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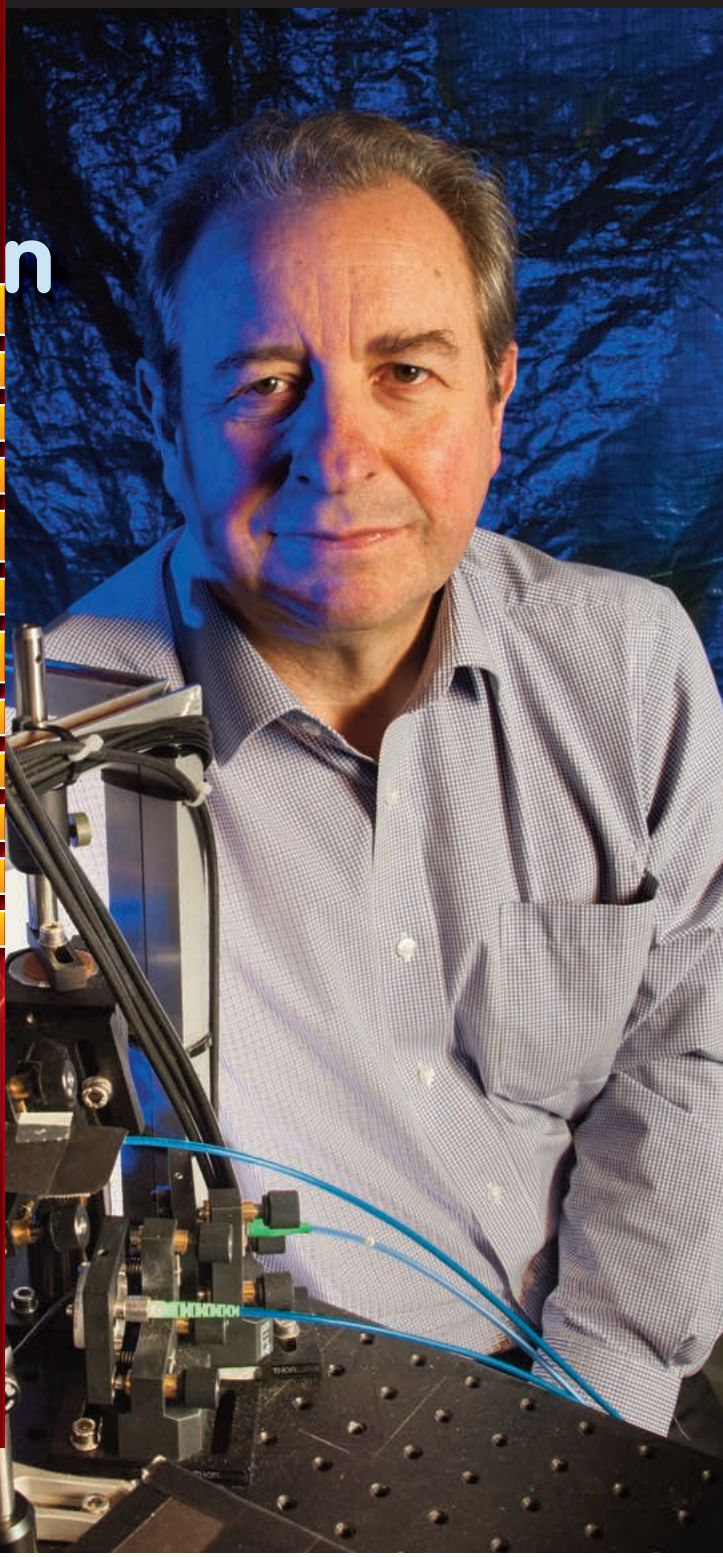

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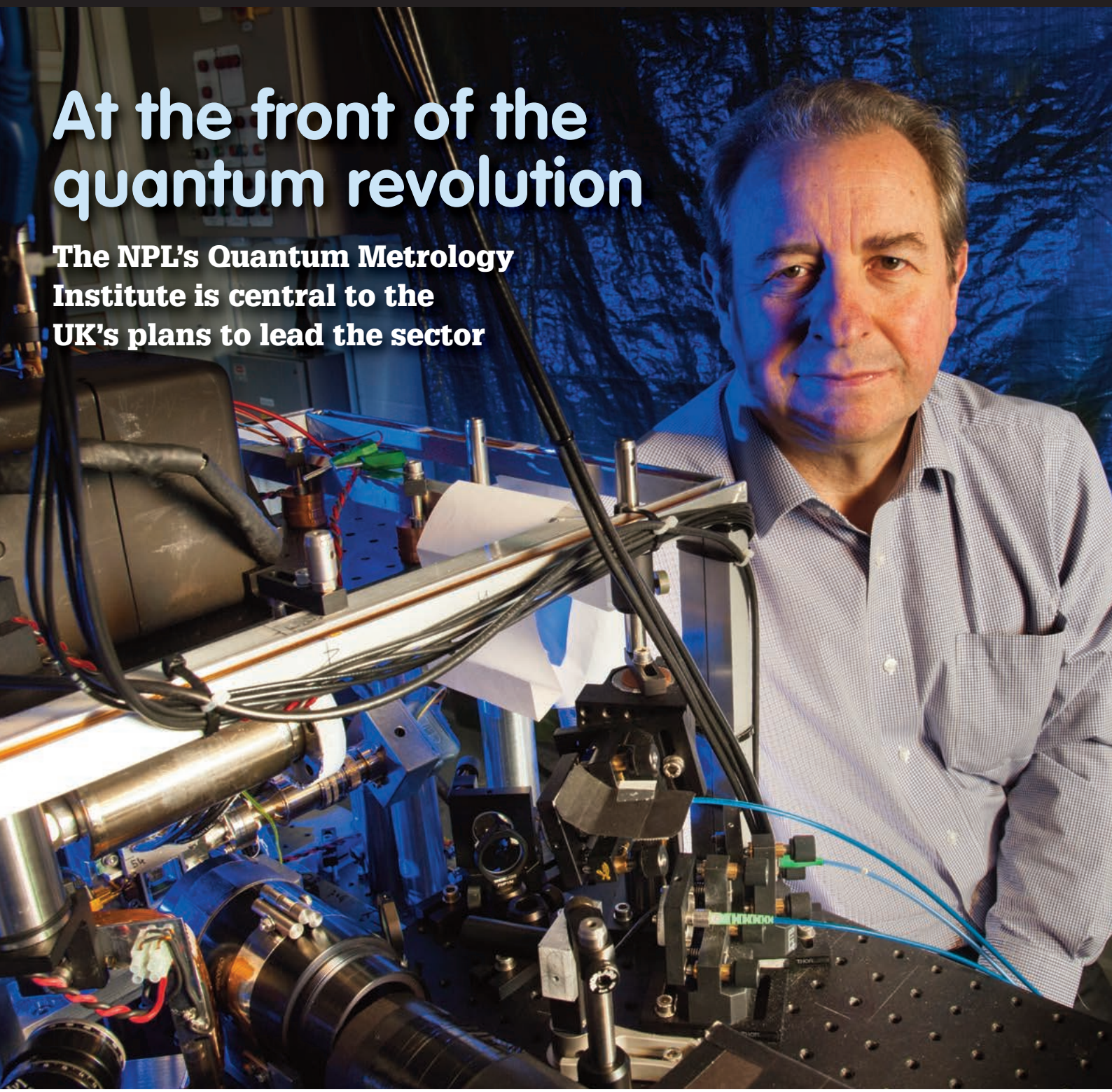

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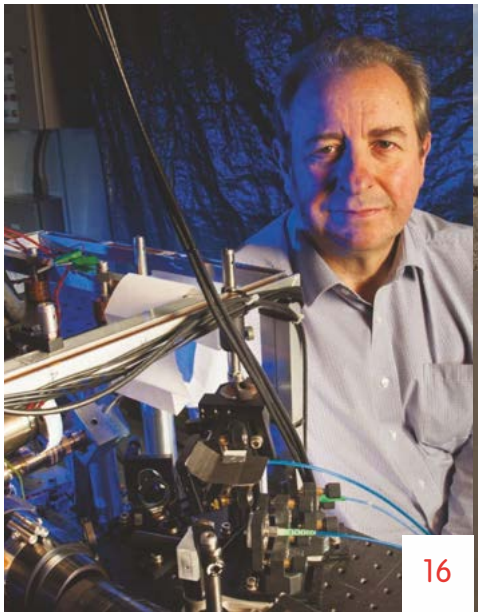
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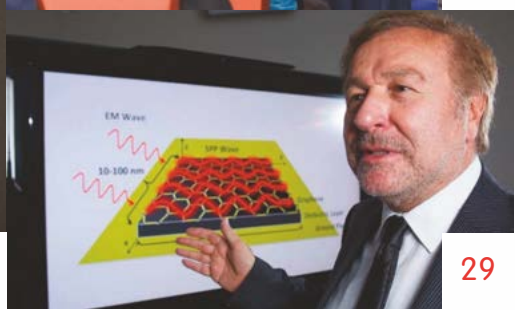

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Too many programmes?

ANOTHER INITIATIVE LAUNCHES TO ADDRESS THE FUTURE OF EUROPEAN ELECTRONICS

When Neelie Kroes – at the time, vice president of the European Commission – challenged Europe's semiconductor industry to double its share of the global semiconductor market to 20% within a decade, there was a degree of foot shuffling from the usual suspects.

Kroes – one of the most dynamic commissioners Europe has seen – was prepared to back action. She launched the so called 10:100:20 plan in May 2013 – €10billion of EC funding, €100bn to be invested by industry, with the result being the 20% market share. Kroes said: "I want us in the driver's seat; the sector wants to be back in the driver's seat. So my message is this: we are going to make Europe the place to make and buy innovative micro and nanoelectronics."

It took some time for the industry to respond, which it did in February 2014 via the 11 strong Electronic Leaders Group. At the time, ELG said it would transform its ideas into concrete action by June 2014 and it met the deadline with an implementation plan. Those ideas, by the way, focused on application areas where Europe was already strong, but also on sectors with potential high growth, such as the IoT and various 'smart' markets.

Last week, a new European body was unveiled, with an impressive list of partners. Set up to support the ELG strategy, PENTA is looking to stimulate up to €1.5billion of investment in electronics components and system R&D over the next five years. Sharp eyed readers will notice that €1.5bn is a bit short of the €100bn investment for which Kroes' plan called.

European initiatives are many and varied; alongside ECSEL – Electronic Components and Systems for European Leadership – there are CATRENE, ENIAC, ITEA3, EURIPIDES2 and EUREKA. Often, it's just as hard to understand how they relate to each other as it is to understand their objectives. In a white paper, PENTA says it will be a flexible and agile programme that identifies opportunities, quickly assesses national governmental support and operates with a short, but effective, approval process. In this way, it says it will enhance the opportunity for rapid competitive exploitation.

In positioning PENTA as 'complementary' to ECSEL, but 'differentiated', is this the ELG's way of saying that existing programmes aren't up to the job?

Graham Pitcher, Group Editor (gpitcher@findlay.co.uk)

UK distribution market set for 'quiet 2016'

The UK distribution market is set for another quiet year in 2016, according to the Electronic Component Supply Network (ECSN). Statistician Aubrey Dunsford said: "The global economy is slowing considerably. People are asking when things will pick up, but nobody has the answer."

