Who’s Who In Silicon Carbide And Gallium Nitride Power Semiconductors

by David G. Morrison, Editor, How2Power.com

This document offers a listing of manufacturers of silicon carbide (SiC) and gallium nitride (GaN) discrete power semiconductors, ICs and modules as well as companies providing related foundry services. Descriptions of each company’s focus and/or product offerings are provided using information taken from vendor websites. This list is current as of the date shown below and will be updated periodically. If you know of additional companies that merit inclusion in these lists, please contact me.

For more information on SiC & GaN power devices, including product and technology news, conference news, and technical articles discussing the use of these devices in power converter designs, see How2Power.com’s section on Silicon Carbide and Gallium Nitride Power Technology.

As of 05/10/2019

SiC & GaN Device And Module Manufacturers

- CISSOID
- Efficient Power Conversion
- Exagan
- Freebird Semiconductor
- GaN Systems
- GaN Power International
- GeneSiC
- Global Power Technologies
- Hitachi Power Semiconductor Device
- Infineon Technologies
- Littelfuse (Monolith Semiconductor)
- Microsemi, A Microchip company
- Mitsubishi Electric
- Navitas Semiconductor
- NexGen Power Systems
- ON Semiconductor
- Panasonic
- Powerex
- Rohm Semiconductor
- Renesas Electronics
- STMicroelectronics
- Texas Instruments
- Transphorm
- United Silicon Carbide
- ViSiC Technologies
- WolfSpeed

Foundary Service Providers

- Ceramic Forum (Ascatron)
- NY-PEMC
- Northrop Grumman
- X-FAB

CISSOID
(Mont-Saint-Guibert, Belgium)

CISSOID is [a] leader in high-temperature semiconductor solutions, delivering standard products and custom products for power management, power conversion and signal conditioning in extreme temperature and harsh
environments. CISSOID provides high reliability products guaranteed from -55°C to +225°C and commonly used outside that range, from cryogenic lows to upper extremes.

(Source: http://www.cissoid.com/company/)

Products include power SiC MOSFETs and diodes, SiC MOSFET & diode power modules and gate drivers for silicon, SiC and GaN transistors.

(Source: http://www.cissoid.com/high-temperature-electronics/)

**Efficient Power Conversion**

(El Segundo, CA)

EPC is a leader in enhancement-mode gallium-nitride-based power management devices. EPC was the first to introduce enhancement-mode gallium-nitride-on-silicon (eGaN) FETs and integrated circuits as power MOSFET replacements in applications such as dc-dc converters, wireless power transfer, envelope tracking, automotive, power inverters, remote imaging and sensing technology (Lidar), and Class-D audio amplifiers with device performance many times greater than the best silicon power MOSFETs. EPC also has a growing portfolio of eGaN-based integrated circuits that provide even greater space, energy, and cost efficiency.

(Source: https://epc-co.com/epc/AboutEPC.aspx)

For a quick summary of their product portfolio, which spans 15-V to 350-V enhancement-mode GaN FETs and ICs, see their Technology Brief TB001 at https://epc-co.com/epc/Portals/0/epc/documents/articles/EPC_eGaN_FET_Product_Brief.pdf.

**Exagan**

(Grenoble, France)

A start-up with established resources. To champion disruptive GaN technology, a flexible, application-focused and partnership-oriented company has been formed, that allows end users to fully understand the capabilities, risks and opportunities for GaN-based converter systems in their product roadmaps. It offers the agility and flexibility of a start-up with a robust, qualified manufacturing chain and established, recognized industrial partners for wafer processing, testing and packaging.

A new generation of GaN-on-Silicon technology. It is Exagan’s belief that superior GaN device performance and product leadership will be achieved by controlling material technology and IP. To this end, teams are working to apply advanced material technology from Soitec and innovative GaN device technology from CEA-Leti that has been developed over the past 10 years through internal and collaborative projects. The resulting GaN-on-silicon technology provides significant advantages in achieving the performance and reliability milestones that will lead to GaN’s widespread adoption in producing electrical converters.

