

Power for change

How gallium nitride technology might revolutionise embedded power device design. By Graham Pitcher.

The market for power devices for use in embedded systems is tough. There are many competitors and a host of different requirements. But ask any specifier or any supplier and you're likely to find one common theme: cost.

Tim McDonald is vice president, emerging technologies, for International Rectifier. He said: "It's all about cost. There are a lot of high performance power devices, but their cost per feature ratio is broadly comparable with silicon." That may not strike you as a problem, but McDonald sees it differently. "New devices have to have a better cost/feature ratio, otherwise customers won't look at them."

McDonald has a close interest in this aspect of the market because IR has recently unveiled what it believes will be a breakthrough power technology. And McDonald said IR's development of GaN based power devices is the 'most substantial effort' in the industry in the last 20 years. "There's a lot of work been

done on GaN as an alternative power semiconductor technology. We've focused on commercialisation of the technology, not just hitting figures of merit," he explained.

One of the reasons why IR has chosen to pursue GaN on silicon is because of the available infrastructure. "The power market consumes about 10million 6in wafer equivalents a year. If you're looking to replace 10% of that with, say, silicon carbide or sapphire based technologies, that's 1m wafers a year and the infrastructure can't support that."

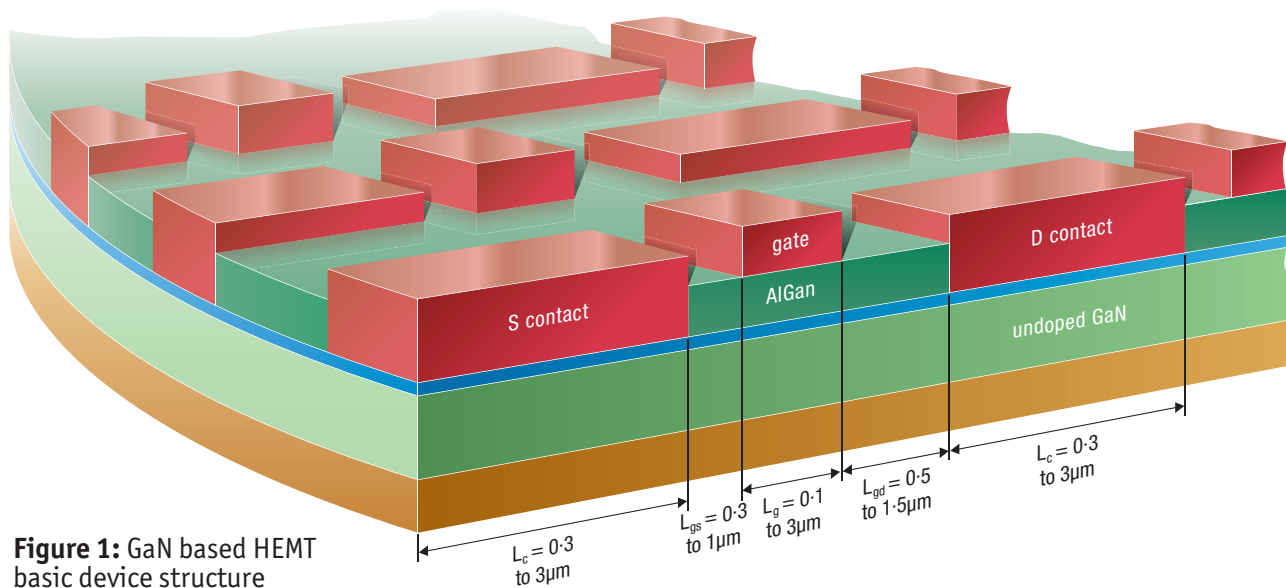
By choosing GaN on silicon, IR can meet its cost targets by accessing a well established process. But that's not to say there aren't problems. "It's a cmos compatible process," McDonald explained, "but the challenges are bigger than they sound. In particular, we have to solve materials problems."

IR's gallium nitride based power device technology platform provides customers

with improvements in key application specific figures of merit (FOM). According to the company, FOMs can be improved by up to a factor of ten compared to silicon based technology. This, it contends, will increase performance and cut energy consumption in a variety of end applications, ranging from computing and communications, automotive and appliances.

"This technology platform and IP portfolio extends IR's leadership in power semiconductor devices and heralds a new era for power conversion," said IR's president and chief executive officer Oleg Khaykin. "We fully anticipate the potential impact of this new device technology platform on the power conversion market to be at least as large as the introduction of the power HEXFET by IR some 30 years ago," he added.

The GaN based technology platform is likely to support developments in power conversion solutions.





