| 1700 V | | | | | | | | | | |

Continuous expansion of portfolio



Vast portfolio of CoolSiC™ MOSFETs complemented with EiceDRIVER™ gate driver ICs

Establishing Villach and Kulim as Infineon's key development and manufacturing cluster for wide bandgap

Villach, Austria



- › Already serves as a strong innovation base and will be expanded
- › 150/200 mm Si lines will be converted to SiC and GaN manufacturing while reusing non specific equipment
 - SiC capacity secured in Villach
 - GaN scaling-up to volume manufacturing

Further expansion in Kulim

Kulim, Malaysia



- › Significant value-added steps, in particular wafer singulation and epitaxial processes
- › Transfers of 200-mm Si and WBG epitaxy as first step
- › Ground is ready for 3rd module

Expansion of SiC and GaN capacity follows long-term manufacturing strategy: Investment of >2bn EUR for 3rd module in Kulim



Rationale

- › Seize structural growth opportunities linked to electrification
- › Prepare manufacturing cluster for acceleration of WBG
- › Create higher resilience of WBG supply by further expanding capacities with Kulim 3 and in Villach
- › Leverage economies of scale

| | | |
|---------------------------|-----------------------------------|--|
| Total frontend investment | >2bn EUR | |
| Revenue potential | ~2bn EUR per year | |
| Groundbreaking | January 2022 | |
| Start of construction | June 2022 | |
| Ready for equipment | Summer 2024 | |
| First volumes out | Second half of calendar year 2024 | |

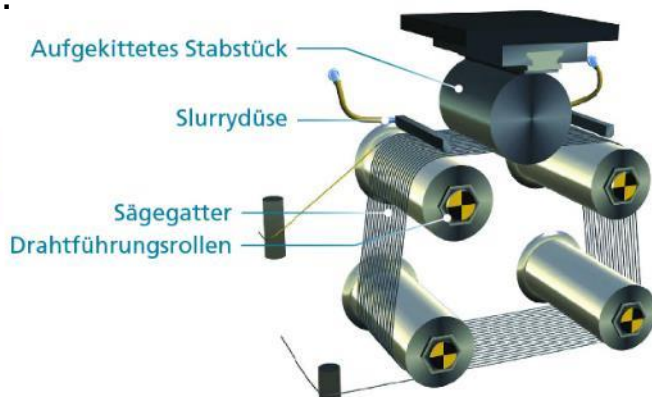
Basematerial strategy - efficient use of available SiC material

SiC Boule 6"
Several cm height typ.

