COMPANY INSIGHT

Raytheon

# Raytheon targets aviation pressure opportunity

*James McGonigal, Executive Responsible for Power and Control Technologies, Raytheon Systems Ltd*

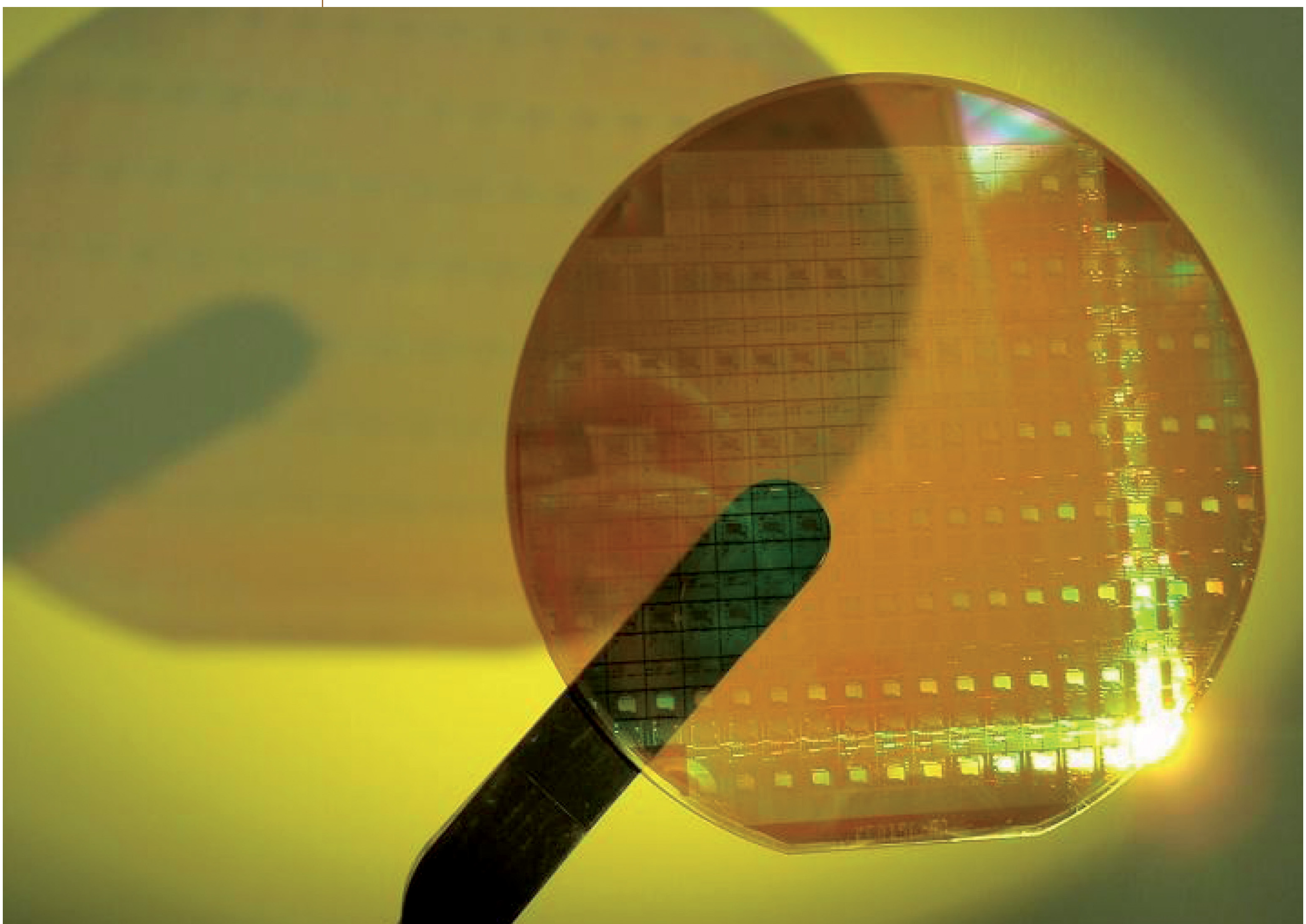
James McGonigal, the executive responsible for power and control technologies at Raytheon Systems Ltd in Glenrothes, Scotland, explains the company's outlook on developing SiC-based power modules for transportation applications.

**Yole Développement: Why is Raytheon interested in SiC and the role it's playing in the future of electric transportation systems?**

**James McGonigal:** We have an ongoing interest in the technology. It originally started in our semiconductor business, but it's moved on to the power electronics side. There, the interest is applying the technology to reduce the size and weight of electrical power systems. Electric transportation includes aircraft, and that's our big focus as opposed to hybrid electric vehicles, the move to more electric commercial aircraft. Despite the recession, traffic numbers are still going up and the fleet's going to double over the next 20 years. There's a lot of pressure on them to make aircraft more efficient. One way to do that is to make them more electric, replace some bleed air and hydraulic systems with electric ones. To do that, they need to be low weight and small size and that's where SiC is very interesting. Also, the distribution voltage in aircraft is going to move to 540 V, so it plays into the hands of SiC.