In fact, Dunsford and ECSN expect demand to remain 'flat'. "This time last year," Dunsford noted, "the OECD was predicting global GDP would grow by 3.9%, but only India bettered that. This year, the prediction is for a 3.3% growth in GDP and 2.4% for the UK. In real terms, that's flat."

ECSN chairman Adam Fletcher believes it's not a question of 'if' a recovery will come, but 'when' and 'how strong'. "I suspect that, in 2016, we will continue to 'bump along' at the bottom of the recovery cycle, with much stronger consistent growth likely into 2017-2018."

Recovery in UK demand could be spurred by investments in infrastructure and by reshoring. "People have been talking about reshoring for some time, but there is now real evidence of it happening. In the future, companies are going to want systems made closer to home and there will be better times for CEMs in the future," Dunsford noted.

Bare Metal Security for embedded products

In a move designed to enhanced security, UltraSOC has extended its on chip monitoring and analytics capability to embedded products ranging from embedded IoT devices to enterprise systems.

Called Bare Metal Security, the features are implemented as hardware running underneath the operating system and complement traditional approaches. It uses UltraSoC monitors to watch for unexpected behaviour, such as suspicious memory accesses or processor activity, at hardware speed. The on-chip hardware is independent of main system functionality and software, meaning system performance is not impacted. The company notes that it will be very difficult for an attacker to subvert or tamper with the approach.

Powering new markets

EX NXP RF POWER BUSINESS TO TRADE AS AMPLEON. **GRAHAM PITCHER** REPORTS.

The RF power business line disposed of by NXP as a consequence of its acquisition of Freescale has opened its doors as Ampleon. The business was acquired in May 2015 by Chinese company Jianguang Asset Management for $1.8billion in a move which not only avoided competition issues, but which also helped to fund the Freescale purchase.

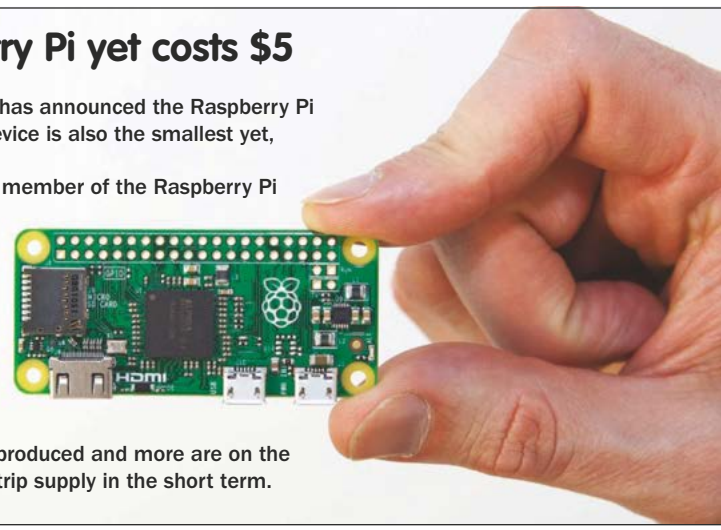
According to CEO Reinier Beltman: "We will be 100% focused on RF power and are very excited to be doing this as Ampleon. We are extremely well positioned to meet the growing market need for power, cost and space efficient RF solutions."

Ampleon will focus on three markets: mobile broadband; multimarket; and RF energy. While mobile broadband currently generates 80% of Ampleon's revenue, demand for RF energy technology is expected to grow quickly in the near future. "We expect the total available market for RF energy products to exceed that of basestations," said Beltman. Market analysts suggests this market could be worth $1.5bn by 2020.

While the RF power business grew its revenues fourfold in its last few years within NXP, many of its customers are outside NXP's new areas of focus. "We have our own technology and products," Beltman continued, "and there is little synergy with the rest of NXP."

Ampleon will take responsibility for the complete range of LDMOS and GaN RF power products previously available from NXP. Some 1250 employees have also transferred to the new company.

Smallest Raspberry Pi yet costs $5



The Raspberry Pi Organisation has announced the Raspberry Pi Zero, which will cost $5. The device is also the smallest yet, measuring 65 x 30 x 5mm.

Described as a fully fledged member of the Raspberry Pi family, the board features a Broadcom BCM2835 application processor, 512Mbyte of LPDDR2 SDRAM, a micro-SD card slot, a mini-HDMI socket and Micro-USB sockets for data and power.

According to Raspberry Pi, while 'several tens of thousands' of units have been produced and more are on the way, it expects demand to outstrip supply in the short term.

Prototype Na-ion battery

French researchers have developed a prototype sodium-ion battery in the 18650 format. The prototypes are said to display performance levels comparable to their lithium counterparts.

According to the team, the batteries have an energy density of 90Wh/kg and the devices are said to withstand more than 2000 charge/discharge cycles with performance being affected.

The researchers are now looking to optimise the technology for future commercialisation.

Nanodots from Q-carbon

Researchers from North Carolina State University have discovered a new phase of solid carbon. Called Q-carbon, it is ferromagnetic, harder than diamond and glows when exposed to even low levels of energy.

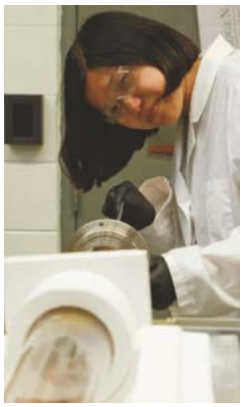
"Q-carbon's strength and low work function make it very promising for developing new electronic display technologies," said Professor Jay Narayan.

According to the team, while it can make Q-carbon films, it is still in the early stages of understanding how to manipulate them.

'White graphene' developed

Researchers at Oak Ridge National Laboratory (ORNL) in the US have created a virtually perfect single layer of 'white graphene', which they say could usher in a new era of electronics.

The material – hexagonal boron nitride – is said to feature better transparency than graphene. It is chemically inert, atomically smooth and features high mechanical strength and thermal conductivity. Because it is an insulator, the researchers believe it will be useful as a substrate and the foundation for the electronics in a range of devices.



With 'white graphene' as a substrate, the researchers believe they can unleash the full potential of graphene, whilst reducing the thickness and increasing the flexibility of electronic devices.

Euro cluster to support ECSEL initiative

PENTA – a new EUREKA cluster – has been launched with the aim of generating up to €1.5billion of investment for research and development in the electronics components and systems industry. According to PENTA, it has already received guarantees for the first €500,000 of funding.

The organisation will support the strategy outlined by the Electronic Leaders Group – set up in 2013 in order to respond to the challenge laid down by Neelie Kroes, then vice president of the European Commission, for Europe to capture 20% of global semiconductor production within a decade. Focused initially on technology underpinning automotive, health and industrial productivity, PENTA says it will also address projects of common interest to industry and public authorities.

Running for five years, PENTA is looking to complement and enhance the collaboration and contribution of the European industrial and technology organisations in the ECSEL Joint Technology Initiative.

Complexity racing ahead

FPGA USER SURVEY HIGHLIGHTS CONTINUING DESIGN CHALLENGES. **GRAHAM PITCHER** REPORTS.

FPGA designers say RTL verification, timing analysis and closure, and hardware debug are the three most challenging tasks they encounter. The finding was part of the results of NMI's latest FPGA Usage Survey, conducted in October.

Doug Amos, director of NMI's FPGA Network, said: "Perhaps the most simple reason for the debug challenge is that design complexity is outstripping the capability of the verification tools used in FPGA projects. This year's survey showed verification was a significant task and accounted for 24% of the time taken. However, the survey also showed that the most modern ASIC like verification techniques were not used widely."

According to Amos, there may be light at the end of the tunnel. "At least one ASIC like technique has started to emerge: assertion based verification." The most popular approaches were in system test, directed test and functional coverage.

A measure of the verification challenge was found by asking those responding to the survey about the non trivial bugs that made it into production. Some were obviously concerned about this issue, but perhaps a more worrying issue was that 11% of respondents admitted to 'more than one' non trivial bug entering production. And 51 respondents saw field upgradability as 'essential' to their design. The most challenging prototyping specific tasks were found to be hardware visibility and debug, implementing externally developed IP and designing and building hardware using the latest FPGAs.

Asked how long their latest FPGA design project took, most answers suggested between 6 and 12 engineer-months; in last year's survey, most projects were taking from 1 to 6 engineer-months.

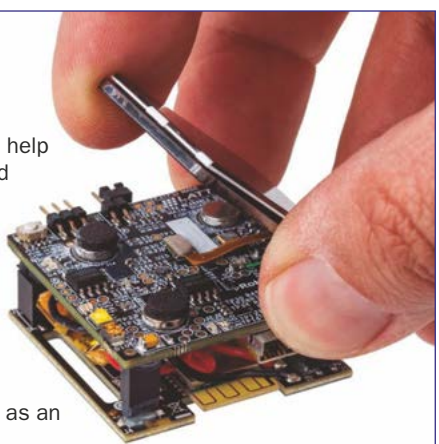
Aerospace and defence remained the most popular application area for FPGAs, followed by industrial, video and image processing and ASIC prototyping. The survey found that 24% of FPGA design projects were targeted at devices with 100k to 500k LUT-FF pairs, but a significant number of designs (22%) were completed for devices offering 10k to 50k LUT-FF pairs. Two projects were using devices with more than 5million LUT-FF pairs. The dominant devices came from Altera's Cyclone and Xilinx' Spartan ranges.

Amos admitted to being 'surprised' at the popularity of ASIC prototyping, given the assumed low number of ASIC starts amongst UK companies. "This is probably explained by the use of FPGAs for prototyping IP and other sub blocks, which are designed here for use in ASIC and SoC projects elsewhere."

The NMI FPGA Usage Survey 2015, supported by New Electronics, Aldec, Altera, FirstEDA, Mentor Graphics, Synopsys and Xilinx, drew responses from 154 users.

• **A panel session at the recent Electronics Design Show discussed whether engineers are using the right programmable platform for their projects. To find out more, go to page 24.**

FPGA based wearables development platform



A development platform from Lattice is intended to help those designing low-power wearable devices. Based on the iCE40 Ultra FPGA, the platform features a large number of sensors and peripherals.

Hardware features and sensors supported by the iCE40 Ultra Wearable Development Platform include a 1.54in display, MEMS microphone, high brightness LED, IR LED, Bluetooth LE module and 32Mbyte of flash memory. The platform also supports sensors capable of measuring heart rate/SpO_2, skin temperature and pressure, as well as an accelerometer and gyroscope. The platform, which measures 1.5 x 1.57 x 0.87in, comes with a wrist strap and a built in battery.

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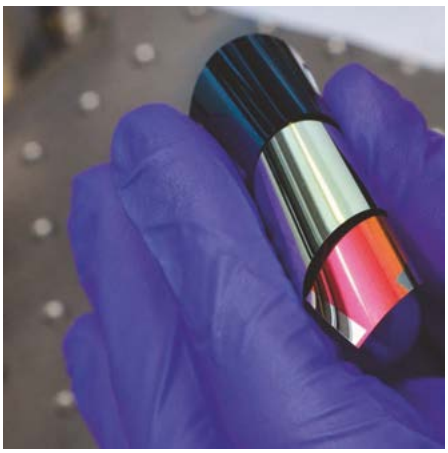
PCMs making a display

PHASE CHANGE MATERIAL COULD SUIT A RANGE OF APPLICATIONS. **TOM AUSTIN-MORGAN** REPORTS.

