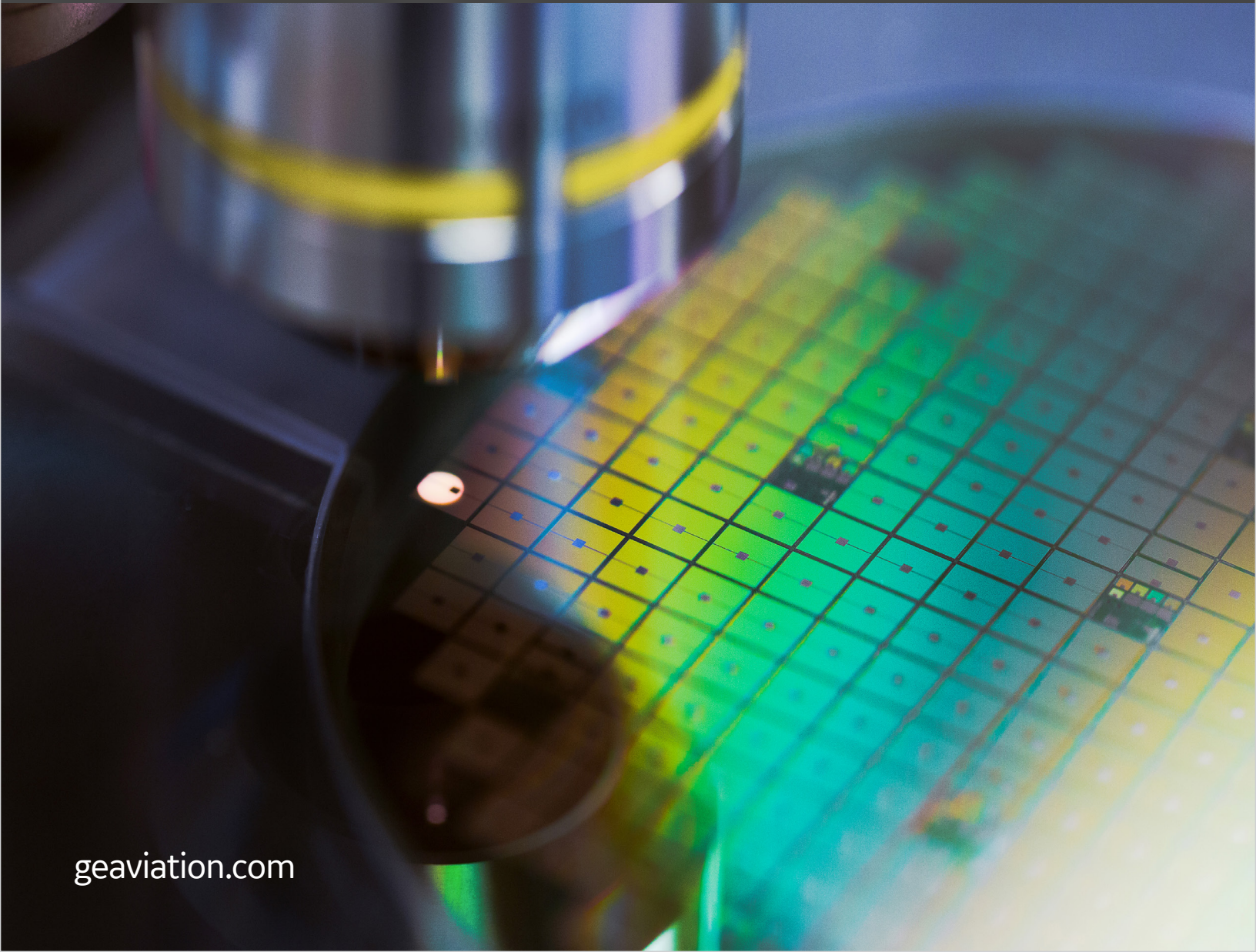




# Silicon Carbide

Leading the way



[geaviation.com](http://geaviation.com)



# Setting a new standard in power savings with silicon carbide

## Imagine ...

the fuel savings  
achieved by reducing  
an aircraft's weight  
by 1,000 lbs.

increasing more  
electric vehicle  
ranges by 10%.

eliminating  
complex and heavy  
cooling systems  
on vehicles.

designing systems  
at power levels not  
yet attainable with  
current technology.

All these benefits are made possible by  
GE's development and progression of our  
Silicon Carbide (SiC) technology.

## Silicon Carbide

Just as Silicon (Si) became the semiconductor standard 30 years ago, SiC is now revolutionizing the electric power industry. It can work at temperatures unreachable by Si chips, and can operate at much higher frequencies because these devices are much more efficient. SiC-based devices can also manage the same level of power as Si devices but at half the size and weight.

### Other GE SiC advantages

- **Highest temperature tolerance**  
in the industry: 200°C rated die, 25°C improvement, reduced cooling system complexity, cost and size
- **Fewer switches**  
Reduced losses, improved size, weight and power capabilities
- **Higher current density**  
2X Power density at same size and weight
- **Higher energy band gap**  
More robust against heat, radiation and electromagnetic disturbances.

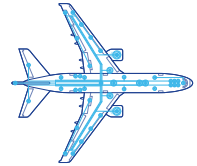
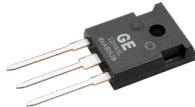
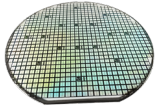
### SiC Technology leader

GE has been a leader in SiC technology development for nearly two decades. From chip design and component engineering to full system implementation, GE has demonstrated class-leading performance in power devices, advanced packaging and power electronics applications. GE offered the Industry's first -55 to 200°C MOSFET.