**YD: Why exactly are SiC devices useful in that circumstance?**

**JM:** One of the main advantages at high voltage with SiC compared to silicon is that you can switch at a much higher frequency compared to silicon at high voltage. At the low voltages you could argue that SiC is not such a great advantage, but certainly at 600 V and above it has big advantages over silicon. By being able to switch



*Making connections: Raytheon's UK foundry, which makes SiC wafers like these for device vendors, helped the company form links it uses to develop wide-bandgap modules (Courtesy of Raytheon Systems Ltd).*

Very high temp operation

High voltage operation

Excellent thermal properties

| Property | Si | GaAs | SiC | GaN |
|---|---|---|---|---|
| Bandgap Energy, Eg (eV) | 1.12 | 1.43 | 3.26 | 3.45 |
| Breakdown Electric Field, $E_B$ (kV/cm) | 300 | 400 | 2200 | 2000 |
| Thermal Conductivity, $\lambda$ (W/cm.K) | 1.5 | 0.46 | 4.9 | 1.3 |
| Electron Mobility, $\mu$ ($cm^2$/V.s) | 1500 | 8500 | 1000 | 1250 |
| Saturated Electron Drift Velocity, $v_{sat}$ ($x10^7$ cm/s) | 1 | 1 | 2 | 2.2 |

High switching frequency

Low reverse recovery

*Fundamental advantage: For aircraft power modules, the size reduction allowed by SiC's high switching frequency at high voltages compared to other semiconductor materials is a key benefit (Courtesy of Raytheon Systems Ltd).*

faster you can reduce the size and weight of the associated passive components in a power system, the capacitors and the magnetics. We've done simulations that show you can reduce the size and weight by up to 80 per cent. That's really the big advantage. Also, the thermal performance of SiC is excellent compared to silicon as well. The fact that the junction temperature can potentially be higher, that makes cooling easier. It's not just switching frequency, although for the areas that we're looking at it is the most important area. In hybrid electric vehicles as well there are definite advantages of moving to SiC. The problem there is that it's a lot more cost sensitive and SiC is still a lot more expensive than equivalent silicon. As far as I can see, it's probably at least 2015 before it would ever go into normal automotive applications.

**YD: What is it about aircraft that is making SiC adoption more preferable in them than in automobiles currently?**

**JM:** A lot of the companies have looked at changing over existing systems into electric using existing technology. I think they feel the size and weight is not acceptable to replace the existing non-electrical systems in aircraft. Wide-bandgap technology is a way to potentially do that. But there are issues going into a market like that as well, where reliability has to be proven. The cost even has to come down to meet their requirements as well, because currently SiC power transistors are very expensive. Obviously, in high power systems, you need to use a lot of them, so there's a cost element there, but you have to balance that against the advantages in size and weight. I think even in aircraft it's still going to be quite a few years before they get implemented. They work to longer timescales anyway. But the demands on cost are not nearly as severe as you find in hybrid electric vehicles.

**YD: Does it look like SiC will be able to meet the aerospace industry's reliability requirements?**

**JM:** For sure. There's no inherent issues with it. It's just an immature technology when it comes to high power switching. Certainly there's reliability data now available for Schottkys implemented in power factor correction systems. There's a lot of good FITS figures and MTBF figures for SiC Schottky diodes, so I think the technology itself is good enough. It's a confidence thing.

**YD: Is there any indication of the kind of devices that are going to be preferred?**

**JM:** We're developing power modules right now to demonstrate and we've chosen one particular type of transistor that we believe will give the highest performance. Other people have looked at other types of transistors. I think what will end up happening is that either one will dominate or that people will use all different types for different reasons.

**YD: You mention the long timescale that aircraft manufacturers plan over. Can you give any detail on the schedule you're expecting for commercial adoption there?**

**JM:** It's similar to the hybrid electric vehicles, for slightly different reasons. You're unlikely to see anything flying before 2014, 2015 I would think, just because of the time to get things qualified. For cars it's mainly a cost thing – although obviously maturity and reliability are important.

**www.raytheon.com**

**James McGonigal, Executive responsible for Power and Control Technologies, Raytheon Systems Ltd**
He has more than twenty years experience in electronic systems and semiconductors, starting his engineering career at Burr Brown Corporation, with subsequent Product Marketing, Sales and Marketing Management, Product Management and Business Unit Management roles at Burr Brown, Motorola, GM Hughes Electronics, Alcatel and now Raytheon in the UK.