# Efficiency drive

Gallium nitride based devices are set to bring a substantial boost to power efficiency. By **Graham Pitcher**.

*EPC's 200V, 25milliohm GaN transistor in bare die format. The device, which is encapsulated and requires no further packaging, can be mounted directly on to a heatsink*

Gallium nitride has long been known to have useful properties when it comes to electronic components. Even so, its application has largely been confined to more exotic areas of the industry, particularly rf transistors.

But GaN is beginning to find application in what could be considered the mainstream, with some of its proponents suggesting its arrival could mark the beginning of the end for the traditional power mosfet.

One of the first companies to bring GaN technology to the embedded power market was International Rectifier (IR), which launched the GaNpowIR platform. But IR is not alone in exploring the application of GaN in the mainstream; a number of companies are now targeting the opportunities, including Efficient Power Conversion (EPC), whose chief executive Alex Lidow held the same role with IR.

Lidow, an unabashed GaN enthusiast, sees the technology offering a 'huge benefit' over silicon. But he realises that, to start the ball rolling, the industry needs to make a 'leap of faith'. "Since we launched EPC, we have won 350 customers," he said. "But we've also seen third parties – Texas Instruments, for example – introducing parts which work with our devices. There is always scepticism of new technology, but we are working with bigger companies as time goes on."

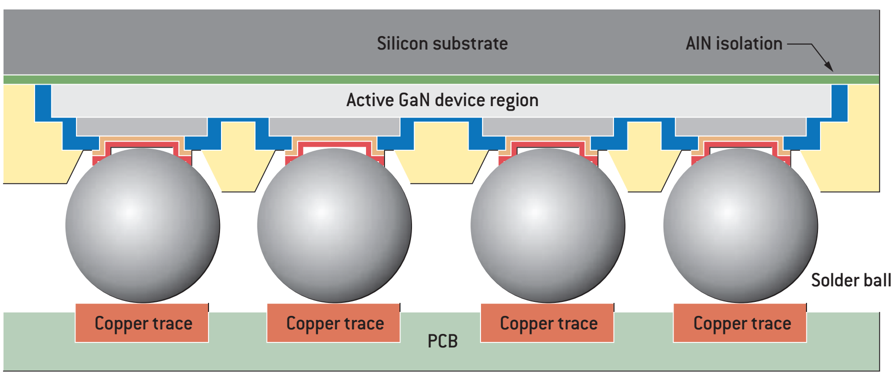
But why should designers consider using GaN based parts? "It's fundamentally superior to silicon," Lidow asserted. "This is because of two very important properties. Firstly, it's critical electric field is 10 times more than that of silicon; terminals can be closer together and this means smaller devices. Secondly, electron mobility is much better than in silicon because different physics is involved."

In silicon, said Lidow, electrons hop from crystal to crystal. "In GaN, electrons are confined in a 2d gas defined by quantum mechanics. There is one probability function which allows them to move easily along the surface at high velocity. When you put these two things together, GaN should be 10,000 times more efficient than silicon."

For the moment, GaN devices aren't showing that level of improvement; EPC's first generation parts showed a five to tenfold boost, according to Lidow. Why has the theory not translated into practice? "When power mosfets were introduced in 1978," Lidow pointed out, "they were 2.5 orders of magnitude away from their theoretical performance. It took time to work out how to squeeze the performance out. It's the same for GaN, but we'll get there."

One of the attractions of GaN, in Lidow's view, is that power mosfet technology is essentially

**Fig 1: GaN on silicon devices can be packaged using flip chip technology**



mature. "Since the turn of the Millennium," he continued, "there have only been incremental, expensive improvements. Why use power mosfets when you can get at least five times better performance 'out of the box' with GaN?"

From his previous experience with power mosfets, Lidow says there are four barriers which stand in the way of the mainstream adoption of GaN technology: will it enable new applications?; is it easy to use?; is it cost effective?; and is it reliable? "As you begin to satisfy these questions," he said, "you gain more customers."

*The EPC9005 development board features two 40V EPC2014 GaN fets in a half bridge configuration with gate drivers*

**Positive factors**

- *New applications*

Lidow believes there are a number of emerging applications which will suit GaN. "In the next few years, we'll see a range of companies introducing products that will transmit power wirelessly over distances of up to 0.5m with good efficiency. In the next 10 years, domestic power sockets will begin to become obsolete. But these applications require high frequency, high power and high voltage abilities, all of which point to GaN."

Another application which requires a similar set of abilities is rf envelope tracking. Lidow said: "GaN will improve the efficiency of rf transmission by up to 40% and, as time goes by, the technology will end up in mobile phones."

And there are also good prospects for using GaN in radiation hard applications. "We've demonstrated that GaN is more than 10 times better than silicon in terms of radiation tolerance and that will open applications in satellites and similar designs," Lidow continued.

- *Ease of use*

In Lidow's opinion, GaN is 'pretty easy to use because it's high frequency'. "Traditional power designers don't know what to do with devices that run at MHz rates; there's a skill set missing. But with the introduction by companies such as TI of driver ics, that problem is largely gone. And the more people use GaN chips, the better it will get."

- *Cost effectiveness*

Because GaN is a relatively new technology, it is still relatively expensive. "But where efficiency is involved, it's valid enough that people can't afford not to use it," Lidow claimed. "There are a number of applications where GaN brings a substantial improvement in efficiency, including power over Ethernet and server power supplies."

- *Reliability*

Because GaN is still in its early days, reliability remains an issue. "We're tracking cumulative hours," Lidow explained, "and working out reliability figures from that. But we've generated five reliability reports which point to GaN having a reliability of millions of hours."

**Manufacturing challenges**

Because GaN is still a developing technology, it's in the early stages of commercialisation. "We do have cost challenges," Lidow admitted, "but we are focused on developing the technology. We're looking at how to grow less expensive epitaxial GaN and working with equipment manufacturers to come up with next generation reactors. Once we get that done, GaN will be cheaper than today's mosfets." Nevertheless, EPC's GaN devices have been designed for manufacture on standard silicon foundry processes.

EPC's technology is based on epitaxial GaN, grown on a standard silicon substrate. "It's not complicated," he continued, "but we're making it on machines designed to make leds. So we do need next generation machines."

He said the manufacturing process is simpler than that for silicon; 'it needs only half the steps'. "A further advantage is that, because GaN is grown on silicon, we can encapsulate it with a layer of glass and that's a packaged product once it's separated."

Lidow sees this as a major advantage. "For power mosfets, the package comprises half of the product cost; and we've got rid of the package. With a package, you have to match resistance, thermal issues and so on. That cost and complication is removed and that's a huge benefit over silicon."

One early decision which EPC took was to develop enhancement mode, rather than the depletion mode, devices. "There are two benefits," Lidow claimed. "One is that all power mosfets use enhancement mode, so GaN devices look like them. And, unlike depletion mode, you don't need to provide a negative voltage in order to hold the power device off."

EPC is well on the way with its road map. "We'll be sampling 600V parts early in 2012," he said, "and this will be followed by third generation products."

Lidow is confident of GaN's potential. Already, market researcher iSuppli predicts the available market will be worth $11billion a year by 2013. "We're going to see explosive growth in demand," he concluded, "and applications will be blossoming on GaN."

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