For Better SWaP, Choose GaN

By: David Silvius, Director, Strategic Marketing, Richardson RFPD

Today's GaN-based products are rising to the challenge of rapidly evolving demands for size, reliability, linearity, power density and energy efficiency, by providing RF system engineers with the flexibility to achieve significantly higher power and efficiency, with lower part count, board space and resultant cost.

GaN technology is suited to meet today's size, weight and power ("SWaP") demands better than older technologies like GaAs because GaN offers:

- Higher power densities leading to reduced combining losses for a given power target
- Increased efficiency over frequency
- Ability to maintain high performance over wide bandwidths
- Higher thermal conductivity / lower thermal resistance (GaN on SiC)

And GaN has better thermal properties than competing GaAs technologies. Thermal conductivity for SiC is roughly 4x that of GaAs. An added benefit is that GaN can support the million hour MTTF reliability benchmark at a junction temperature of 200°C or higher versus 150°C for GaAs. These thermal advantages do not solve the thermal problem at the system level; however, they bring the thermal management concern down to a reasonable design trade-off for the system engineer.

To date, the defense industry has benefitted most from advances in GaN technology, primarily due to the pulse and continuous wave GaN power devices from suppliers like M/A-COM Tech, Microsemi, Nitronex, TriQuint, and UMS.

M/A-COM Tech recently announced its portfolio of GaN in plastic high power transistors. Packaged in a convenient 3x6mm plastic package and well suited for pulsed radar, TDMA amplifiers, ultra wideband power amplifiers, and high power SatCom applications, the wideband transistors should compete well against traditional GaAs devices, thanks to GaN's higher power density.

Microsemi is focused on high pulsed power products for avionics and radar. Their 1011GN-700ELM GaN power transistor is specifically designed for extended length message Mode-S transponders and is capable of delivering 700W of pulsed peak power and over 21 dB power gain with greater than 70% efficiency at 1030 MHz. For S-Band radar applications, there is the Microsemi 2729GN-500, offering 12 dB gain, 500W of pulsed RF output power at 100µs pulse width, and 10% duty factor across the 2700 to 2900 MHz band.

In addition to significant funding from DARPA, GaN development is now occurring globally. Europe-based supplier UMS has introduced a family of high-performance GaN HEMTs with up to 50W Psat CW and up to 6 GHz frequency coverage from their wafer foundry in France. UMS has also recently released a 0.25µ GaN HEMT foundry process to support industry development of new GaN components.

Besides pulse power, GaN is finding use within CW applications, such as commercial and military communications. The inherent broadband and high gain features of GaN lend themselves well for fixed mobile markets. The ability of GaN to maintain gain and stability at lower DC voltages is especially suited for mobile and portable communications, such as, military manpack and land mobile radio handsets.

Nitronex has been a leader in GaN manufacturing with their unique GaN on Si process that allows for higher volume manufacturing using a lower cost substrate. Their 28V, 5W NPTB00004 and NPTB00025 RF power transistors are increasingly popular for military communication applications.

Linearization techniques, as they relate to envelope tracking and digital pre-distortion (DPD) systems, also impact GaN power amplification applications. For example, Scintera's SC1894 is a 3rd generation RF PA linearizer (RFPAL) that provides improved correction and a wider operating frequency over previous generations. It also offers advanced features including temperature-compensated gate biasing, dual RF power measurement, temperature sensor, and quad-ADCs/quad-DACs that, for example, can be used to measure the output of an RF reverse power detector or the drain current of the final stage PA.

And GaN is branching out to encompass more than power amplification. For example, TriQuint Semiconductor's new GaN-based switches are capable of achieving up to five-times the power handling as GaAs.

GaN switches achieve high levels of power handling in a small form factor, particularly versus insertion loss. For example, a 3 Watt GaAs switch at 6 GHz may have about 2 dB insertion loss, whereas a 40 Watt GaN switch at 6 GHz may have less than 1 dB insertion loss for the same amount of isolation. Additionally, GaN switches require very low current — measured in microamps (µA) as opposed to milliamps or even amps for pin switches. And because GaN essentially brings more power per mm^2 to the table, small but higher power-handling components are needed to switch that level of power. TriQuint's TGS2351-SM, for example, can switch 40W, as compared to GaAs FET-based switches which can typically switch between 3 and 10 Watts in a similar board space.

Applications include radar, EW and communications — all of which require the output power versus size advantage that is only available through GaN. There is also plenty of GaN development in the works for commercial markets like weather and marine radar, CATV, and cellular infrastructure. For these applications, cost is a bigger driver than it is for defense applications; but as the cost of GaN is coming down, it is certainly more of an option today than it was just two years ago. Even today, GaN offers cost benefits over other technologies when viewed in terms of dollars-per-watt, as opposed to the standard dollars-per-square-millimeter comparison. As the frequency increases from S-band and X-band to Ku-band, GaN's dollars-per-watt cost offers a markedly better value than GaAs and other existing technologies, both now and in the years ahead.