Exagan’s 650-V and 1,200-V high-power transistors are developed using proprietary G-Stack material technology. Backed by a robust supply chain of established silicon foundries and test companies, G-FET product family exhibits extremely low conduction and switching loss, enabling very high operating frequencies. Equipped with such devices, customers will be able to rethink their systems and application roadmaps to achieve unprecedented system integration and efficiency levels.

(Source: http://www.exagan.com/en/company/vision/)

For information on G-FET and G-Drive (an embedded gate driver), see http://www.exagan.com/en/products/portfolio/.

**Freebird Semiconductor**

(Haverhill, MA)

Freebird Semiconductor is a fabless design and domestic (USA) manufacturing company offering advanced high-reliability wide-bandgap power switching technology. We are focused on delivering enhancement-mode
gallium nitride power transistors (eGaN HEMT) with game changing first in class eGaN-based portfolios facilitating evolutionary advantages over silicon-based solutions.

Freebird Semiconductor provides the industry’s first portfolio of proven radiation hardened "eGaN" based high-reliability power switching transistors addressing critical space-borne environments with Freebird Semiconductor patent filed design technologies.

A high-reliability performance qualification test vehicle is employed with guaranteed radiation hardness assurance. Complimentary non-radiation hardened portfolio alternatives address avionic and high end industrial requirements.

Lead by a management team with broad experience in these markets, Freebird Semiconductor aims to impact the future in high-reliability power management markets!

(Source: https://www.freebirdsemi.com/about/)

For more information on their discrete eGaN devices, see https://www.freebirdsemi.com/high-reliability-discrete-semiconductor/.

**GaN Systems**

(Ottawa, Ontario, Canada)

Our GaN enhancement-mode transistors implement GaNPX Packaging and Island Technology to provide lowest $R_{DS(on)}$, lowest gate charge, lowest capacitance and lowest internal and external parasitics. This results in lower power losses, higher power density, and lower systems costs.

(Source: https://gansystems.com/gan-transistors/)

**GaN Power International**

(Vancouver, British Columbia, Canada)

GaNPower International is proud to offer GaN power devices and all-GaN power ICs. We currently have limited engineering samples in stock for 650-V and 1200-V with current capability ranges from 10 A to 60 A. We also have limited samples for monolithic power IC with all-GaN driver. The devices and ICs come in several packages including TO-220, TO-252, TO263, DFN and LGA. In addition to GaN devices and IC, we also offer power system solutions with GaNPower patented technologies that take advantage of the high frequency and high efficiency switching characteristics of GaN.

(Source: https://iganpower.com/ganhemts/)
**GeneSiC**
(Sterling, VA)

GeneSiC is a pioneer and world leader in silicon carbide technology while also invested in high-power silicon technologies. The global leading manufacturers of industrial and defense systems depend on GeneSiC’s technology to elevate the performance and efficiency of their products. GeneSiC holds leading patents on wide-bandgap power device technologies.

High-temperature SiC bare die products:

- Schottkys
- JFETs
- SJTs
- Thyristors
- PIN Rectifiers

(Source: https://www.micross.com/genesic-semiconductor/)

**Global Power Technologies**
(Lake Forest, CA)

Global Power Technologies Group (“GPTG”) is an integrated development and manufacturing company dedicated to products based on silicon carbide (SiC) technologies and amorphous magnetic materials. These products will be foundational to the power electronics and energy industries in future years where advanced technologies are needed for low cost, highly efficient power generation, conversion and transmission.

Products being commercialized and under development include SiC epitaxial wafers and SiC discrete power devices, as well as SiC-based power modules and subsystems for the EV/HEV, server, solar inverter, lighting, and power industries. Fast switching inductors based on novel amorphous magnetic materials supporting SiC technology are also part of the GPTG technology portfolio.

Manufacturing services
- Custom chips & wafers
- Epitaxial wafers

SiC devices
- Bare die
- SiC Schottky diodes
- Hermetic SiC Schottky rectifiers

SiC modules
- SiC modules
- Hybrid SiC SBD modules
- SiC MOSFET modules

Silicon modules
- Fast recovery rectifier
- Schottky diode
- IGBT modules
- MOSFETs

Systems
- Sub-systems

(Source: https://www.gptechgroup.com/index.php/en/)

**Hitachi Power Semiconductor Device**
(Tokyo, Japan)
[The company] will introduce large-capacity IGBT/SiC modules that contribute to high efficiency for [the] inverter.


