GaN ON SiC: THE ONLY VIABLE LONG-TERM SOLUTION FOR 5G

5G telecom infrastructure design requires technologies that deliver performance and efficiency. GaN on SiC checks all the boxes.

The 5G wave that's been building for many years will finally come to shore in 2019. Early (but extremely limited) service rollouts will gain much fanfare and the first round of 5G-enabled devices will begin to hit markets. Wider commercial deployments, however, are still off in the distance and will be a slow but growing wave from 2020 to 2025. CCS Insight predicts 1 billion 5G users globally by 2023. Cisco says 5G devices and connections will be make up 3% of global mobile devices and connections by 2022, and nearly 12% of global mobile traffic will be on 5G cellular connectivity by 2022.

The frenzy surrounding 5G is well-founded. The availability of higher network bandwidth, lower latency and incredibly fast data speeds will spur a wealth of new applications across every industry, from manufacturing to energy to transportation and beyond. Smart cities, smart manufacturing, autonomous vehicles and connected transportation can all be realized through the availability of 5G.

5G is also bringing a new thinking around the technologies and infrastructure design needed to deliver connectivity that meet these new requirements for bandwidth, latency and data speed. It will not only require densification on the macro level — meaning more base stations — but also densification of power on the device level. Today's telecommunications infrastructure design requires technologies that best match a number of criteria for the application, including heat, speed, power, efficiency, size and cost.

There are several types of semiconductors available to RF designers, including:

- Laterally diffused metal oxide semiconductor (LDMOS), a wide-bandgap semiconductor material with high-output power capability that utilizes silicon wafer substrates.

- Gallium nitride (GaN), a wide-bandgap semiconductor material known for its high levels of thermal conductivity, heat capacity and hardness, and low sensitivity to ionizing radiation, that utilizes either silicon or silicon carbide (SiC) wafer substrates. GaN on SiC has demonstrated to be a better solution overall for wireless communications because of its thermal conductivity, materials matching, efficient and total lifecycle cost.

As 5G increasingly matures, the technology that meets all of its requirements — especially at the higher frequencies being utilized for 5G — is GaN on SiC.

5G CHALLENGES

Why is 5G so different than previous generations of wireless technologies in terms of technology requirements?

It breaks down to three key elements:

- **WIDER BANDWIDTH IS REQUIRED.** The continuous explosion in mobile data is well documented; Cisco's Virtual Networking Index says demand for mobile data will exceed 49 exabytes of data per month by the year 2021. To support that level of data at higher speeds, more spectrum needs to be utilized. The wider the spectrum band, the faster data can travel. 5G standards allow for an order of magnitude wider bands (1 GHz+), allowing for much faster throughput.

  However, "if you try to do wide bandwidth at high power, then LDMOS will not be optimal most of the time," said Simon Wood, senior director of RF product development and applications at Wolfspeed, "while GaN on SiC can easily support the tenfold increases in download speed."

- **NEW FREQUENCY RANGES ARE IN PLAY.** 5G will bring the usage of two new frequency bands at 3.5 GHz and 4.8 GHz to help meet the growing demand for throughput. Conventional LDMOS silicon technologies generally operate well below 3 GHz. "Once you are into these higher frequencies being opened for 5G, LDMOS doesn't work well," Wood said. In addition, "there is a tipping point at which SiC outperforms Si, and 2.7 GHz is that tipping point."

- **SIZE MATTERS.** 5G base stations, especially in urban areas, have size requirements to slide easily into their already well-developed surroundings. Because GaN on SiC semiconductors are more efficient, GaN on SiC chip can be about 20 percent smaller and more watts can be placed on a 6-inch wafer, meaning smaller base stations designs and oftentimes easier installations are possible.

Why GaN on SiC?

Compared to LDMOS, GaN on SiC offers significant improvements in 5G base station performance and efficiency:

- **BETTER THERMAL CHARACTERISTICS.** GaN on SiC has much better thermal conductivity compared to other materials, dissipating heat more efficiently and effectively, allowing devices to run at a much higher voltage and higher power density than other technologies.

- **SMALLER ARRAYS POSSIBLE WITH SAME PERFORMANCE.** Because of GaN on SiC's superior thermal characteristics, power per device can be much higher than can be achieved with GaN on Si. This means a 32x MIMO array is feasible rather than a 64x, for example, leading to smaller base stations.

- **RUGGED ENOUGH FOR 5G DEMANDS.** GaN on SiC is robust, reliable, and hardened, with a high breakdown voltage with minimal performance degradation.
- **BETTER EFFICIENCY AT HIGHER FREQUENCIES.** LDMOS works best in lower frequencies. In the higher frequencies being utilized for 5G, such as 3.5 GHz, GaN is 10% to 15% more efficient than LDMOS.
- **SIGNIFICANT RUNWAY FOR FUTURE OPTIMIZATION.** Silicon-based technologies like LDMOS have been in use for years and are reaching the end of their optimization lifespan. By comparison, GaN is in early generations with significant room for improvement and extensions.

GaN on SiC has emerged as the frontrunner to take on all of the challenges and requirements brought about by the introduction of 5G networks. Simply stated: “If you want the best performance, you need to be using GaN for 5G,” Wood said.