
# The Prospect of GaN Technology

# Go GaN - Go Green

*This is the first entry in a four-part series of guest columns by David Schnaufer of Qorvo*

Over the past 10 years, gallium nitride (GaN) technology has firmly established itself in the high-power RF amplification and non-RF power global markets. Over this timeframe, GaN technology has been developed on substrates such as silicon carbide (SiC), silicon (Si), GaN, and even diamond, enabling it to address both niche and mainstream applications. The RF engineering community continues to push for GaN, because of GaN's high breakdown voltage, wideband gap, ruggedness, efficiency, and thermal management capabilities.

It is widely known that GaN amplifiers operate and deliver more energy per square millimeter than alternative gallium arsenide (GaAs) or Si options. This higher power handling is the main driving force for GaN development creating more markets and products for the technology than originally anticipated. With all this power capability in a small die periphery and package size, more opportunities will continue to open.

**A Choice of Substrates**

The most popular GaN offerings today are GaN-on-SiC and GaN-on-Si substrates. GaN on SiC is the most common substrate for high-frequency RF power applications, mostly due to its higher performance capabilities and high thermal conductivity. GaN on Si, although popular in some RF power applications, has somewhat lower performance and thermal conductivity, due in part to the lower thermal capability of Si. GaN on Si promises lower chip cost because of the lower cost of its Si substrate. However, the potential cost savings are more than outweighed by the benefits of GaN on SiC in thermal management and power density, making them ideally suited for those applications that demand higher performance, smaller package size, and higher ruggedness.

So how are these two popular GaN technology options maturing? For both GaN on SiC and GaN on Si, the economies of scale are steadily materializing. As each of these processes continue to mature and fabrication yields improve, GaN on both SiC and Si will continue to carve out more market space among other mainstream technologies. As the race between these two frontrunners continues and their market share increases, industry experts say both GaN-on-SiC and GaN-on-Si suppliers will show process enhancements. These enhancements will allow new capabilities and choices for designers, as well as the industry. One of the most important differences between GaN on SiC or Si is heat management. It is important for design engineers to manage system-level heat through device design, substrate choices, and package design. Most designers choose GaN-on-SiC devices in RF microwave applications because its thermal properties are more efficient than GaN on Si, while GaN on Si is widely used in low frequency power switching electronics and light emitting diodes (LEDs).

**GaN: A Growing Market**

GaN is doing very well in the marketplace. Over the last few years, Si laterally diffused metal oxide semiconductor (LDMOS) coverage in the high-power, 2GHz RF space has decreased approximately 15 percent, while greater than 20 percent of the market share now uses GaAs or GaN technology. According to Strategy Analytics' report, "GaN RF Market Update: 2014-2019, revenue for GaN RF devices in both military and commercial applications will grow at a compound average annual growth rate (CAAGR) of more than 20 percent, to nearly $560M in 2019." In 2014, military applications accounted for slightly less than 50 percent of GaN RF total revenue, and analysts predict communications will be an even stronger growth area for GaN in the future.

**Is GaN the New Green?**

We hear in many articles that GaN technology is "more green" than current Si- or CMOS-based technologies.  But, what does this really mean? Let's break it down into two distinct areas: lower installation cost and lower system-level operating costs.

First, GaN helps to lower overall installation costs in several ways. A key advantage of GaN is its wider bandwidth, unlike its narrowband predecessor Si LDMOS. This wide-bandwidth capability equates to fewer devices in a system chain. Rather than using a Si LDMOS band-splitting chain, which requires many high-power RF devices, one GaN device can take the place of many Si LDMOS components. This equates to fewer tuning components, a smaller board area, and less engineering time required for the same system output and design. Consequently, less energy is required for manufacturing and system development, making GaN a greener technology. Another way GaN reduces installation costs comes from its high thermal conductivity. Because GaN can work under high heat and has a small device periphery, a smaller heat sink is required, requiring less development energy and less space. This also provides an advantage in operating cost because the system requires less cooling. In addition, GaN switches or low noise amplifiers (LNAs) also require less electrostatic discharge (ESD) protection because of GaN's high breakdown properties. By substituting GaN in these types of devices, less ESD protection is required, resulting in a decrease in insertion loss and increase in overall system output. Overall, GaN achieves several advantages such as reduced bill of materials, current consumption, and size reduction—all of which make GaN greener than other technologies.

Next, we will look at lower system-level operating costs. GaN amplifiers consume 20 percent less current than GaAs for the same system linearity and output power. Because GaN amplifiers deliver more energy per square millimeter than GaAs or Si, it continues to be the engineer's first choice in many applications. Lower system current means the entire system runs cooler, requiring fewer fans or air conditioning to cool everything down and therefore less energy. Less energy is greener.

**The Prospect of Maturity**

Based on analyst and market feedback, GaN technology is beginning to benefit from economies of scale, becoming profitable in mass production. As this trend continues, GaN will soon be the go-to technology for many markets once held by incumbent technologies, such as Si LDMOS. GaN suppliers are now beginning to see glimmers once dreamt about during the technology's development—a mature and thriving RF power technology.

# Links for Article:


- TGA2585-SM    2.7-3.7 GHz 18W, Link: http://www.triquint.com/products/p/TGA2585-SM
- TGA2583-SM    2.7-3.7GHz 11W, Link: http://www.triquint.com/products/p/TGA2583-SM
- TGF2819-FL   DC-3.5 GHz 100W, Link: http://www.triquint.com/products/p/TGF2819-FL
- TGF2819-FS   DC-3.5 GHz 100W, Link: http://www.triquint.com/products/p/TGF2819-FS
- TGA2599-SM    5-8 GHz 2W driver, Link: http://www.triquint.com/products/p/TGA2599-SM
- TGA2559-FL    14-16 GHz 3W, Link: http://www.triquint.com/products/p/TGA2559-FL

- GaN FET's, Link: http://www.triquint.com/products/all/standard-products/gan-fets


- *Qorvo has written two resources*— GaN RF Technology For Dummies® *and* RF Applications of GaN For Dummies®—*in conjunction with John Wiley & Sons, Inc., to help customers learn more about the basic technology of GaN and its applications in RF design. Download your free e-books today at www.qorvo.com/gan-for-dummies.*
- FAQ:GaN Thermal Analysis for High-Performance Systems, Link: http://www.triquint.com/products/d/faq-gan-thermal-analysis-for-high-performance-systems
- Bias Techniques for GaN and pHEMT Depletion Mode Devices, Link: http://www.triquint.com/products/d/bias-techniques-gan-phemt-depletion-mode-devices
- A High-Efficiency, Small-Size GaN Doherty Amplifier fro LTE Micro-Cell and Active Antenna System Applications, Link: http://www.triquint.com/products/d/gan-doherty-amplifier-lte-micro-cell-mar2013