**SiC (Full SiC)**
- Ultra-low switching loss with SiC MOSFET
- High current density package
- Low inductance
- Scalable, easy paralleling

**SiC (Hybrid SiC)**
- Advanced Trench HiGT—sSiPT [High conductivity IGBT—Soft low injection punch through]
- SiC Schottky barrier diode
- Ultra-low recovery loss with SiC diode


**Infineon Technologies**
(Neubiberg, Germany and El Segundo, CA)

Infineon Technologies occupies the unique position of being the only company currently offering silicon (Si), silicon carbide (SiC), insulated-gate bipolar transistor (IGBT) and gallium nitride (GaN) devices. Based on proven, high-quality volume manufacturing, Infineon's CoolSiC solutions combine revolutionary technology with benchmark reliability.

Infineon’s GaN solution is based on the most robust and performing concept in the market—the enhancement mode (e-mode) concept, offering fast turn-on and turn-off speed. CoolGaN gallium nitride products focus on high performance and robustness, and add significant value to a broad variety of systems across many applications such as server, telecom, wireless charging, adapter and charger, and audio. CoolGaN switches are ease-of-use and easy to design-in with the dedicated GaN EiceDRIVER gate driver ICs from Infineon.


**Littelfuse (Monolith Semiconductor)**
(Chicago, IL)

Silicon carbide Schottky diodes

SiC MOSFET manufacturer offering premium silicon carbide MOSFETs.
- Extremely low gate charge and output capacitance
- Low gate resistance for high-frequency switching
- Ultra-low on-resistance; RoHS compliant, Pb-free, Halogen-free

(Source: https://www.littelfuse.com/products/power-semiconductors/silicon-carbide.aspx)

**Microsemi, A Microchip company**

SiC MOSFET—700 V, 1200 V, 1700 V

SiC Schottky barrier diode—700 V, 1200 V, 1700 V

Available in through leads and surface-mount packages and chip
SiC Modules

(Source: https://www.microsemi.com/product-directory/606-discretes)

**Mitsubishi Electric**

(Tokyo, Japan)

Mitsubishi Electric began developing SiC as a new material in the early 1990s. Pursuing special characteristics we succeeded in developing various elemental technologies. In 2010, we commercialized the first air conditioner in the world equipped with a SiC power device. Furthermore, substantial energy-saving effects have been achieved for traction and FA machinery. We will continue to provide competitive SiC power modules with advanced development and achievements from now on.

**SiC power modules appropriated by application**

(Source: http://www.mitsubishielectric.com/semiconductors/catalog/pdf/sicpowerdevices_e_201704.pdf)

Also, see http://www.mitsubishielectric.com/semiconductors/products/powermod/sicpowermod/index.html

**Navitas Semiconductor**

(El Segundo, CA)

Navitas was founded by a management team with an extraordinary track record of innovation and business creation in power electronics. In aggregate, the team is credited with industry achievements and successes that include over 200 issued patents, 200 industry papers & presentations and the development of over 100 industry-leading power semiconductor technologies including the industry’s first commercial planar power MOSFETs, first high-voltage power ICs, first driver + MOSFET integration, first application-specific power MOS chip-sets, first cascode GaN power FETs and many others across all major power electronics markets.

(Source: https://www.navitassemi.com/about/)

Navitas Semiconductor is the world’s first and only GaN Power IC company, founded in 2014 and based in El Segundo, CA, USA... A proprietary process design kit monolithically integrates the highest performance GaN FETs with GaN logic and GaN analog circuits. Navitas GaNFast Power ICs enable smaller, higher energy efficient and lower cost power for mobile, consumer, enterprise and new energy markets.

(Source: https://www.navitassemi.com/navitas-presents-industry-leading-ganfast-charging-technology-at-premier-european-power-electronics-conference/)

**NexGen Power Systems**

(Santa Clara, CA)
NexGen Power Systems is revolutionizing power electronics with technology solutions utilizing GaN on GaN discrete semiconductor devices, modules, and systems that increase efficiency and reliability of power conversion systems while dramatically reducing their cost, size, and weight.

