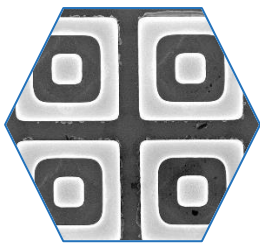




## SiC Transistor Comparison 2021

*Comparing the technology and cost of 37 SiC transistors from Wolfspeed, Rohm, STMicroelectronics, Infineon, IXYS/Littelfuse, onsemi, Microsemi, UnitedSiC (now Qorvo), GeneSiC, and Toshiba.*



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The market outlook for SiC devices is promising. According to Yole Développement, it is expected to grow from \$716M to \$3B for the period 2020 - 2025. Nevertheless, the technical panorama of SiC devices is still varying, and every manufacturer has its own solutions to die design and packaging integration. This leads to strong competition, which will accelerate technical innovation and lower prices. Moreover, SiC business models are still very different. We are seeing (and will continue to see) a restructuring of the supply chain driven by the main cost factors.

Since the commercialization of the first SiC device in 2001, the performance of SiC devices and the value that they add have been gradually proven. Their price has also become increasingly acceptable to end-users.

SiC transistors still have some technical and commercial challenges to face, despite the value they add. These include the wafer price and the complexity of some process steps specifically, SiC epitaxy, SiC etching, and high-temperature implantation. These challenges still hinder SiC adoption on a large commercial scale.

In this report, System Plus Consulting presents an overview of the state-of-the-art of SiC transistors. We cover 37 SiC transistors (33 SiC MOSFETs and 4 SiC JFETs) from six voltage classes: 650V, 900V, 1000V, 1200V, 1700V, and 3300V. The transistors are from Rohm,

STMicroelectronics, Wolfspeed, Infineon, Littelfuse, IXYS (part of Littelfuse), onsemi, Microsemi, UnitedSiC (now Qorvo), GeneSiC, and Toshiba, and they target different power applications (including three automotive-qualified devices).

This report provides detailed optical and scanning electron microscope (SEM) pictures of the devices' packaging and structure, with a focus on transistor design. Also included is an estimated manufacturing cost of the analyzed SiC transistors and their selling prices, providing physical, technological, and manufacturing cost comparisons between them.

### COMPLETE TEARDOWN WITH:

- SiC benchmark and technology roadmap
- Detailed optical and SEM photos
- Precise measurements
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis
- Estimated selling price
- Comparisons of technology design parameters, performance (figure of merits, current density), and costs (wafer, die, component, and cost per ampere)
- SiC MOSFET vs. Si IGBT die \$/A cost comparison of different manufacturers

## TABLE OF CONTENTS

### Technology & Market

- SiC benchmark
- SiC technology roadmap by manufacturer

### Company profile

- Rohm, STMicroelectronics, Wolfspeed, Littelfuse/IXYS, Infineon, onsemi, Microsemi, UnitedSiC (now Qorvo), Toshiba, GeneSiC

### Physical Analysis

- 650V MOSFETs & JFETs: Rohm, STMicroelectronics, Wolfspeed
- UnitedSiC (now Qorvo)
- 900V MOSFETs: Wolfspeed
- 1000V MOSFETs: Wolfspeed
- 1200V MOSFETs: Wolfspeed, Rohm, STMicroelectronics, Littelfuse, Infineon, onsemi, Microsemi, GeneSiC, IXYS, Toshiba
- 1700V MOSFETs: Wolfspeed, Littelfuse, Rohm, Infineon, STMicroelectronics
- 3300V MOSFETs: GeneSiC

### Technology and Physical Comparison

- Device performance comparisons (FOMs, current density)

- Device design comparisons

### SiC Transistors Manufacturing Process Flow

- Supply chains
- Process for: Wolfspeed, Rohm, STMicroelectronics, Littelfuse, Infineon, onsemi, Microsemi, UnitedSiC (now Qorvo), IXYS, Toshiba, GeneSiC

### Cost and Price Analysis

- Yields explanation & hypotheses
  - ✓ For each sic transistor:
  - ✓ Wafer cost
  - ✓ Die cost
  - ✓ Packaging cost
  - ✓ Component cost
  - ✓ Component price

### Cost Comparison

Comparisons Include Wafer, Die Costs, Die Ampere Cost

SiC MOSFET Comparisons Per Voltage Class

SiC MOSFET & SiC JFET Cost Comparison

SiC MOSFET Vs. Si IGBT Die Ampere Cost Comparison

## AUTHORS



**Amine Allouche** serves as a Technology & Cost Analyst, Power Electronics. Amine holds a master's degree in Micro & Nanotechnologies with a focus on integrated systems from Grenoble's Polytechnic Institute (France). He also graduated from the Ecole Polytechnique Fédérale de Lausanne (EPFL) (Lausanne, Switzerland) and the Politecnico di Torino (Italy).



**Tom Herve** has joined System Plus Consulting as a Microelectronic Laboratory Technician in order to strengthen the laboratory team. In 2020, Tom was graduated from the University of Blois where he obtained a Technical degree (DUT) in Physical Measurements. He previously worked on different subject among which precipitation of zinc oxide.

## RELATED ANALYSES



### DENSO SiC Power Module in the Toyota Mirai II

Discover the technology, design, and cost analysis of DENSO's SiC module, the first to be used in fuel cell electric vehicles.  
December 2021



### GeneSiC 1200V Gen3 and 3300V Gen2 SiC MOSFETs

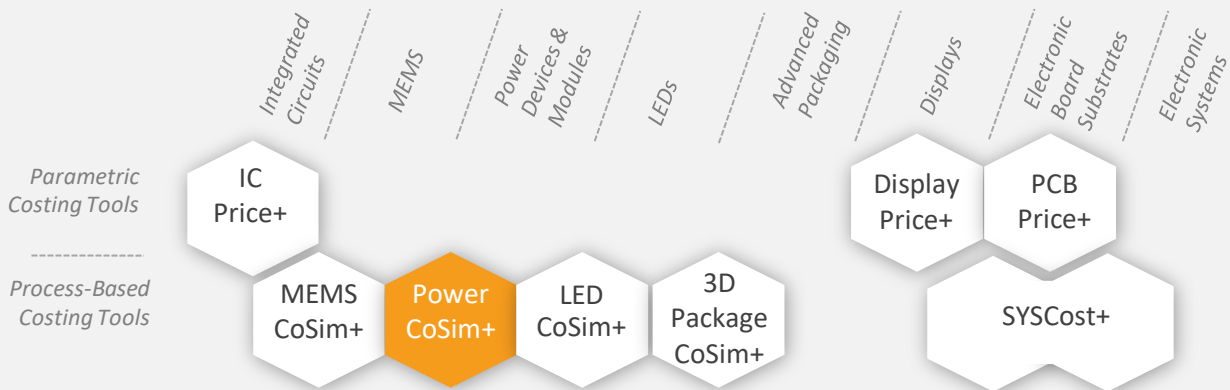
Discover the cost and technology choices of the first commercially available discrete 3300V SiC MOSFET from GeneSiC.  
August 2021



### Power SiC: Materials, Devices and Applications 2020

Despite the COVID outbreak, SiC-based design wins have multiplied for electric vehicle applications and will drive the SiC market beyond \$2.5B by 2025.  
November 2020

## COSTING TOOLS



Our analysis is performed with our costing tool Power CoSim+.

System Plus Consulting offers powerful costing tools to evaluate the production cost and selling price from single chip to complex structures.

### Power CoSim+

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## ABOUT SYSTEM PLUS CONSULTING

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