Oxford University spin out company Bodle Technologies believes phase-changing materials (PCM) could be used in applications ranging from security and anti-counterfeiting, as well as in enabling more energy efficient displays.

The PCM used by Bodle is the same as those used in rewritable CDs and DVDs but, instead of using lasers to change the state of the material from amorphous to crystalline and vice versa, Bodle's technology can be switched using optical, electrical and mechanical probing techniques.



"One thing we were asked by a number of people was whether we could use the technology to save power in mobile devices," said Dr Peiman Hosseini, Bodle's co-founder and chief technology officer. Mobile devices and displays use LCDs or OLEDs to transmit images and require a powerful backlight to be viewed which is highly power intensive. "Our technology doesn't require a backlight as it uses ambient light to reflect an image. It is similar to the way in which a Kindle works except that ours can create very deep, rich colours."

A layer of PCM is sandwiched between two layers of a transparent electrode; these materials appear either transparent or 'metallic-looking'. By placing the layers in a specific order, colourful films can be created by thin-film interference, controlled by a tuneable electric pulse. Changing the optical property of one layer changes the interference conditions that, ultimately, change the colour of the whole stack.

"Unlike a backlit device, which is hard to see in bright sunlight, the images created by our device will look better the more ambient light hits the display," Dr Hosseini claimed. "What's more, the device only draws power when the image moves. For small mobile products it would increase battery life by several times."

The PCM technology could also be used to provide practically unbreakable security in future currencies, ID cards and official documents. "Next generation currency and passports will be made from plastic as it is cheaper to manufacture than paper," Dr Hosseini explained. "We can apply a functional coating of our technology to a credit card or passport and have features that appear or disappear when it is excited by an electrical pulse or even mechanical pressure."

Bodle expects to produce a prototype in each area by the end of 2016 and will focus on the most promising which will then be placed into a pilot programme with its industry partners. Dr Hosseini predicted that a commercial product could be ready in three to four years.

Self healing gel developed for flex circuits

A self healing gel developed by researchers at The University of Texas at Austin is said to repair and connect electronic circuits. The material could find application in flexible electronics, biosensors and batteries.

The UT Austin material is said to exhibit high conductivity and strong mechanical and electrical self-healing properties. Assistant professor Guihua Yu, who developed the gel, said: "In the last decade, the self healing concept has been popularised by people working on different applications, but this is the first time it has been done without external stimuli."

Yu believes the self-healing gel would not replace typical metal conductors, but it could be used as a soft joint. "This gel can be applied at the circuit's junction points because that's often where you see the breakage," he said. "One day, you could glue or paste the gel to these junctions so the circuits could be more robust and harder to break."

Yu's team is also looking into other applications, including energy storage, where it may help batteries to better store electrical charge.

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Security: taking the next steps

HITEX' ARM USER CONFERENCE LOOKED AT COMPLEXITY, SECURITY, THE IOT AND THE NEXT STEPS IN THE EVOLUTION OF THE ARM CORTEX-M RANGE. **NEIL TYLER** REPORTS.

Hitex' ARM User Conference in Warwick is becoming one of the key events in the embedded calendar. The latest, held at the end of November, addressed a range of issues, including complexity in the design process and the new mbed OS for IoT devices.

Ian Johnson, a product manager with ARM, discussed the ARMv8-M architecture, launched last month at TechCon in San Diego. According to Johnson, v8-M brings improvements in the instruction set, the memory protection unit and the security model of Cortex-M processors.

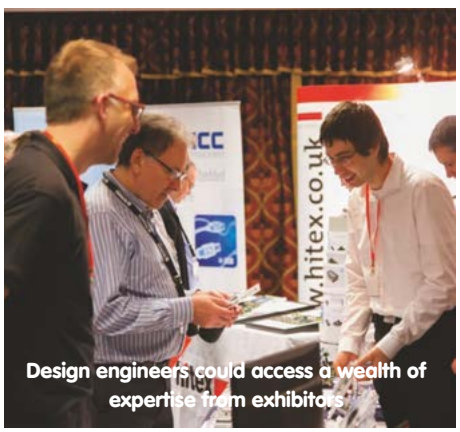
"We are looking to improve productivity and the performance of processors but, more importantly, it's about bringing greater security to the embedded domain," he explained.

"Part of improving device security is the ability to offer greater separation and our new architecture can isolate the resources you trust from those you don't."

Trusted software is software that has been well tested, perhaps certified, and is usually run in conjunction with hardware offering a cryptographic function, Johnson explained.

While it was vital to reduce the attack surface when it came to embedded systems, he warned that while v8-M improves levels of security, 'it should be seen as the foundation for improved levels of security, not a solution'.

Johnson explained that ARM was bringing optional security extensions to embedded processors through its TrustZone Technology and would be enabling the containerisation of software and the simplification of security assessments of embedded devices.



Design engineers could access a wealth of expertise from exhibitors

Security was discussed at length during the event. Haydn Povey, CEO and founder of Secure.Thingz, said the IoT had been described by the UK's intelligence services as a 'slow motion train wreck'.

He warned that robust security would be possible only if it encompassed the full lifecycle of devices and systems, especially when it came to multivendor devices and those which are managed remotely.

According to Povey, while designers would endeavour to deliver secure applications, they were not infallible. "You have to make the presumption that all systems will be compromised; systems must be designed for recovery, update and remediation."

In a wide ranging presentation, Povey pointed to numerous hacks that had had an impact on the real world – from personal identity theft to the failure of industrial systems. "The worry is that if you can't trust your data, the idea of big data and the benefits derived from it will be compromised. ARM's v8-M architecture and approaches like it are a start in providing the security we need. But a lot more needs to be done."

In his keynote address opening the conference, Hobson Bullman, general manager of ARM's development solutions group, talked about trends in software development tools and how to best deal with growing design complexity.

"Using the right tools is crucial," he said and warned that 'complexity was affecting all embedded systems'.

He said that, in future, engineers would have to be able to address the need for enhanced security, embrace higher level languages and be prepared to work with more standardised IoT platforms.

"When we talk about embedded security, that will include encryption, the virtualisation of secure software, reducing the attack surface and providing secure debug – not opening your systems to attack will be crucial."

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Preparing future defence technologies

Neil Stansfield, head of Knowledge, Innovation and Futures Enterprise at Dstl, talks to **Neil Tyler** about how UK science is helping to drive forward future defence technologies

Formed in 2001, the Defence Science and Technology Laboratory (Dstl) ensures that innovative science and technology can contribute to the defence and security of the UK. It supplies specialist services to the Ministry of Defence (MOD) and other government departments and, through its Centre for Defence Enterprise, funds innovative research that could have a potential defence application.

A technology transfer arm, Ploughshare Innovations, also ensures that IP generated by Dstl in the course of its work is exploited, through commercial licensing or the creation of spin out companies.

Able to trace its origins back to 1664 with the establishment of the Royal Carriage Works in Woolwich, Dstl is one of the principal government organisations focused on delivering science and technology to the UK's defence and security operations.

Neil Stansfield, head of Knowledge, Innovation and Futures Enterprise at Dstl suggested: "The importance of science can't be underestimated, but it is often misunderstood. My role at Dstl is to assess how well placed the UK is on the global stage to address future technical and systemic challenges and it is vital that we put science and technology squarely at the front of our nation's capabilities." Although we spoke before the events in Paris, he warned that: "We drive collaboration with scientists from across the UK to harness the technology we need to keep us ahead of the 'bad boys'."

Since the 1950s, three technology offsets have driven innovation among key Western countries, such as the US and UK.

"The first came with the rise of the Warsaw Pact," said Stansfield. "Its superior numbers meant we had to use technology to offset its threat. In 1972, in the face of nuclear equilibrium with the Soviet Union, a second offset gave rise to GPS, stealth technology and, arguably, the development of the Internet. These technologies gave us that little bit of 'magic' with which to confront a more powerful opponent."

The third and latest offset strategy highlights investments in new space capabilities, advanced sensors, communications and munitions, missile systems and cyber capabilities, as well as in such technologies as unmanned undersea vehicles, advanced sea mines, high speed strike weapons, advanced aeronautics, electromagnetic rail guns and high energy lasers.

"The big difference today is that many of the advances we are seeing are being driven by the commercial sector, rather than the state's military laboratories – as was the case in the 1960s and 1970s," Stansfield explained.

"Robotics, autonomous operating guidance and control systems, visualisation, biotechnology, miniaturisation, advanced computing and big data, and additive manufacturing like 3D printing – all these technologies are being driven by the commercial sector."

Collaboration with the commercial sector is therefore vital, according to Stansfield, because defence research and development no longer dominates the UK R&D landscape as it did 40 years ago.

"We still account for a sizeable spend," he explains. "But, compared to the 1960s, defence accounts for a tiny share of total government spending."

Part of the MOD, Dstl employs 3500 people across three sites, soon to be two. "With an annual budget in excess of £600million, our role is to maximise the impact of science and technology to the benefit of the UK's defence and security needs. Work on chemical and bio-defence weapons and counter terrorism is retained in-house, but the rest involves engagement with others. Dstl only undertakes work in-house for reasons of national security or political sensitivity," he explained.

NEIL STANSFIELD

Neil Stansfield is head of the Knowledge, Innovations and Futures Enterprise at the Defence Science and Technology Laboratory. He leads the MOD's programme for identifying and harnessing emerging and disruptive technologies.

He has spent 25 years in a range of senior defence and security policy, strategy, and science and technology roles, working across government and the private sector, nationally and internationally.

"I would contend that we have been on a war footing since 1996 and that has had a serious impact on long-term planning as most of our resources – which aren't finite – have been used to address operational requirements. It's meant dealing with 'low' tech threats, such as landmines, by developing and deploying high tech solutions.

"We've been using up our high tech, turning it into kit, but there has been little restocking of the cupboard, if I can use that analogy."

As a result, Dstl has taken the decision to allocate 20% of its budget to developing future disruptive technologies.

"The technologies we've identified won't be ready for five, 10 or 20 years, but we have to take a long term strategic approach."

There are five so called 'Horizon Technologies', explained Stansfield. "Quantum technology, Big Data, robotics or fully autonomous systems, synthetic biology and advanced manufacturing."

Dstl is, for example, funding research into quantum technology, which could have the potential to transform timing, navigation and sensing significantly.

While the research is cutting edge, it can involve techniques that could be of concern to the wider public. For example, Stansfield talked about the development of boron carbide, a ceramic material using a process involving e-coli.

"The technique we use to produce this ultra-tough armour is conducted in a fully contained environment, but I accept we need to re-assure the public that our work is responsible and conducted in a safe way. Part of my role is, therefore, to communicate the role of military research.

"It is critical that the UK builds a research and science environment that attracts and retains the best," he said.

"I believe that, with the development of InnovateUK and the network of Catapults, the UK is putting in place the infrastructure necessary to support innovation in the UK."

Stansfield also believes that the defence industry in the UK is well placed to exploit these new technologies. "However, these are technologies that will not only revolutionise the military but will also have a massive impact on the wider economy," he concluded.

Harnessing quantum

Launched last month, the Quantum Metrology Institute forms an essential building block in the UK's efforts

November saw the opening of the Quantum Metrology Institute (QMI). Based at the National Physics Laboratory (NPL) in Teddington, it forms a key element in the UK's efforts to exploit quantum technology commercially through the National Quantum Technologies programme.

Quantum theory first appeared in the early part of the 20th Century and was used to explain how light and matter behave at a fundamental level. Today, a new generation of quantum technologies has been created through engineering and exploitation of naturally occurring quantum effects.