We have assembled a world-class team of engineers with proven track records in inventing, developing, and commercializing semiconductor technologies. Our internal expertise and competence encompasses GaN epitaxial growth, materials characterization, device design and processing, electrical characterization, reliability testing, and product development.

Our focus is in developing and manufacturing vertical power semiconductor devices built in homoepitaxial GaN layers formed on bulk GaN substrates. We have established licensing and supply agreements with multiple GaN substrate vendors, giving us access to the highest quality and lowest cost bulk GaN substrates.

(Source: https://nexgenpowersystems.com/about/)

NexGen plans to enter full-scale production in 2019 at its $100 million fabrication facility in New York.

(Source: https://nexgenpowersystems.com/)

Vertical design is simple and scalable. True GaN uses conventional p-n junctions in a vertical, three dimensional design. Devices can be reliably scaled for higher current by increasing device area, and scaled for higher voltage by increasing device height.

True GaN devices are inherently reliable. True GaN devices meet or beat JEDEC, the industry standard, with avalanche capability and resilience to unexpected voltage disturbances. Devices are self-healing and circuits often don’t require external voltage clamping components.

(Source: https://nexgenpowersystems.com/technology/)

**ON Semiconductor**

(Phoenix, AZ)

Silicon Carbide (SiC) diodes (510)

- Configuration dual common cathode (12)
- Configuration single (57)
- Configuration with Schottky diode (16)
- Device grade automotive (3)
- Device grade commercial (63)

(Source: https://www.onsemi.com/PowerSolutions/search.do?searchType=others&query=SiC+Schottkys)

ON Semiconductor...will be launching and exhibiting a new silicon-carbide (SiC) based hybrid IGBT and associated isolated high current IGBT gate driver at the PCIM Europe 2019 Exhibition and Conference in Nuremberg beginning May 7th. The AFGHL50T65SQDC uses the latest field stop IGBT and SiC Schottky diode technology to offer low conduction and switching losses in multiple power applications, including those that will benefit from reduced reverse recovery losses, such as totem pole based bridgeless power factor correction (PFC) and inverters. The device co-packages a silicon-based IGBT with a SiC Schottky barrier diode, resulting in an excellent tradeoff between the lower performance of silicon-based solutions and the higher cost of entirely SiC-based solutions. The high-performance device is rated for 650 V operation.
Panasonic

( Osaka, Japan)

The features of X-GaN developed by our company are as follows.

- Safe power device: realization of normally off
- Driving method equivalent to Si-MOSFETs: Gate electrode structure hard to break
- Enabling design easier: Current collapse free

X-GaN by Panasonic has adopted the HD-GIT structure, has high reliability and high robustness. We offer X-GaN in the most optimal package for a wide range of applications with low output power to high power output. It adopts DFN 6 x 4 of small footprint for low power application, DFN 8 x 8 of high frequency operational package for middle output application, PSOP of high thermal dissipation for high power application. In addition, all X-GaN products employ Kelvin source. We are offering products that have stable switching operation at high frequency while minimizing the influence of source parasitic inductance by Kelvin source [connection].

![](https://www.onsemi.com/PowerSolutions/newsItem.do?article=4324)

Panasonic's proprietary DioMOS (Diode-integrated MOSFET) structure enables a size reduction of SiC modules by adding the free-wheel diode functionality, which is necessary for power supplies and inverters, to transistors. At APEC 2019, Panasonic [introduced] SiC-DioMOS-related solutions.

(Source: https://news.panasonic.com/global/topics/2019/66484.html)

Powerex

(Youngwood, PA)

SiC MOSFET modules and Hybrid Si/SiC IGBT modules

Powerex and Mitsubishi continue to expand their product offering with the newest power semiconductor technology, silicon carbide. SiC offers significant advantages over traditional silicon-based devices in power applications requiring low losses, high frequency switching and/or high temperature environments. This product line includes cutting edge SiC MOSFET modules as well as hybrid Si/SiC (Si IGBT/SiC SBD) modules.
Applications include:

- High efficiency inverters
- High frequency power supplies
- High temperatures environment
- Energy saving power systems (fans, pumps and consumer appliances)
- High frequency type power systems (UPS, high speed motor drives, induction heating, welder and robotics)
- High temperature power systems (power electronics in electric vehicle and aviation systems)

(Sources: [https://www.pwrx.com/summary/SiC-Modules.aspx?c=55](https://www.pwrx.com/summary/SiC-Modules.aspx?c=55) and [https://www.pwrx.com/Promotion/FullSicHybridDesign](https://www.pwrx.com/Promotion/FullSicHybridDesign))

**Renesas Electronics**

(Tokyo, Japan)

SiC Schottky barrier diode

We offer high-performance products with low forward voltage ($V_F$) and high-speed reverse recovery time ($t_{rr}$) for increasing device efficiency. We are also employing a new material (silicon carbide: SiC) for products with even higher efficiency.


**Rohm Semiconductor**

(Kyoto, Japan and Santa Clara, CA)

ROHM is at the forefront in the development of silicon carbide (SiC) power devices and modules, improving power savings in a number of applications. These applications include:

- High-efficiency inverters in dc-ac converters for solar/wind power supplies
- Electric/hybrid vehicles power conversion
- Power inverters for industrial equipment and air conditioners
- X-ray generators
- Thin-film coating processes

Our portfolio includes SiC Schottky barrier diodes (SBDs), SiC MOSFETs, full SiC power modules (which integrate SiC SBDs and MOSFETs), and high heat resistance power modules. These compact and efficient semiconductor devices have the potential to substantially reduce end-product size.

Product highlights:
- SiC power devices (166)
- SiC Schottky barrier diodes (80)
- SiC MOSFET (34)
- SiC power module (18)
- SiC Schottky barrier diodes bare die (15)
- SiC MOSFET bare die (19)

(Source: https://www.rohm.com/products/sic-power-devices)

SiC Schottky barrier diodes

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>Rated Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>650V</td>
<td>6A~100A*</td>
</tr>
<tr>
<td>1200V</td>
<td>5A~50A</td>
</tr>
<tr>
<td>1700V*</td>
<td>10A~50A</td>
</tr>
</tbody>
</table>

*Under development

(Source: https://www.rohm.com/sic/sic-sbd)

Full-SiC power module integrating SiC MOSFETs and SBDs An original electric field mitigation structure, along with a novel screening method, are utilized to maintain reliability and enable the development of the first mass production system for full-SiC power modules. These new modules integrate SiC SBDs and MOSFETs, making high frequency operation above 100 kHz possible (unlike conventional products).

(Source: https://www.rohm.com/sic/full-sic-power-modules)

SiC MOSFET

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>On-Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>650V</td>
<td>120mΩ</td>
</tr>
<tr>
<td>1200V</td>
<td>45mΩ~450mΩ</td>
</tr>
<tr>
<td>1700V</td>
<td>100mΩ~1150mΩ</td>
</tr>
</tbody>
</table>

(Source: https://www.rohm.com/sic/sic-mosfet)

**STMicroelectronics**

(Geneva, Switzerland)

Due to the improved thermal design of ST's power electronics systems, our silicon-carbide (SiC) MOSFETs ensure good robustness thanks to the industry’s highest temperature rating of 200ºC and voltage ... and a very small variation of the RDS(on) even at high temperatures.

(Source: https://www.st.com/en/power-transistors.html)

Our portfolio includes a wide range of operating voltages for industrial and automotive applications such as traction inverters, on-board chargers & fast chargers, dc-dc converters, SMPS/high-end PFCs, auxiliary power supplies, and UPS/solar/welding.
Our wide STPOWER product portfolio combined with state-of-the art packaging and protections for high reliability and safety helps designers find the right solutions for customized, high-efficiency applications that will last a long lifetime.


**Texas Instruments**

(Dallas, Texas)

We provide gallium nitride (GaN) power devices and easy-to-use modules that meet next generation system requirements and our high standards of quality and reliability.

Integration for maximum performance. Our family of GaN solutions integrate high-speed gate driver, EMI control, over temperature, and over current protection with 100-ns response time. Integrated devices offer an optimized layout to minimize parasitic inductance, maximized dv/dt immunity (CMTI), and reducing board space. Wide portfolio offers an easy to use solution to unlock the full benefits of GaN technology for almost every application.