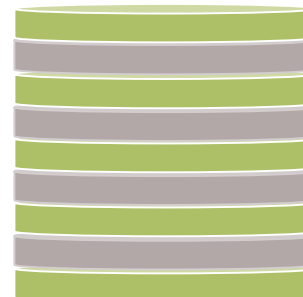


+

Traditional Wire-Saw



=



350µm SiC „dust“

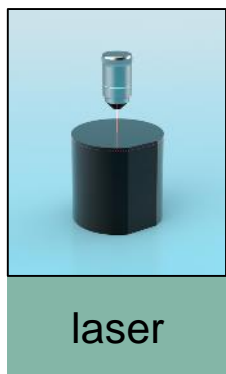


**~50%
usage**

350µm SiC wafer



SILTECTRA – Cold Split technology



100µm SiC „dust“
potential down to 50µm



**>75%
usage**

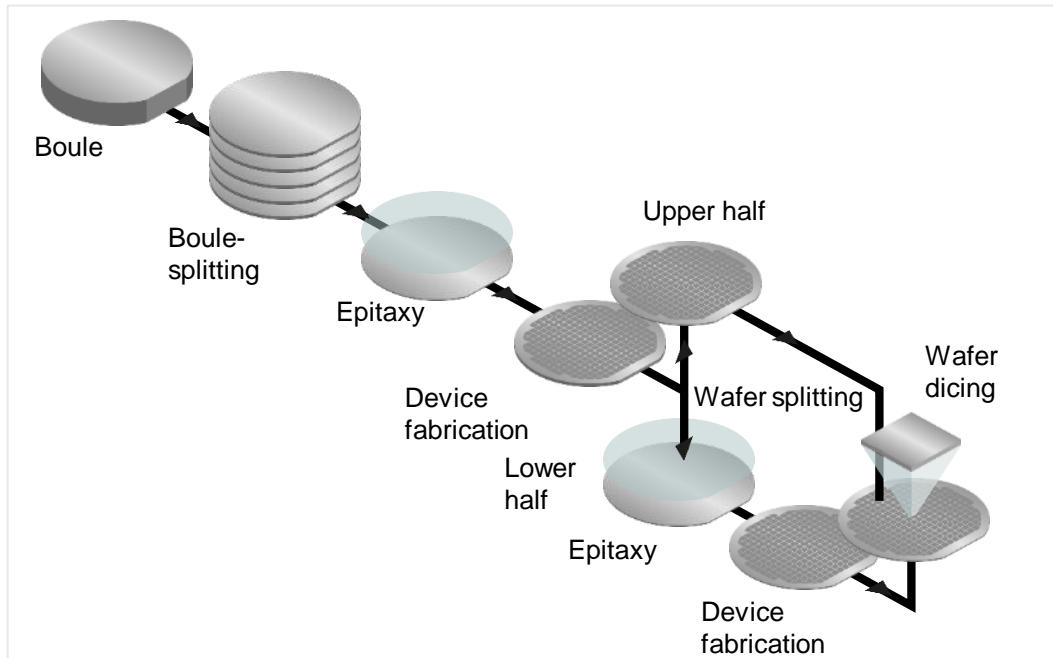
350µm SiC wafer

potential down to <<350µm



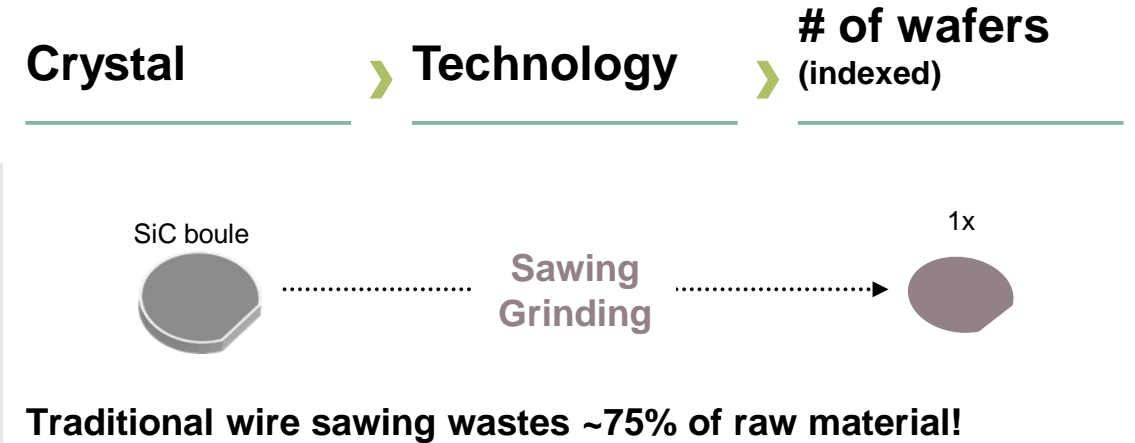
Cold Split technology leads to significant reduction of raw material losses during SiC manufacturing

Cold Split technology



- › First products qualified on Cold Split technology
- › Ramping pilot line and prepare volume production
- › 3 supplier LTAs for boules and wafers in place

History



Today



Future



Interested in technology details ?

Please join us live for IS24 on Thursday 24th, at 2:35 pm

“New Failure Mechanisms Relevant for SiC Power Devices: Background and How to Tackle Them”



Part of your life. Part of tomorrow.