The science community believes the UK is well placed to emerge as a global leader in what is being described as a 'quantum revolution' and those behind the launch of the QMI believe it will help to accelerate the development of the UK's burgeoning quantum technology industry.

"Collaboration is at the heart of what we do here at the NPL," explained Dr Rhys Lewis, director of the QMI, speaking at the launch of the Institute. "When the NPL was established at the turn of the 20th Century, its purpose was to apply scientific research in a practical way to every day industry and commercial life. That was the case back in 1902 and it certainly remains the case with quantum technology in 2015. Our aim, with the launch of the QMI, is to build links between the science community and industry in order to drive economic growth and job creation in the UK."

The NPL currently employs more than 500 scientists in many disciplines, along with more 200 guest workers and students from around the world. Owned by the UK Government, it works in partnership with the Universities of Surrey and Strathclyde and is a centre of collaborative scientific research in the UK. More than 100 scientists will be working for the QMI, focusing on quantum technologies in a number of new laboratories.

The QMI, funded through a £4million investment from the UK National Quantum Technologies programme, is intended to house the UK's primary capability to test and validate new designs, prototypes and products based on quantum technology.

"We have a 10 year vision, but only five year's money". Sir Peter Knight

Developers, investors and end users will be able to access the facility's extensive resources and, at its launch, the QMI was described as being the 'go to' place for quantum technology commercialisation.

"We want to be able to attract the very best scientific talent and ensure sustained inward investment," said Dr Lewis.

"The UK has long been recognised as a leader in quantum research and we now have the chance to build a solid and successful industrial base around fundamental science and engineering excellence. We want to inspire a generation of new quantum technologists from UK schools and universities," explained Sir Peter Knight, QMI chair.

Disruptive technology

Quantum science has the potential to generate the kind of disruption caused by quantum mechanics in the last Century, which led to the development of semiconductors, microprocessors, lasers, nuclear energy, thermal imagers and the like.

"We refer to that as Quantum 1.0," said Dr Lewis. "What the QMI heralds is Quantum 2.0."

In 2013, the UK government allocated £270million towards the development of a range of quantum technologies in what was seen as one of the biggest single investments ever made in a disruptive technology.

Sir Peter played a pivotal role in securing this support, cajoling and encouraging various players to work together and to present their ideas to Government.

"We talked with interested parties before meeting government," he explained. "There was a lot of goodwill across all parties, who are determined to ensure that this works. Our aim remains to create a fully functioning quantum ecosystem that is capable of bringing UK manufacturing and our scientific expertise together, with a view to creating an industry capable of delivering clear benefits to the UK economy."

While the UK is well placed, it is not alone when it comes to investing in quantum technologies. Since 2010, a growing number of countries have started to invest money and resources. China, Korea and the Netherlands have all pledged support and, while the UK government is investing significant sums, it only covers the next five years.

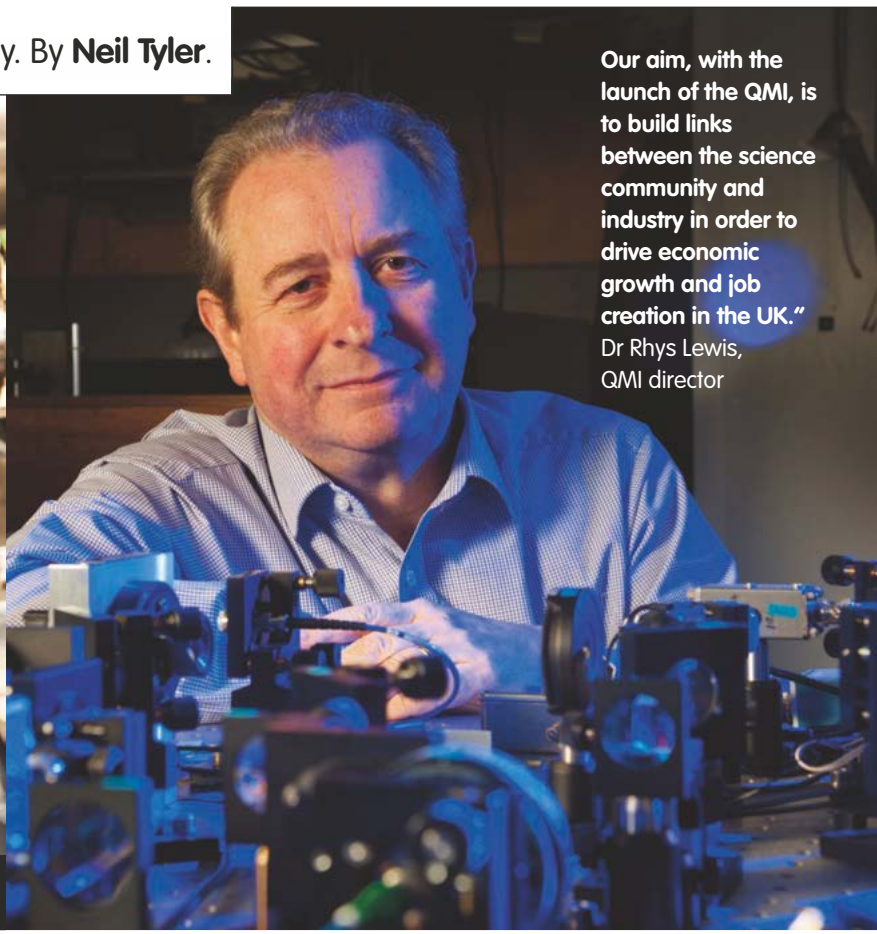
"We have a 10 year vision, but only five year's money," said Sir Peter, speaking before the Chancellor's Autumn Statement. "We need to move into the development phase of R&D."

The UK's funding was divided between the Engineering and Physical Sciences Research Council (EPRSC), InnovateUK and the NPL, with the bulk of

technology for UK plc

to become a global leader in quantum technology. By **Neil Tyler**.

Miniature ion clocks and microtraps: Trapped ions can be probed to provide microwave or optical clock signals



Our aim, with the launch of the QMI, is to build links between the science community and industry in order to drive economic growth and job creation in the UK." Dr Rhys Lewis, QMI director

Cover photo: Charlie Milligan

the funding going to the EPRSC to fund a network of quantum technology research hubs, which is now up and running.

The hubs are led by Birmingham University (sensors and metrology), Glasgow University (quantum enhanced imaging), York University (quantum secure communications) and Oxford University (networked quantum information systems).

Five key quantum areas have been identified: secure communications; metrology; sensing; simulation; and quantum computing. All are seen as vital to the creation of a dynamic and successful industry in the UK that will require a range of innovative engineering and manufacturing techniques to fully exploit them.

Quantum clocks, which use laser cooled atoms, are expected to a have a significant role working alongside existing technologies to improve vulnerabilities currently associated with GPS based timing systems.

"There is a need for increased accuracy, especially in financial services," Sir Peter explained. "Today, in the City of London and on Wall Street, complex algorithms perform trades worth billions of pounds, requiring high precision time stamps, which can only be addressed through quantum technology."

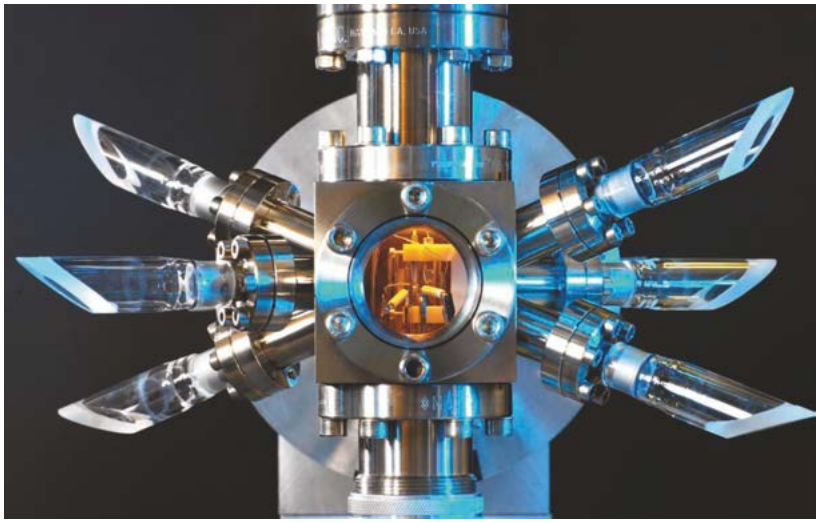
Likewise, the increasing volume of data and the threat to that data posed by hackers means that improved data communications and security are needed.

"Using quantum technology, it will be possible to ensure that data is not tampered with," Sir Peter asserted.

Importance of collaboration

"In order that we benefit from these new technologies, collaboration is crucial and the UK is lucky that, when it comes to quantum technology, it has a very well connected community," he continued. "It has certainly benefited our efforts to create a national organisation, especially at a time of austerity when resources remain limited. We have a network of universities, laboratories and industrial partners that are working together to deliver an integrated, national programme to exploit the UK's excellent research base."

Both Sir Peter and Dr Lewis expressed surprise at the way



A strontium end cap ion trap, used as part of NPL's strontium ion optical clock project

in which Government responded to their initial approach.

"When we first approached the Government, I was taken aback but certainly encouraged by its ability to see quantum technologies as an emerging technology," Sir Peter noted. "It wasn't fixated on an immediate return on any investment it might make.

"Before we spoke, we had been obliged to carry out a comprehensive SWOT analysis on quantum technology in the UK and what our capabilities were. Our academic capability is certainly impressive and we have been successful at spawning a significant number of university spin-offs and SMEs – just look at the photonics industry in the UK where, by our reckoning, we have more than 1500 companies generating more revenue than the pharmaceuticals industry," suggested Sir Peter.

The key question was how could the UK develop and create a viable ecosystem capable of supporting a fast growing quantum technology industry?

"That was crucial," he conceded. "Companies and organisations need to engage with one another. That is an important element within any successful innovative culture because companies need to feed off one another. That type of relationship goes a long way to producing a lot of good science."

Sir Peter accepted their talks about funding came at a fortuitous time as George Osborne, the Chancellor, had been talking about the importance of turning the UK into a 'knowledge based' economy, which would require longer-term investment if great science was to be commercialised successfully.

"The key was getting the industry to talk as one," Sir Peter noted. "It didn't matter how many agencies were involved, as long as we worked together. If you look at the US, there are 11 agencies, but they don't talk to one another – it is a fractured ecosystem."

Among the key partners in the UK are EPSRC, Innovate UK, the Department for Business, Innovation and Skills, NPL, GCHQ, the Knowledge Transfer Network and the Defence Science and Technology Laboratory (Dstl).

"We have set up a board that focuses on developing a common strategy. It meets monthly, involves all the various interested parties, organises resources and steers the UK's quantum programme.

"The four hubs have their own advisory boards and half their membership is made up of people from business," he continued. "Our aim is to establish a coherent government, industry and academic quantum technology community that will, ultimately, provide the UK with a world leading position in the emerging quantum technology market. Create the right infrastructure and we will be able to deliver on the ambitious future opportunities we have identified."

Recent developments in the laboratory suggest there are real opportunities for the UK in this field of advanced science, suggested Sir Peter.

"What we are looking to do is build an exploitation strategy to put that science to practical use in the real world."

Among those agencies playing a leading role in the development of quantum technology is the Dstl which is providing considerable financial support.