GaN power integration. Confidence in device and system level reliability. We are an industry leader in semiconductor technology, with longtime experience in bringing reliable semiconductor products to market. With GaN technology qualified through accelerated 20 million device reliability hours of in-application hard switching testing, our GaN gives engineers confidence of device and system level reliability.

(Source: http://www.ti.com/power-management/gallium-nitride/overview.html)

**Transphorm**

(Goleta, CA)

Transphorm is a global semiconductor company, leading the GaN Revolution with the highest performance, highest reliability GaN devices for high-voltage power conversion applications. To ensure this, Transphorm deploys its unique vertically-integrated business approach that leverages the industry’s most experienced GaN engineering team at every development stage: design, fabrication, device and application support. This approach, backed by one of the industry’s largest IP portfolios with over 1000 patents, has yielded the industry’s only JEDEC- and AEC-Q101-qualified GaN FETs. Transphorm’s innovations are moving power electronics beyond the limitations of silicon to achieve over 99% efficiency, 40% more power density and 20% lower system cost—and here’s how we do it.

(Source: https://www.transphormusa.com/en/company/)


**United Silicon Carbide**

(Monmouth Junction, NJ)

UnitedSiC technology and products are uniquely positioned to leverage the lower cost of outsourced manufacturing capabilities in silicon carbide substrates, epitaxy, and foundries for production device fabrication. This dynamic is what continues to fuel the growth of digital and analog ICs and the time is now for silicon carbide (SiC). This advancement for SiC will create lower cost of goods, better continuity of supply, and improved quality for these demanding markets.

(Source: https://unitedsic.com/about/)

UnitedSiC’s UJ3C and UF3C series of silicon carbide FETs are based on a unique cascode configuration, where a high-performance SiC fast JFET is co-packaged with a cascode optimized Si-MOSFET to produce the only standard gate drive SiC device in the market today.

(Source: https://unitedsic.com/cascodes/)
The UJ3N series are high-performance SiC normally-on JFET transistors with options ranging from 650 V to 1700 V. This series exhibits ultra-low on resistance ($R_{DS(ON)}$), as low as 25 mΩ, and low gate charge ($Q_G$) allowing for low conduction and reduced switching loss... The devices are also commonly used in series connection with a Si-MOSFET as robust "supercascodes," which give all the advantages of wide bandgap technology with very high operating voltages and easy gate drive.

(Source: https://unitedsic.com/sic-jfets/

### SiC Schottky diodes selector guide

<table>
<thead>
<tr>
<th>New</th>
<th>Part Number</th>
<th>Package</th>
<th>V</th>
<th>If typ</th>
<th>QG typ</th>
<th>VF typ</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>UJ3D6654TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>4 A</td>
<td>9.3 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6658TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>8 A</td>
<td>19 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6610TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>10 A</td>
<td>23 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D65518TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>15 A</td>
<td>36 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6580K3D</td>
<td>TO-247-3L</td>
<td>650 V</td>
<td>20 A</td>
<td>23/46 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6592TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>20 A</td>
<td>46 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D660T3S</td>
<td>T020-2L</td>
<td>650 V</td>
<td>30 A</td>
<td>72 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6460K3D</td>
<td>TO-247-3L</td>
<td>650 V</td>
<td>60 A</td>
<td>72/144 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D6596TS</td>
<td>T020-2L</td>
<td>650 V</td>
<td>5 A</td>
<td>14.5 nC</td>
<td>1.5 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1208TS</td>
<td>T020-2L</td>
<td>1200 V</td>
<td>2 A</td>
<td>12 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1205TS</td>
<td>T020-2L</td>
<td>1200 V</td>
<td>5 A</td>
<td>27 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1210K3</td>
<td>TO-247-3L</td>
<td>1200 V</td>
<td>10 A</td>
<td>51 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1215K3</td>
<td>TO-247-3L</td>
<td>1200 V</td>
<td>10 A</td>
<td>27/56 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1210TS</td>
<td>T020-2L</td>
<td>1200 V</td>
<td>10 A</td>
<td>51 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1220K3</td>
<td>TO-247-3L</td>
<td>1200 V</td>
<td>20 A</td>
<td>51/102 nC</td>
<td>1.4 V</td>
</tr>
<tr>
<td>✓</td>
<td>UJ3D1250K3</td>
<td>TO-247-3L</td>
<td>1200 V</td>
<td>50 A</td>
<td>240 nC</td>
<td>1.5 V</td>
</tr>
</tbody>
</table>