McDonald continued: "If you look at FOMs, lower is better. For example, the power mosfet enabled the switch mode power supply. Before that, with bipolar technology, the power supply would have been as big as a computer."

However, McDonald noted that recent progress has been slowed by approaching physical limits. "But GaN has a lot ahead of it and I believe it will have the same significance as the power mosfet did in the 1970s. It will bring higher density levels and better power efficiency."

One instance of where McDonald believes the approach will bring benefits is in power conversion. "With power conversion," he noted, "if you design for high efficiency, there's a trade off against higher cost and lower density. GaN will bring a better trade off."

Similarly, McDonald believes GaN will allow the development of new topologies. "The technology will be used at first to 'drop in' to existing sockets. However, it will also offer the opportunity to go back to square one and design from the ground up."

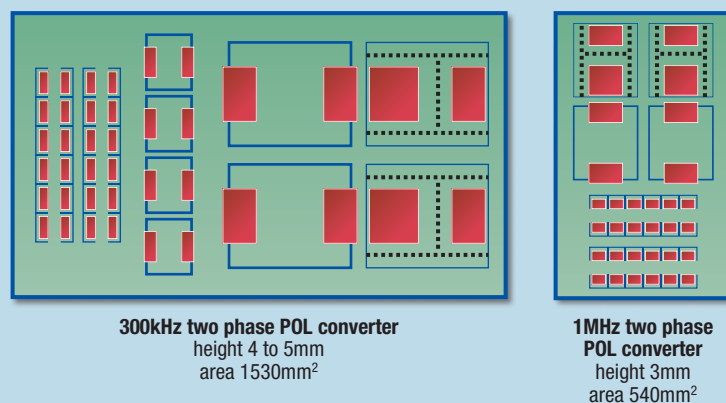
The potential of GaN can be appreciated if you consider the relationship between specific on resistance and breakdown voltage. McDonald explained: "Breakdown voltage is a critical property and, at a given breakdown voltage, GaN has a lower specific on resistance. That makes it a preferred material."

According to McDonald, other materials may offer similar levels of performance. "SiC has a way to go before it reaches the theoretical limit and we believe it has a place in the market, including higher voltage applications."

But he believes that GaN will perform much better at lower voltages, offering a significant improvement over silicon. "GaN will be commercialisable over voltages ranging from 20 to 1200V," he contended.

So how does GaN work? "The magic happens at the interface between GaN and AlGaIn," he claimed. "Strain differences between the two materials bring the piezo effect into play and this creates a high concentration of electrons in a confined space. This brings high conductivity, which forms a channel." This approach

Figure 2: Increasing frequency reduces footprint



(see figure 1) does not require the body diode needed in a purely silicon process and offers what McDonald calls 'true bidirectionality'.

One particular application where McDonald expects GaN to outperform other approaches is voltage regulation. "There are two issues here; battery life and form factor. When it comes to voltage regulation, you want to operate at low frequencies for high efficiency, but that means a bigger footprint. A typical solution occupies 1530mm², which can be decreased by increasing the frequency to

increasing operating frequency by a factor of five," McDonald asserted. "And, beyond that increase in efficiency, the technology will also allow voltage regulators to be coupled with the load to reduce parasitics while increasing operating frequency dramatically." In his opinion, it will be possible for 12V in, 1.2V out, 100A power stages running at 60MHz to be produced in the next five years.

McDonald contrasted GaN technology with the IRF6641, an existing IR product. This 200V single channel power mosfet has an R_{ds on} of 51mohm at 10V.

"I believe it will have the same significance as the power mosfet did in the 1970s." **Tim McDonald**, International Rectifier

1MHz (see figure 2). However, this decreases efficiency and battery life. GaN lets you shrink the size of the solution by a factor of three with the same efficiency."

Another FOM which McDonald believes to be important is $R_{on} \times Q_g$, the product of the on resistance and gate charge. Using 30V fets as a comparison, McDonald noted next generation silicon products would offer an FOM of around 45. "GaN will offer an FOM of 30 this year and is likely to offer a factor of ten improvement in the next five years."

But it's solution size where GaN is likely to have the biggest impact. "GaN will halve the solution size whilst

"With GaN technology, the R_{ds on} figure will be 15mohm. The benefit will be a smaller switch or a smaller chip."

One of the first applications for GaN will be dc/dc synchronous buck converters, said McDonald. But he also expects it will be used for general purpose point of load dc/dc converters.

"It will be used in performance sensitive markets where efficiency is king," McDonald concluded. The first production devices from IR will be aimed at 30V applications and should appear this year. These will be followed by 200V parts in 2010 and 600V devices in 2011.