According to Neil Stansfield, head of Knowledge, Innovation and Futures Enterprise at Dstl: "We are supporting the QMI as quantum technology will lead to high-accuracy navigation systems capable of working even if conventional GPS systems are not available and sensor technologies capable of identifying objects hidden in structures or in the earth.

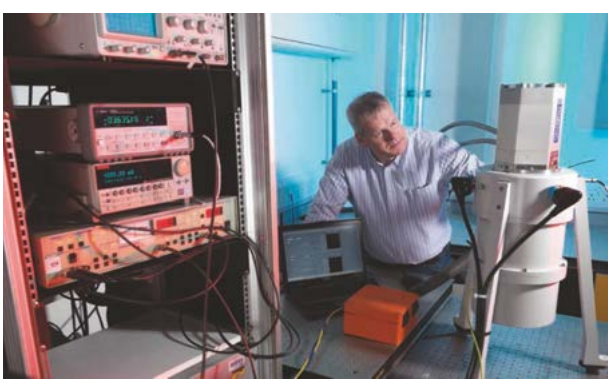
"Quantum technology has the potential to significantly advance UK defence and security in a range of areas whether timing and navigation or sensing," suggested Stansfield.

The UK's National Quantum Technologies programme was set up to support investment in research, innovation, skills and technology demonstration to help business in the UK to commercialise the technology.

"To that end, the programme can offer grants to help companies identify and develop uses and applications for these new technologies across a broad range of markets," explained Sir Peter.

So is the UK well placed to become a world leader in new quantum technologies?; can the UK, with its high performing research base and network of innovative business, establish a leading position?

It will require sustained Government investment, a dynamic workforce capable of meeting the needs of the industry and the free flow of ideas, people and innovation. But, for once, all the elements do appear to be in place.



Speed, comfort and reliability

Electronics technology is set to play a central role in Hitachi's Class 800/801 InterCity Express trains, currently being developed. By **Neil Tyler**.

The new Class 800 InterCity Express train (above) will look to incorporate the very latest technologies

The UK brought railways to the world and was traditionally a major exporter of locomotives and railway rolling stock, but times have changed and the UK's domestic train industry is now dominated by overseas companies like Bombardier, Siemens and Hitachi.

These companies have, however, brought significant investment to the UK and Hitachi recently opened an £82million Rail Vehicle Manufacturing facility in Newton Aycliffe.

The factory, which will employ around 750 people and house Hitachi's European research and development facility, was built to produce Hitachi's 800/801 InterCity Express (IEP) trains for the UK's East Coast and Great Western Main Lines, with production scheduled to begin in 2016.

Hitachi has a long association with high speed trains, such as the Shinkansen (bullet train) in Japan, while in the UK it has supplied the Ashford based Class 395, a 140mph commuter train which runs from Kent to St. Pancras.

According to Koji Agatsuma, head of technical at Hitachi: "The rail industry has to work with a large number of component suppliers from across Europe (among those supplying components for the 800/801 Series are Harting, Siemens, Huber+Suhner and BMAC) and many components for cost reasons are off the shelf. It is crucial that we can integrate these components into specific systems."

Obsolescence is a key issue for the industry and, as a result, Hitachi has decided to supply many of the components for the 800/801 Series itself. "It's one way of managing obsolescence," suggests Agatsuma.

Recent developments in the rail industry have focused on increased speed, comfort, and reliability, but new rolling stock also needs to be more energy efficient.

Consuming less energy

"The 800/801 Series needs to consume less energy, while carrying more passengers in greater comfort. While we are supplying the rolling stock, we have also signed a long-term maintenance deal so our focus has to also be on reducing whole life industry costs," explains Agatsuma.

Hitachi's decision to bring train manufacturing back to the North East came after the Government awarded it a £5.7billion Intercity Express contract, but that also included a 27 year maintenance deal.

"The 800 series will be in service for 35 years, so we need to be able to deliver carriages that are significantly more efficient, so we need to reduce the weight of each carriage. Lower weight means reduced levels of wear and tear of the track and that will help to reduce maintenance costs in the longer term."

Standards play an important part in the rail industry and these cars have been designed to comply with European railway standards, such as the Technical Specifications for

Interoperability and the UK's Railway Group Standard.

"Customer safety regulations change every year. We need to be able to not only meet all EU and UK regulations but also address the needs of different business models."

The IEP project involves replacing 40 year old rolling stock with 866 high speed cars. Each train-set will consist of five or nine cars, but a 12 car configuration is also planned.

Designed to be as streamlined as possible, the cars are intended for high speed operation, so a number of environmental measures have been employed to reduce noise and air resistance.

On train technology

Hitachi is deploying an on-board information system that uses the Ethernet-Autonomous Decentralised Train Integration System (E-ATI). Developed by Hitachi, E-ATI – a backbone communication system intended to improve the system's reliability – uses a fully independent dual routing system.

The system's displays have been designed to meet European and UK standards and the rolling stock has been fitted with onboard servers that can exchange information with trackside systems using 3G and Wi-Fi communications. However, in line with the brief to future proof these trains, they can also support 4G and WiMAX communications.

"When it comes to the passenger experience, whether we provide onboard entertainment systems will be determined by the operator's business model. There are no technical issues preventing us from doing so, but as passengers tend to use their personal devices to access entertainment, it is more important that we provide a secure and effective Wi-Fi service," explains Agatsuma.

Onboard technology will also enable train operators to receive live rolling stock information and to access the train's on-train data recorder. Other onboard devices will enable operators to transmit and update schedule information and seat allocation data, as well as update onboard software.

GPS is used to provide location information, to update and control internal and external display panels and to manage door interlock controls. It is also used to instruct drivers on how to minimise power consumption, based on the timetable, the location of trains and the correct power supply, depending on the type of track the train is using. An EN compliant energy meter records energy consumption.

The series is fitted with the Train Protection and Warning System, widely used in UK trains, while the Great Western service will also use the British Rail-Automatic Train Protection system. All units will feature an ETCS (Level 2) system developed by Hitachi.

Together, these various safety systems will enable the rolling stock to employ more sophisticated control systems capable of operating with different ground side signalling systems; simplifying train data entry procedures for rail crew and on-board equipment control functions.

Bimodal power

"Key to their successful deployment will be the carriage's ability to run on different infrastructure (for example, non-electrified sections of the UK's infrastructure). As a result, we have had to develop a bimodal power solution," says Agatsuma. "These trains can operate with a dual power source. While power can be taken from overhead wires, we have also installed a diesel engine under the floor. These units need to be able to run across the entirety of the UK's rail network."

According to Agatsuma, the bimodal power unit is capable of selecting the right power source from either the main transformer or the GU. Weight is an issue, so the power supply converter – designed using fewer components – is lighter.

To help further reduce the weight of the carriages, aluminium was used for the body while composite materials were employed in the carriages and in the train's front end.

The provision of air conditioning in these trains was considered a crucial requirement, according to Agatsuma.

"If the power to these units was to fail, temperatures can soar in summer and plummet in winter. While accuracy is important, reliability is crucial," he suggests. "The UK rail network is old, so power interruptions can and do occur. These trains have been developed so that each car has its own power unit; should power be lost, it will be possible to maintain conditions in each carriage and there is enough power to drive the train, at reduced speed, to the next station."

Commercial operation is scheduled to begin in 2017 and operation trials have already started.

"It is crucial that we can integrate [off the shelf] components into specific systems."
Koji Agatsuma

The new black

The 'blackest material yet', featuring carbon nanotubes, could help to improve the performance of satellite based instrumentation.

By **Graham Pitcher**.

Carbon nanotubes have been seen as having a wide range of potential applications for many years, but their use in the 'real world' has been a long time coming. The first research into such structures was reported in 1952 by a Russian team, but it wasn't until the 1990s that the technology began to gain some traction. Even today, their use – particularly in industrial applications – remains the exception.

Despite the extended gestation period, applications in the electronics world continue to remain elusive. Whilst some see huge potential for carbon nanotubes (CNTs) to be used in supercapacitors – even ultracapacitors as a car battery replacement – research continues into their potential use in transistors in a post Moore's Law industry. IBM, for example, is working in this field and expects to launch devices featuring CNTs within the next five years. But it remains a challenge to make CNTs with the correct orientation for use in such devices and, hence, the required properties.

Nevertheless, CNTs are finding application in what might be seen as complementary areas, including the space industry. And one application developed by nanomaterial specialist Surrey NanoSystems is what's claimed as the blackest material yet made. Called Vantablack, the material is composed of vertically aligned nanotube arrays applied to a substrate using a manufacturing approach called photothermal chemical vapour deposition (PT-CVD). According to the company, this enables CNTs to be synthesised at temperatures compatible with widely used engineering alloys. In other words, it says, CNTs can be applied to 'real' products.

"Vantablack is a major breakthrough in the application of nanotechnology to optical instrumentation", said Ben Jensen, the company's chief technology officer. "For example, it reduces stray light, improving the ability of sensitive telescopes to see the faintest stars, and allows the use of smaller, lighter sources in space borne black body calibration systems."

Because of the way in which Vantablack is engineered, it acts as an effective trap for incident radiation; the CNTs ensure that light is bounced around a number of times before the energy is absorbed. And, by defining the density of CNTs and their length, the reflectance of the material can be tuned for use with a particular part of the spectrum.

Jensen said: "Vantablack was originally intended for use in the infrared (IR) spectrum, where it exhibits a total hemispherical reflectance (THR) of less than 0.15% across wavelengths ranging from 1 to 15µm. It is therefore used as the functional coating in IR systems such as thermal cameras, calibration targets, analytical instruments and large scale scientific experiments, where absorption of incident radiation defines performance

Above: A sample of Vantablack
Right: Looking through the filter of a PT-CVD furnace during catalyst activation

limits. This is equally true in defence related applications, such as target acquisition, night vision sights and signature reduction, where Vantablack's ultra low reflectance and ultra high emissivity across a range of frequencies provides a tactical advantage."

One particular application which Surrey NanoSystems has in mind is satellites, where the material is suitable for coating internal components, as well as for use in MEMS based optical sensors and Earth observation instruments. In fact, Vantablack will be used in an optical instrument aboard a satellite being launched in January 2016.

These instruments operate in the IR spectrum as the Earth's atmosphere is largely transparent at these wavelengths. However, they need to be calibrated at a known low temperature. Jensen noted: "Excellent front to back thermal conductivity of the source is required, together with maximum uniform emissivity across wavelengths of interest to ensure maximum sensitivity and signal to noise ratio of the instrument." He added that such devices need to be light, compact and able to withstand space flight.

In the past, this function has been performed by aluminium alloys which have been anodised using the Martin Marietta Black (MMB) treatment, but

One particular application which Surrey NanoSystems has in mind is satellites, where the material is suitable for coating internal components, as well as for use in MEMS based optical sensors and Earth observation instruments.

Jensen pointed to some downsides. "This treatment results in a THR of around 1.5% at the benchmark 5µm wavelength and there is a spectral feature near this wavelength. MMB coatings also exhibit some mass loss when exposed to space vacuum, giving the potential for contamination of sensitive optics."

The company says that no other organisation – including NASA – has been able to achieve in situ deposition of aligned CNT arrays at temperatures of less than the melting point of space qualified aluminium alloys. As part of the process, different catalysts were developed to achieve the required density of aligned nanotubes, whilst ensuring strong adhesion to the underlying substrate.