**ViSIC Technologies**
(Nes Ziona, Israel)

ViSiC Technologies was founded in 2010 to develop and market high-power transistor products based upon compound semiconductor gallium nitride (GaN) material aiming to replace most of the silicon (Si) products used in power conversion systems. The core team consists of experts in GaN device technology and power applications. ViSiC’s products are unique and differentiated providing the features system designers need, along with significant cost and performance advantages.

Our technology is scalable in current and voltage. ViSiC’s unique, patented technology is based on deep knowledge of GaN transistor physics. It employs GaN die design for high efficiency and advanced embedding packaging design to create fast devices. Our devices are easy to use, have a small footprint and a record performance-to-price ratio.

ALL-Switch (Advanced Low Loss Switch) line. Our 650-V and 1200-V ALL-Switches are system-in-package (SIP) devices. Safe operating functions are integrated within the package, providing a robust and reliable solution. ViSiC’s switches feature low $R_{DS(ON)}$, exceptionally fast switching performance, ultra-low switching energy and a conveniently small footprint. Our ALL-Switch products are an ideal fit in performance power conversion applications requiring high efficiency, high power density and low system cost.

(https://visic-tech.com/about/)

**WolfSpeed, A Cree Company**
(Research Triangle Park, NC)

WolfSpeed leads the known universe in the manufacture of silicon-carbide Schottky diodes, MOSFETs and power modules, and our gate driver boards are a springboard for optimum power energy conversion straight out of the
These state-of-the-art components provide increased efficiency, higher switching frequency and reduced system size and weight in a variety of applications.

Our SiC MOSFETs replace silicon devices with higher blocking voltage (>1700 V), avalanche rated to >1800 V and lower switching and conduction losses. We created the first SiC MOSFET five years ago and have been perfecting the technology ever since.

Wolfspeed has the broadest portfolio of SiC Schottky diodes, with more than two trillion field hours and 15 years of experience, combined with the fastest delivery times. Our diodes feature the MPS (Merged PiN Schottky) design which is more robust and reliable than standard Schottky barrier diodes. Pairing Wolfspeed SiC diodes with SiC MOSFETs creates a powerful combination of higher efficiency and reduced component pricing when purchased together.

SiC power modules

Gate driver boards

Materials products

Wolfspeed is a fully integrated materials supplier with the largest and most diverse product portfolio serving our global customer base with a broad range of applications. We are a technology commercialization leader with the capacity and scale to bring large-diameter wafers to the market in mass production volumes. Wolfspeed has long proven expertise in SiC and GaN materials technology advancement with the focus and commitment to bring high-quality solution platforms across all applications.

Foundary Service Providers:

**Ceramic Forum**

SiC Device Foundry Services

Ascatron offers total solutions for SiC power device development. From the design stage of SiC device planning, to prototyping, evaluation, pilot production and large-scale mass production, Ascatron furnishes customers with optimum solutions for each stage. At the KTH Royal Institute of Electronics, Sweden, Ascatron has a 1300 m² clean room, where they make Epi up to 150-mm wafers, and device prototypes.

Beginning with the announcement of the 4.5-kV PiN-piode in 1999, there has been a profusion of developmental results, especially in high-voltage power devices, developed and prototyped according to our customer’s design, such as SiC diode with embedded p-region, SiC-IGBT, SiC-SJ type MOSFET etc. Ascatron also undertakes manufacturing with specific processes such as embedded epi, trench layer formation, heat treatment, SJ structure formation etc.
**New York PEMC**

(Albany, NY)

NY-PEMC provides foundry services for standard or customer-supplied designs and custom process development and research for a complete device flow as well as individual fabrication modules.

The open baseline flow for 1.7-kV MOSFET available to PEMC customers includes access to a process design kit (PDK) to aid the design of discrete components, development of optimized and next generation designs, and facilitates simulation of device performance on the physical level as well as a part of package, complete power conversion system, or a more complex circuit.