### GE SiC ... 20+ years of experience

1991	First SiC photodiode studies for UV, combustion.
1995	World's first SiC op amp with high temperature operation.
1998	SiC Flame Tracker (UV combustion monitor) enters production. First SiC product.
2006	1.2kV, normally off, SiC DMOS power devices demonstrated.
2009	Transition SiC line to 4" wafers, best-in-class MOSFET performance.
2011	Fully capable 4" SiC fabrication in place, demonstrated MOSFET $V_{TH}$ stable @ 200°C.
2012	Aerospace converter with 98.5% @ 75kW, 20KHz.
2013	AEC-Q101 qualified 1.2kV SiC MOSFET with industry-leading performance.
2014	ISO9001: 2008 QMS for 4" fabrication. 200°C rated 1.2kV, 50mΩ Gen1 AEC-Q101 qualified.
2015	6" Device fabrication and packaging.
2017	200°C rated surface mount. 1.2kV, 25mΩ Gen3 AEC-Q101 qualified.
2018	Benchmark ultra-low inductance module for high-performance MW apps. Aviation programs launched.
2020	Aviation industry-first SiC converter with GE SiC certified.

# Silicon Carbide



WAFER	DEVICE	MODULE	LRU	SYSTEM
Industry-leading source	<ul style="list-style-type: none"> <li>3x higher reliability</li> <li>&lt;25% switching losses</li> <li>4x switching frequency</li> <li>2x power density</li> <li>AEC-Q101 qualified</li> </ul>	<ul style="list-style-type: none"> <li>↑ Power and current density</li> <li>↓ Resistance and inductance</li> <li>↑ Robustness</li> </ul>	<ul style="list-style-type: none"> <li>↓ Weight</li> <li>↑ Power density</li> <li>↑ Power quality</li> </ul>	<ul style="list-style-type: none"> <li>↑ 1-5% system efficiency</li> <li>↑ 2x power density</li> <li>↑ 2x reliability</li> <li>↑ Sustainability on MEA narrowbody</li> <li>↓ 500-1,000 lbs weight</li> <li>↓ 1-3% Fuel Burn</li> </ul>

GE has invested more than \$150M over 13 years to aggressively develop state-of-the-art SiC for new applications. By leveraging the company's longstanding industrial breadth and technical depth as well as thousands of scientists worldwide, GE will continue to lead the way in advancing the state-of-the-art in SiC.

GE offers electrical power products with levels from 1kW to 1MW for vehicular applications that operate in harsh environments like aerospace, industrial, and military applications. SiC-based power modules are an enabling technology for advanced power electronic systems. These modules increase GE's Line Replaceable Unit's (LRU) power density by up to 2X while reducing weight up to 50% while simplifying interconnect layouts. Our vertically integrated experience—from chip to system level architecture—gives an unprecedented advantage for optimizing design and packaging density for complex applications. With GE's SiC experience, you can save development time to field superior power electronics products that meet your high performance demands.

## SiC application experience

GE has been making significant progress in hybrid-electric flight, high power vehicle systems, and electric propulsion systems because of our SiC and system-level expertise. Systems with power capabilities that used to be impossible are now possible, and they also happen to be smaller, lighter, more efficient, and cooler than their Silicon predecessors. SiC MOSFETs and power packaging experience are key components to GE's success in making these achievements possible for the world.

GE is looking at a future of aviation and hybrid-electric aircraft that might seem far off for some, but not for GE. Our Global Research Center (GRC) in conjunction with GE's Aviation business is currently developing a SiC-based, lightweight inverter for MW-class power conversion working to NASA-set goals for power density and efficiency under two programs.

## Silicon Carbide

This novel inverter will advance the state-of-the-art by leveraging GE's ultra-high efficiency and high voltage SiC power devices to achieve an industry best power conversion peak efficiency (goal of 99%) and power density (goal of 19kW/kg for the active components). This SiC-based 1MW inverter will be ground-tested and represents the first step towards a lightweight flight-worthy inverter to enable hybrid-electric aircraft applications. This technology could revolutionize how we travel in the future.

GE's advancements in SiC and high-power system designs have caught the attention of the US Army. GE has been working with the U.S. Army's Tank Automotive Research, Development and Engineering Command (TARDEC) to develop high voltage architectures for ground combat vehicles high-power demands that can meet future requirements in the world's most challenging environments. Our systems have been extensively tested in the lab and field tested to show that they will meet the challenge. All of this has been possible due to GE's SiC and design capabilities and through the partnership and funding from TARDEC. Additional information about GE's partnership with TARDEC can be referenced [online](#).

With this new generation of rugged components, GE customers are setting new standards for reliable, economical system performance.

### A new standard

GE's SiC-based high efficiency DC to DC converter utilizes GE's 1200V SiC MOSFETs packaged in our advanced liquid-cooled power modules. GE has developed advanced Planar Magnetic technologies to compliment the SiC device, yielding high power density and reduced weight.



**20kW DC-DC Converter**  
610Vdc/28Vdc

### The future

The world is moving towards electrification, hybrid systems, and renewable energy. The next 20+ years will bring about the revolution in electrical power systems that can propel an aircraft and allow electric vehicles to charge rapidly with a greater range than fossil fuels. Renewable energy will be maximized through highly efficient power electronic devices.

The future of power electronics is boundless, and GE is poised to lead the industry through the SiC transformation.

### For additional information

954-984-7000

[Request online](#)



## About GE Aviation

GE Aviation, an operating unit of GE (NYSE: GE), is a world-leading provider of commercial and military jet engines and components as well as integrated digital, electric power and mechanical systems for aircraft. GE Aviation also has a global service network to support these offerings.

[geaviation.com](https://www.geaviation.com)

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