A further problem surrounds MMB – it is subject to the US' ITAR regulations and is, therefore, generally unavailable. While other approaches are available, all are seen to be less acceptable.

Jensen said that, for a solution to be better than MMB, it not only needs to have a better THR, it also needs a flat spectral response between 2 and 12µm. "The coating is also required to retain its optical properties after space qualification to ESA standards and to be thermally stable and chemically inert."

Jensen pointed out that Vantablack also improves instrument reliability. "This is of paramount importance where subsequent intervention, such as the decontamination of optics, is impractical. Further, Vantablack's flat spectral response ameliorates the need for compensating circuitry that otherwise adds complexity and weight."

Vantablack is said to be the most effective light suppression material available. "Its blackness offers a range of aesthetic design possibilities," Jensen concluded, "and it is the closest anybody will come to looking into a black hole."

Flexoelectric MEMS device is just 70nm thick

Researchers from the Catalan Institute of Nanoscience and Nanotechnology, Cornell University and the University of Twente have developed the first integrated flexoelectric microelectromechanical system on silicon and claim the 70nm thick device could enable new applications.

Professor Guus Rijnders from the University of Twente believes it will be possible to create flexoelectric materials with a thickness of just a few atomic layers. "You could make sensors that can detect a single molecule, for example," he said. "A molecule would land on a vibrating sensor, making it just fractionally heavier, slowing the vibration just slightly. The reduction in frequency could then easily be measured using the flexo-electric effect." In addition to ultra sensitive sensors, flexoelectric materials could also be useful in applications that require a limited amount of power, such as pacemakers and cochlear implants.

According to the researchers, the desirable attributes of flexoelectricity are maintained at the nanoscale, while the figure of merit – bending curvature divided by the applied electric field – of the first prototype is comparable to state of the art piezoelectric bimorph cantilevers. Like piezoelectric materials, flexoelectric devices can either generate electricity when deformed or change their shape when a voltage is applied. However, while the piezoelectric effect decreases with thickness, the team claims the thinner the material, the stronger the flexoelectric effect becomes.

While piezoelectricity is hard to demonstrate in silicon, the flexoelectric effect can be exhibited by any dielectric material. The team believes that all high-k dielectric materials used currently in transistor technology should be flexoelectric, thus providing a route to integrating 'intelligent' electromechanical functionalities within current transistor technology.

Picking the

Do engineers know what they like and like what they know? A panel at the recent Electronics Design Show discussed the topic. By **Graham Pitcher**.

Engineers can select from a range of technologies which might be appropriate for their next design. Options include ASICs, FPGAs and embedded CPUs. But there is a suspicion that, rather than selecting the platform which will be best for the job, engineers fall back on something with which they're familiar.

But is this suspicion true? Looking to explore this issue, *New Electronics* – in association with NMI – assembled a panel session at the recent Electronics Design Show.

Opening the proceedings, moderator Doug Amos wondered why designers use a particular silicon approach. "Engineers don't have all the answers," he said, "and sometimes they don't have all the questions. It may well come down to familiarity – although there may be a better approach, it's what the designer knows.

"An engineer might look at the options, but do they have enough time to evaluate them? Is custom silicon too expensive? Do FPGAs use too much power?"

Each panel member was asked to produce three silicon related assumptions and to discuss them briefly (see box). First up was Clive Bunney from Swindon Silicon Systems.

"We live in a digital age, but it's an analogue world," he said. "Everyone talks about things like MIPS, but anything you talk to is an analogue interface.

"And people suggest custom ASICs are too expensive, but it depends on the project. They assume ASICs will cost 'multimillions of pounds' and so they can't use them, but that may not be the case because it depends on what you're trying to do. If you want a small sensor interface which talks to a larger processor system, an ASIC might be appropriate."

Andy Culmer, engineering director with services company ITdev, said software related design methodologies are being adopted by the FPGA community and pointed out that FPGAs are more than arrays of gates. "The hard blocks in the latest FPGAs perform just as well as the equivalent blocks in ASICs."

His third assumption was that FPGAs will be replaced by GPUs. "We need a choice between FPGAs and processors," he contended, "because designers need programmability. Will we still need FPGAs? Yes, they will work side by side with GPUs and CPUs for optimum performance."

Adam Taylor, e2v's chief engineer, addressed design assumptions. "People say FPGAs don't require as tight a specification as an ASIC. They do; you must do this properly otherwise you'll be battling from day one."

His second assumption was that FPGAs require less discipline to design than an ASIC. "FPGAs allow you to sleep easily at night," he contended, "but not on the job."

Finally, he addressed an assumption that the platform was more important than the design. "You can ask whether you need an FPGA, an ASIC or something like an Arduino, but what you need is the right tool for the job."

Concluding the opening statements was Richard York, ARM's VP of embedded marketing. "There is a belief that only SoC companies can build SoCs. But you can build a chip without a design team; many companies do. If you write the specification properly – as you should – an ASIC can fit."

He also contended that old technology is valid. "There's a lot of investment on the trailing edge," he pointed out, "and 90nm is now on its fourth generation with many companies. Older nodes are also getting better."

His final point was to address a belief that ASICs cost millions. "If you want to build an ASIC test chip," he said, "it only costs $16,000. Even a

3 The assumptions challenged

Clive Bunney
1: We live in a digital world
2: IoT is all about computation
3: Custom ASICs are too expensive

Andy Culmer
1: Software methodologies can't be applied to hardware design
2: FPGAs are just arrays of gates
3: FPGAs will be replaced by GPUs

Adam Taylor
1: FPGAs don't require as tight a specification as an ASIC
2: FPGAs require less design discipline than ASICs
3: The platform is less important than the design

Richard York
1: Only SoC companies can build SoCs
2: Older technology isn't improving
3: It costs millions to build a chip

electronics design show

Our panel

Moderator: *Doug Amos,* manager, NMI FPGA network
From left in photograph:
Clive Bunney, technical director, Swindon Silicon Systems
Andy Culmer, engineering director, ITDev
Adam Taylor, chief engineer, e2v
Richard York, VP, embedded marketing, ARM

perfect platform

65nm device costs only $42,000. Building ASICs is just another arrow in the designer's quiver. The answer might be no, but you need to think about it."

Discussing the assumptions

Moderator Doug Amos picked up on York's figure for test chips. "Is that number right?" York said the first thing to do is to get a prototype and find out if it meets the spec. "The $16k is the full cost," he said, "including 30 or 40 samples. Although it doesn't include your design costs, it's no more expensive than an FPGA or discrete based system."

Asked what you got for the money, York continued: "For $16k, you'll get 25mm^2 of silicon capable of running at several hundred MHz.

Swindon Silicon's Bunney noted the company only designs at 90nm or larger. "The 'bleeding edge' isn't appropriate for high voltage and analogue doesn't scale in the same way as digital. At 65nm, you'll get four times more digital circuitry, but very little improvement in analogue."

ITDev's Culmer said he had been involved with mixed signal ASICs in the past and had used multiproject runs. "It cost $40k on a 0.18µm process, but we managed to lay out four copies of the design in the available area, then got them resawn, so we ended up with 160 devices, instead of 40."

Amos asked for a show of hands of those who design chips. "There are a few here," he said. When he asked who used FPGAs and CPUs, many more responded.

A contribution from the floor pointed out that while prototyping proves the design works, the money only comes in when you go to production. York responded: "You find out whether it's right and are you ready to commit?"

Bunney noted the cost of high volume manufacture wasn't 'orders of magnitude' higher. "Costs get higher when you test," he pointed out, "so there are development costs. But if you amortise those costs over hundreds of thousands of devices, that's not so high."

The discussion turned to when an ASIC might be appropriate. Bunney gave the example of a sensor interface, where physical constraints mean an ASIC is the only choice.

"Mopping up things into an ASIC is one of the key benefits," he contended.

York agreed: "System integration benefits can be valuable. For example, an 80% reduction in components can cut $50 from the BoM and that pays for itself quite quickly."

Another contribution from the floor wondered about tool suite and IP costs. York pointed out those costs aren't relevant. "You'll use a services company with expertise and the tools," he advised. "Give them a spec and get silicon back; don't do anything in between."

But one attendee was worried about the inflexibility of ASICs. "We generate boards on short time scales," he noted. "It's the fear of getting locked into silicon that isn't quite right or where requirements change. So while we could use an ASIC, it's all about time to market. What are the timescales?"

Bunney said most foundries have a fixed time from tape out to samples. "Normally, it's about 14 to 16 weeks. But while multiproject wafers (MPW) are the cheapest route to prototypes, they run on fixed schedules and that could be one every two or three months. You have to allow for that and make sure you tape out before the shuttle runs.

"However, there are other ways of getting devices, including multilayer masksets. While these are more expensive than MPW, they bring more flexibility."

Amos wondered what were the implications of specification changes. "You have some control over an FPGA, but is this all needed up front with an ASIC?"

"Engineers don't have all the answers and sometimes they don't have all the questions. [The choice of platform] may well come down to familiarity – although there may be a better approach, it's what the designer knows."

Doug Amos (above left)

e2v's Taylor noted: "It's all about getting the specification right. Once you've taped out an ASIC, you can't change things, so some projects in which I've been involved have more people doing verification than design."

Bunney agreed that a good specification was paramount. "You can build some flexibility into the design if it's in the spec. You have to know what you want because making changes is costly. Spend time up front getting it right."

Amos steered the discussion towards FPGAs. "How many use embedded processors?," he asked the audience. About two thirds of them said they did. "FPGAs bring flexibility," he believed, "and so does software, but does it bring headaches?"

Taylor pointed to increasing levels of abstraction. "I know of a design where there wasn't a single line of VHDL; it was all done in Matlab. But how do you verify that?"

York also reported that a piece of hardware had been developed by a Taiwanese company without a single hardware engineer being involved. "It was all written in OpenCL," he said, "and mapped. While you still need hardware engineers, defining systems through the software they will run is the way forward."

Amos wondered whether VHDL knowledge is needed nowadays. Taylor wondered whether testbenches could be written in C. "It comes down to working out where you need to invest your effort and when a design is 'good enough'."

Culmer said it pays to understand what the code is being translated into. "Having a hardware background is useful," he contended, "particularly when you need to drop in a VHDL block and instantiate it."

Summing up, Amos said: "We've had some good questions and great observations. We hope you will now go away and test your assumptions."