For additional information on the gate oxide and gate-stack reliability, qualification reports of full devices and SiC MOSFET datasheets, a list of standard processes, processing equipment offered and other specific questions please fill out the information request form.

**Silicon carbide process capabilities**

- Photolithography resolution down to 0.3-µm feature with 0.04-µm alignment accuracy
- Thermal oxidation and gate stack processes
- Films deposition and etch
- High-temperature implant
- High-temperature implant anneal
- Backside metal deposition
- Ni, Al, Ni/Au deposition and etch
- Inline parametric and reliability electrical testing and characterization
- SiC defect inspection and yield management
- Open baseline for 1.7-kV MOSFET based on General Electric technology
- Custom development and manufacturing

**Facilities and Infrastructure**

- Class-1 capable cleanroom with ISO-9001 quality MES controls and ESD protection
- Capacity to produce 50,000 wafers per year
- New equipment specified for 200 mm, capable of processing 150-mm wafers
- Full complement of metrology and analytical equipment
- Extensive SiC materials analysis capability with leading edge surface inspection equipment
- Incoming SiC wafer surface inspection to electrical probe yield prediction capability

(Source: [http://ny-pemc.org/process-capabilities](http://ny-pemc.org/process-capabilities))

**Northrop Grumman**

(Linthicum, MD)

Trusted foundry for silicon (Si), silicon carbide (SiC), gallium arsenide (GaAs)

High-temperature, high-frequency, radiation-hardened Si, SiC, SiGe, and GaAs capabilities

The Northrop Grumman Mission Systems foundry, located in Linthicum, Maryland, maintains a wide range of processes for both internal and external customers. We offer a full feature facility from state-of-the-art design capabilities, multiple processing nodes, electrical testing, environmental and QCI screening, and failure analysis.

**Our capabilities**

- 150-mm Si
- CMOS* (180 nm, 0.5, 0.8, & 1.25 µm)
  - BiCMOS (10 V*, 15 V, 40 V*, 60 V)
  - SONOS*

SiC & GaN

- SiGe bipolar
- 100-mm GaAs
- 100-mm GaN-on- SiC, GaN-on-Si, indium-based nitrides
- 75-mm SiC
  - Schottky SIT and ion implanted SIT

* Radiation hardened

(Source: https://www.northropgrumman.com/Capabilities/TrustedFoundry/Pages/default.aspx)

**X-FAB**

(Lubbock, TX)

X-FAB has established a 6-inch silicon carbide foundry line with a capacity of 1,500 SiC wafers/month fully integrated within the silicon wafer fab located in Lubbock, Texas. With the support of the PowerAmerica Institute, X-FAB’s goal is to accelerate the commercialization of SiC power devices by leveraging the economies of scale, automotive quality system and equipment set that have been established in its silicon wafer fabrication line.

**Benefits**

- 6-inch SiC processing capabilities
- Leveraging the economies of scale of an existing 6-inch silicon fab
- Automotive quality standards e.g. IATF-16949
- Strong focus on IP protection
- Second source solution for IDMs with own SiC manufacturing line

**SiC Process Capabilities**

- High-temperature implant
- High-temperature implant anneal
- SiC wafer thinning
- Backside metal deposition (Ti/Ni/Ag)
- Backside laser anneal
- Ni deposition and etch

**Available Tools for SiC Processing**

**Photolithography**

- Canon i3 Steppers [CD: 0.6um, Align: ± 0.2um]
- TEL Mark V Coat/Develop Tracks

**Deposition**

- Novellus Concept 1 PECVD [Oxides, BPSG ILD, nitrides]
- AMAT Endura PVD [Ti, AlCu, TiW, Ni]
- Thermco LPCVD Furnace [PolySi]

**Etch**

- Dry Etch: LAM TCP, LAM 45XX
- Wet Etch: FSI-Mercury

**Implant**

- Species supported: P, B, N2
- Varian E500 mid-current implanter
- Axcelis GSD high-current implanter
- Axcelis VHE (very high energy) implanter

(Source: https://www.xfab.com/technology/sic/)