Powering change

GaN transistors are set to enable new high power applications. By **Graham Pitcher**.

RF and microwave applications are becoming increasingly important as the world becomes more reliant upon wireless communications. But supporting the mobile phone network is just one aspect of the technology; radar is another burgeoning application. Enabling all these applications is the seemingly humble rf transistor.

Jeff Shealy is vice president and general manager of RF Micro Device's (RFMD) Defense and Power business. He said: "At a high level, the applications range from commercial to defence, with commercial applications focusing on infrastructure. Depending on which market report you read, it's a $1billion market, with 40% of devices purchased for communications basestations."

But there are other applications for rf transistors. "Industrial and emerging markets also use these parts," Shealy noted. "An example is ballasts used in high lumen lighting applications, such as stage and stadium lighting, and there are medical applications in irradiation."

Radar and wireless communications dominate the applications for high power transistors. Both markets have different drivers, however. While wireless network operators are looking to improve power efficiency, raw power is often more important for radar developers. RFMD believes it can cater for both markets with the launch of a range of rf power transistors manufactured on a gallium nitride (GaN) process. This 0.5μm process supports power densities in excess of 5W/mm and gains in excess of 14 at 2.1GHz.

Shealy said: "What the GaN process enables is devices to run at higher voltages." The GaN process enables bias voltages of 48 or 65V. "The higher the voltage, the higher the output power," Shealy noted, "which means higher voltage is the way to go."

With radar, range is proportional to the square root of power, so being able to apply higher power allows the radar to 'see' further. "Current arrays are large," Shealy noted, "and can have up to 1000 elements, each of which needs to be driven." So higher power and more efficiency makes sense.

Higher power electronics can also allow the antennas for multiple radar systems to be consolidated, said Shealy. "Ships can be made to be more 'stealth oriented'."

Despite the fact that RFMD has just launched its first GaN based product, the company describes GaN as 'a mature, robust technology with extraordinary reliability'. It says that, compared to GaAs and Si, its GaN process has higher breakdown voltage and power densities and this enables applications not possible with competing technology.

Because GaN transistors have a high power density, this enables smaller devices, in turn reducing capacitance, boosting impedance, broadening bandwidth and reducing cost.

"If you translate this back to the mobile market," said Shealy, "it allows operators to run at higher voltages for smaller periods during peak loads; power is available."

Military applications are also enhanced. "Electronic warfare is enabled by high impedance devices. Jamming multiple channels with one

HMS Somerset

High power radar can make ships such as HMS Daring more 'stealth oriented'

device is advantageous, particularly when you are trying to counter improvised explosive devices."

A further area of interest for RFMD is military communications and private radio networks. "Basically," Shealy commented, "new radios for these applications are looking at convergence of frequency bands. On the commercial side, emergency response teams can access multiple communications bands from one radio, allowing them to communicate with multiple agencies. On the military side, it allows switching between different bands for security purposes, as well as the establishment of private communications."

According to Shealy, all of these applications can take advantage of higher output power. "Bandwidth is driven by an improvement in impedance and efficiency."

RFMD is the largest III-V manufacturer and currently accounts for 25% of all GaAs wafer starts. The GaN process is colocated with the GaAs lines and, says RFMD, this allows III-V expertise to be applied to GaN production.

"RFMD is a III-V company," Shealy emphasised. "Alongside GaAs products, it had a small amount of business based on an ldmos silicon process. That

supported 28V; this is a migration to 48 or 65V."

The first GaN transistor is the RF3931. "It's the first of a new family," Shealy continued, "which will cover the range from 10 to 120W." The RF3931 is a 48V 30W high power discrete amplifier designed for a range of applications.

It offers high efficiency and flat gain over a broad frequency range in a single amplifier design. The unmatched GaN transistor is packaged in a hermetic, flanged ceramic package, which provides thermal stability. Ease of integration is said to be enabled through the incorporation of optimised matching networks external to the package.

The GaN process supports a breakdown voltage of 300V. "So we're not limited by how high we can run the bias," Shealy added. "In fact, we're more limited by packaging technology. We have voltage to spare and, as we work to improve packaging and heat sinking, we will see higher output power. We can push the technology further before we reach the thermal limit."

He contrasted the application with GaN leds. "These have been available for some time," he noted. "But with high voltage technology, everything has to be right. If you have defects or the device isn't designed correctly, you can have excessive leakage and parasitics begin to impact the device's ability to be effective. Our focus has been on optimising GaN for high voltage."

In fact, GaN has been available to RFMD since 2001, when it acquired some R&D technology. "But RFMD is a conservative company," Shealy admitted, "and we don't rush technology to production when it's not ready."

Shealy said it is useful to think of the RF3931 and its counterparts as building blocks. "We can scale this part to achieve higher output power," he said, "but they can also be operated in pulse mode. In that mode, you can get double the output power. If you put two 120W devices in the same package and combine them effectively in pulse mode, you can get 500W. This enables higher power, higher efficiency solutions in smaller packages."

Meanwhile, RFMD has received its first order from a tier one wireless base station oem for a GaN based product. The order, for the RFG1M09180 180W broadband power transistor, will support the global expansion of 4G wireless networks.

Concluding, Shealy said the GaN process is 'revolutionary'. "If silicon can 'play', it will, but we're enabling new applications for high power equipment which couldn't be achieved before."

£1.34million funding for diamond based high power rf transistor development

The Microwave Power using Diamond project, or MPower-D, has received £1.34million from the Technology Strategy Board as part of a £3m effort to develop diamond based high power, high temperature microwave transistors. The partners are looking to develop a demonstrator microwave pulsed power amplifer capable of producing in excess of 100W

The project will use deposit thin layers of diamond using chemical vapour deposition technology. Diamond so created is expected to offer unusual properties, including high breakdown voltage and high temperature operation.

According to Diamond Microwave Devices, one of the project's partners, devices produced using the technology could have the potential to provide superior microwave power and higher operating temperatures than existing semiconductor devices and technologies.