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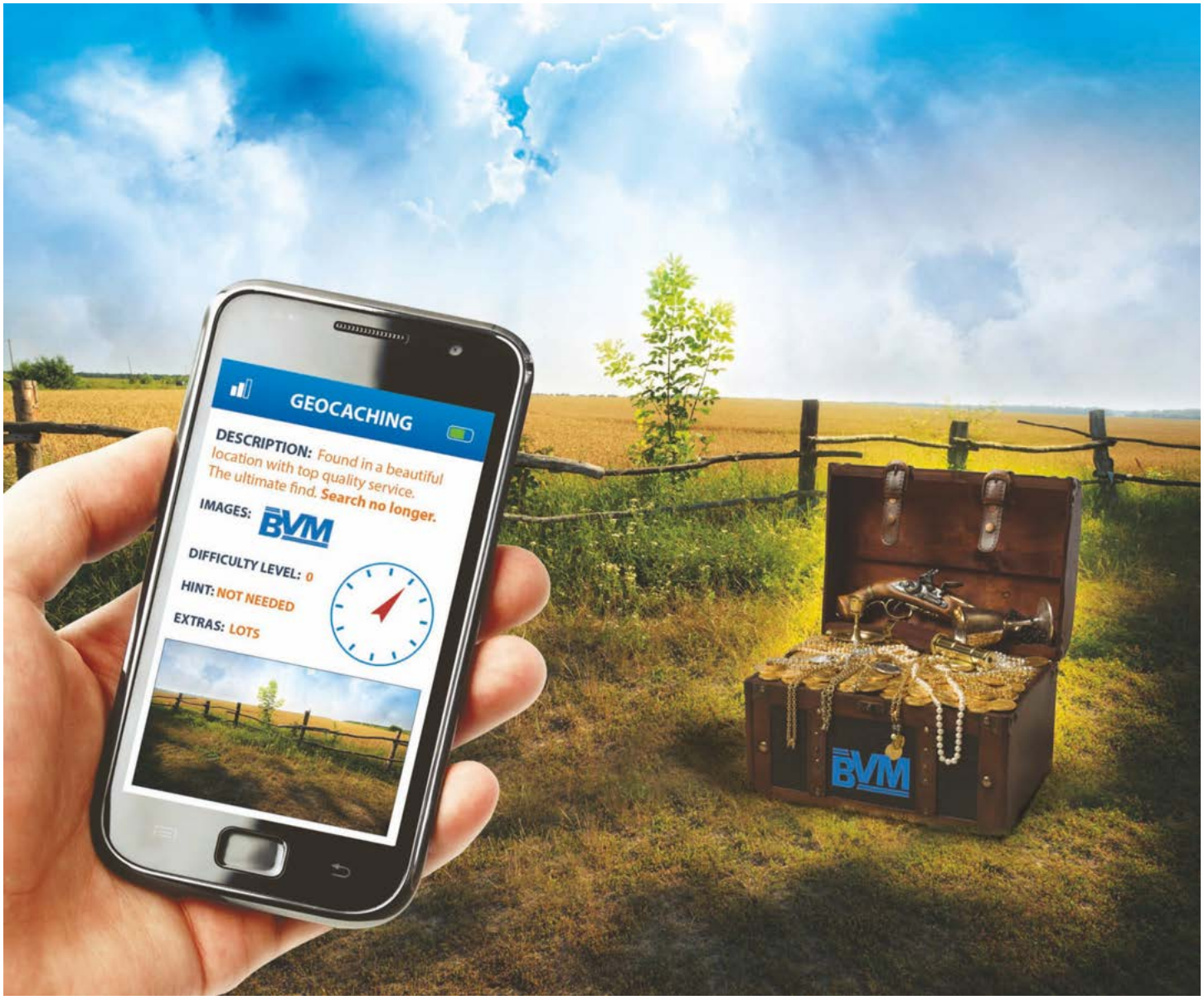

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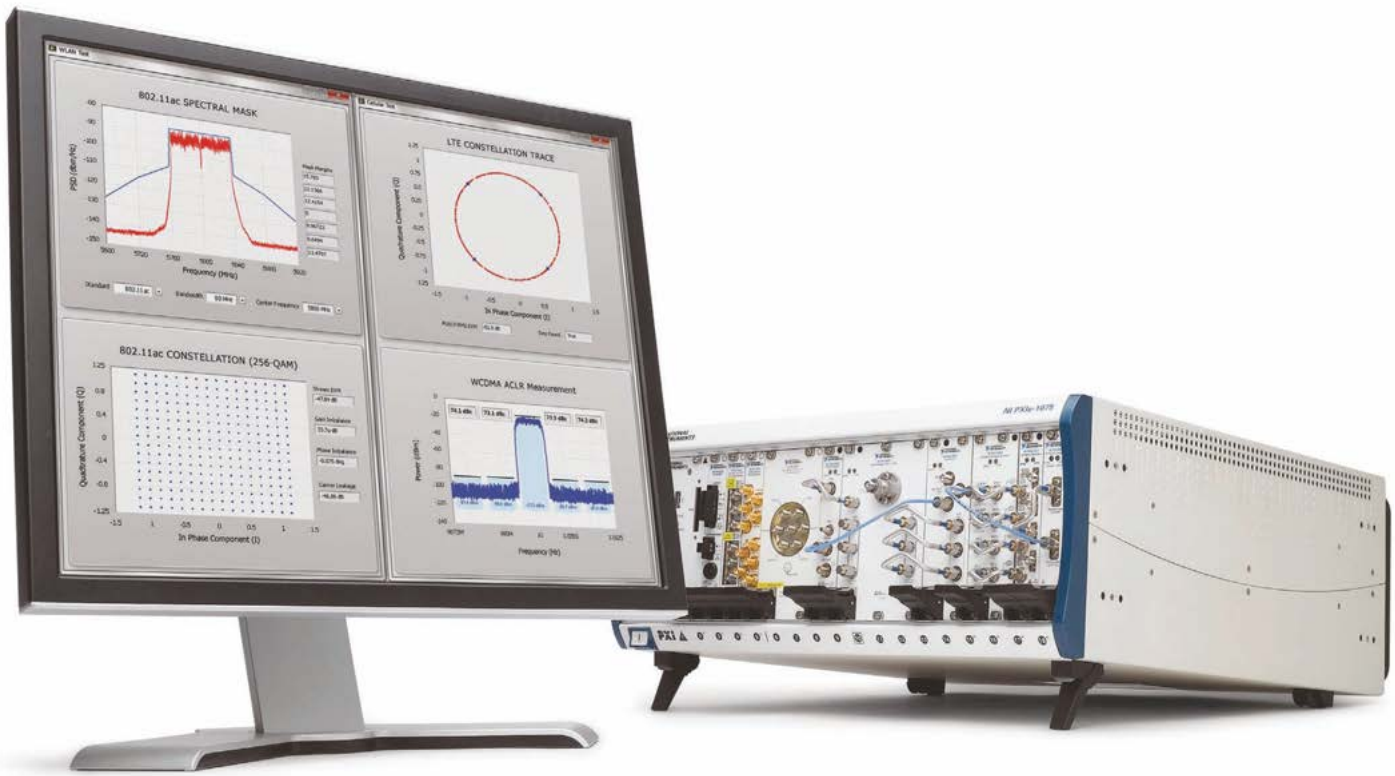

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NATIONAL INSTRUMENTS

Making massive MIMOs

Massive arrays of miniature graphene antennas are set to enable high speed short range communications in the terahertz spectrum. By **Graham Pitcher**.

The communications issues related to the Internet of Things have been discussed over the last few years and a range of solutions is available, although some remain proprietary.

But a new set of challenges is emerging as designers look to enable communications between devices taking advantage of nanotechnology. In the words of Ian Akyildiz, pictured below, professor of telecommunications at Georgia Tech in the US: "We're now talking about the Internet of Nanothings." And the research is being enabled by graphene.

"I first had the idea about nanoscale communications in about 2006," he said, "but I thought the only way nanoscale machines could communicate would be through biology. But my PhD student Josep Jornet said we should look at electromagnetic means and we realised we could enable this in the THz band – and we found graphene."

Transmitting at more than 1Tbit/s

Jornet started to explore how graphene could be used to create antennas and, between them, the team had success in its first year. "We validated performance, presented the concept at a conference and applied for a patent," Prof Akyildiz noted.

What graphene enabled was an antenna that supported data rates in excess of 1Tbit/s, but only over distances of up to 1m. "That's impractical for many applications," he added.

Jornet, now an assistant professor at the State University of New York (SUNY), said that graphene has extraordinary properties when it comes to its use in antennas. "The most important thing is that it supports the propagation of surface plasmon polaritons and this is the key property that enables the development of small, efficient antennas.

"Plasmons – surface confined waves – exist in other materials," he continued, "but generally at optical frequencies. This is the first time it has been achieved at the low end of the terahertz spectrum."

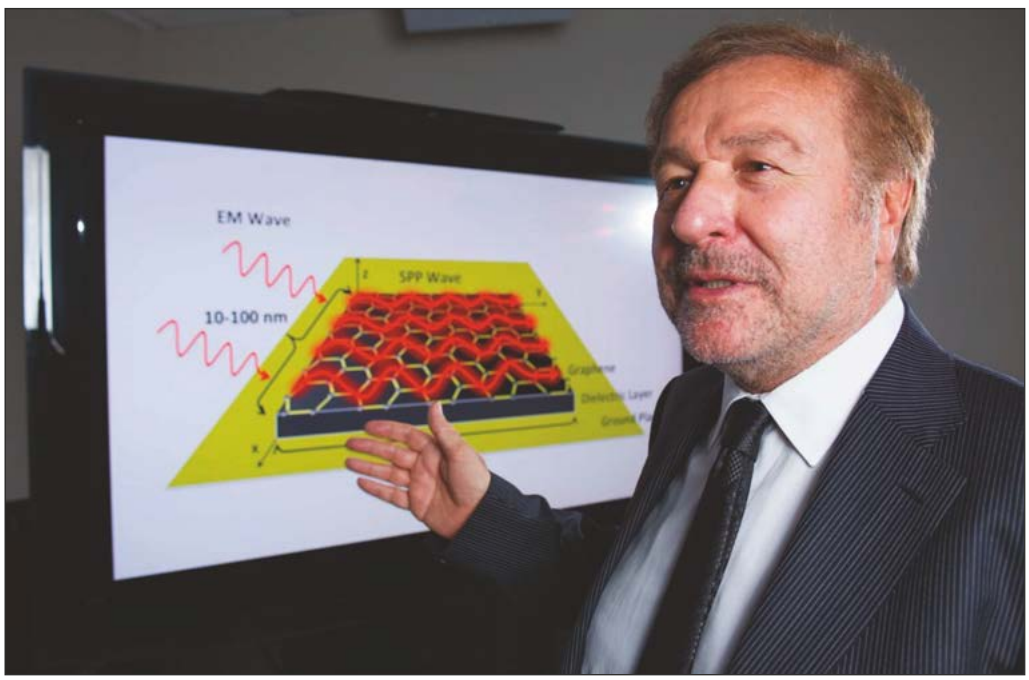
"Our project shows the concept of graphene based nano antennas is feasible."
Prof Ian Akyildiz

"When electrons in graphene are excited by an incoming electromagnetic wave, they start moving back and forth," Prof Akyildiz explained. "Because of graphene's properties, this global oscillation of electrical charge results in a confined electromagnetic wave on top of the graphene layer."

It would be possible to take advantage of plasmons in metals such as silver and gold, but this would mean devices operating at hundreds of THz. "While those frequencies might offer advantages in communication speed," Prof Akyildiz, pointed out, "their range would be limited by propagation losses to just a few microns." And copper is ruled out because it doesn't support plasmons.

The nano antenna developed by the Georgia Tech team, working with researchers from SUNY, comprises a layer of graphene on a dielectric and a ground plane. "The graphene must be on top of a dielectric, such as gallium arsenide," Prof Akyildiz said. "Metallic antennas don't need this extra layer. It's not like we have taken a classical design and used graphene; there's a lot of IP involved in our antenna."

While the team is working on single



graphene antennas, their research holds out the prospect of something far more exciting – ultra massive MIMO antennas. Prof Akyildiz noted that the concept of MIMO antennas – many inputs, many outputs – emerged about 10 years ago.

"The first such devices were 2 x 2; now, it's up to 64 x 64 and the approach is in the plans for 5G. But it has to be limited to small numbers – perhaps 100 x 100 – because you need a certain spacing between each antenna to avoid interference problems. But how much space is there in a small phone for a 100 x 100 MIMO?" he asked

Ultra massive MIMO antennas

Jornet added: "There has been much talk about massive MIMOs, but they are more likely to be used in basestations; we're talking about using them in a mobile phone. When we work with graphene, we can make things smaller and put them closer together. We may be able to create a 1k x 1k MIMO and put it anywhere."

Prof Akyildiz says 1024 graphene nano antennas can be created in an area of about 1mm^2. "Plasmonic nano antenna arrays exhibit high gain, which can help us to increase the communication distance at THz frequencies," he said. "For example, a 1k x 1k beamforming set up can provide a gain of about 80dB; enough to establish a 2Tbit/s link at 10m when transmitting at 1THz – more than two orders of magnitude better than any existing standard."

Transmission distance, however, remains a challenge. "The atmosphere affects signal propagation at higher frequencies," Jornet noted. "However, there are windows that allow longer distance transmission. We have ideas for distance aware modulation techniques and may be able to transmit over 50m, but we're still looking for more."

But the ultra massive MIMO array is, for the moment, a concept. "We have developed analytical and simulation models," Prof Akyildiz continued. "Fabrication and experimental validation will follow in the near future."

"Our project shows the concept of graphene based nano antennas is feasible, especially when taking into account very accurate models of electron transport in graphene," he concluded. "Many challenges remain, but this is a first step toward creating advanced nanomachines with many applications in the biomedical, environmental, industrial and military fields.

"It may take another couple of years, but but they could change the entire communications paradigm because they're so tiny."

However, one other problem remains to be solved: the cost of graphene. Jornet said: "We can use small samples of graphene in the lab; enough to make an antenna and transceiver. We're hoping the materials people can reduce the production cost so our antennas can be mass produced."

Printable antennas may bring low cost and flexibility to a range of applications

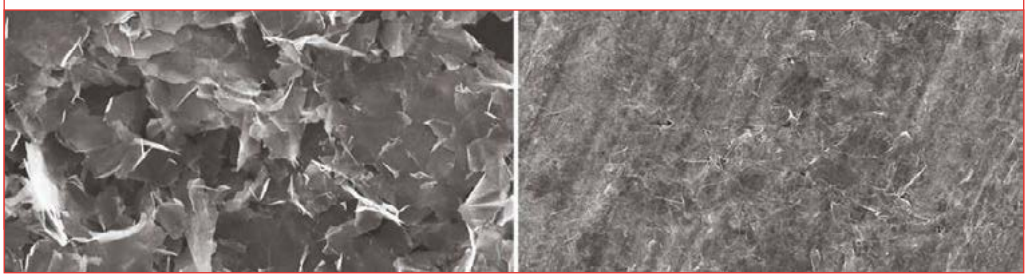
Researchers from the University of Manchester have used compressed graphene ink to print an RF antenna measuring 14cm x 3.5mm onto a piece of paper. According to the team, the antenna performed well enough to make it practical for use in RFID tags and wireless sensors.

Graphene ink is usually made by mixing graphene flakes with a solvent, and sometimes a binder. Graphene ink with binders usually conducts electricity better, but only after the binder – an insulator – is broken down by annealing. But this high temperature process limits the surfaces onto which graphene ink can be printed.

The team found that by printing and drying the ink, then compressing it with a roller, graphene's conductivity was increased by more than 50 times.

Researcher Dr Zhirun Hu said: "What makes printed graphene attractive for antenna applications is its ultra low cost and flexibility and the fact that it can be printed on any substrate without needing a high temperature process. We can use screen printing to produce graphene antennas, which suits low cost mass production."

Expanding, Dr Hu noted: "Being able to print antennas on any substrate means we could see a disruptive technology for low cost, wearable communications products. In addition, we'll be able to print a complete RF transceiver in the near future."

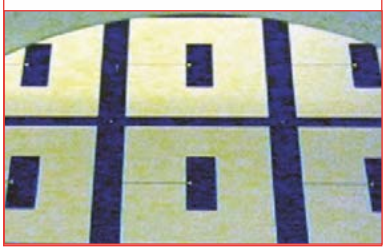


Electron microscope images show the graphene ink after it was deposited and dried (left) and after it was compressed (right)

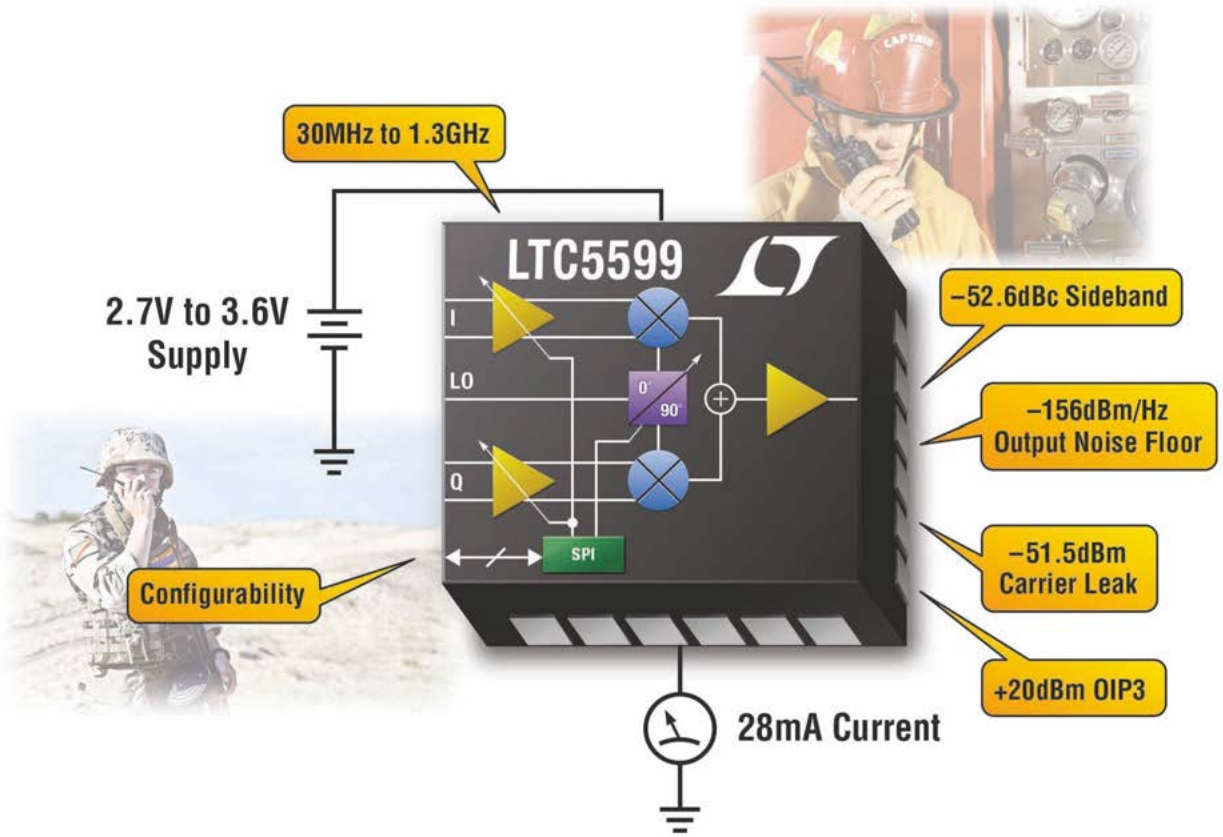
Tunable graphene antenna

Europe funded Project Nano RF has demonstrated a graphene antenna that operates in the microwave spectrum and which can be tuned using an external voltage. The antenna is less than 1mm thick, with a diameter of 100mm, which makes it one of the smallest such devices.

According to the researchers, the main application for the antenna will be in RF communications, where its tunability will allow switching of communication channels.



90mW I/Q Modulator



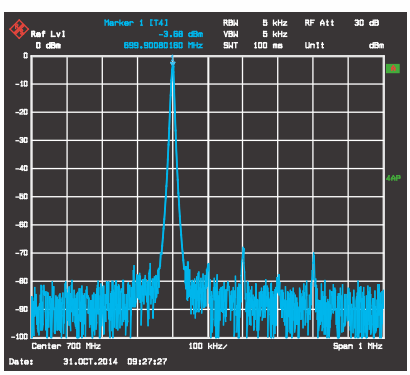
Powered from a single supply from 2.7V to 3.6V, the LTC®5599's 28mA supply current extends battery run time. The modulator offers superb –52.6dBc sideband and –51.5dBm carrier suppression—without the need of calibration. Its low noise floor of –156dBm/Hz and 20dBm OIP3 capability ensure outstanding transmitter performance. The LTC5599's built-in configurability allows users to optimize performance from 30MHz to 1.3GHz, minimizing external components and saving costs.

Features

Built-in Configurability Features:

- Gain Adjustable from 0dB to –19dB, with Supply Current Change from 35mA to 8mA
- Improves Sideband Suppression from –52.6dBc to –60dBc
- Reduces Carrier Leakage from –51.5dBm to –60dBm

Output Spectra (Optimized)



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Exploiting a UK patented invention

New Electronics has partnered with leading intellectual property law firm D Young & Co LLP to offer guidance to companies on how to protect their IP. In this issue, **Charlotte Musgrave** takes look at the different ways in which a patent can be exploited.

A UK patent gives you the legal right to stop others from making, using, selling or importing your patented invention in the UK, even if those others conceived of the patented invention independently. You can use this right to keep your competitors out of the UK market for the patented product, giving yourself a monopoly position as defined by the scope of the patent claims. In this scenario, your competitors would need either to withdraw from the market entirely or, perhaps, offer an alternative or even inferior product or process. Either way, you gain a competitive advantage.

Using your patent in this way is beneficial if, for example, you wish to manufacture a patented product or to subcontract the manufacture to a third party and take the income from selling the product yourself. Another approach might be to use your patent to enter into a joint venture with a third party manufacturer, where you would contribute the patent right and the partner would contribute the manufacturing facility and expertise.

Defending your patent rights

Your patented product and any related commercial literature should be marked with the patent number to make third parties aware of your patent.

Sometimes, the very existence of your patent may be enough to dissuade would-be competitors; in other cases, some degree of negotiation or mediation may be required to preserve your monopoly. In the worst case, it might be necessary to take legal action against the competitor through the courts or, in some cases, the UK Intellectual Property Office. If your infringement action is successful, the courts are able to force the infringer to pay compensation for the infringement of the patent, usually running from the date of publication of the application which matured into the patent, to issue an injunction to prevent further

infringement, and to award you a proportion of your costs. Where significant and unrecoverable damage to your business is likely as a result of the infringement, an injunction before trial can be obtained under particular circumstances, although this is uncommon. Various other minor legal remedies may also be available. Where infringing articles are being imported into the UK, then it is useful to note that customs officers can (on request) confiscate goods which appear to infringe a patent.

Exclusive and non-exclusive patent licencing

Another way of exploiting a patent is to encourage other parties to use the patented invention – for a price. You can offer licences to other parties in return for royalties, which will allow them to use the patented invention under the terms set out in the license agreement.

An exclusive licence provides the licensee with a monopoly for the patented invention – even excluding you as the patent holder. You may wish to offer this type of licence if you do not want to work the patent yourself and if maximum profit would be derived by offering exclusivity to a single company.

In contrast, a non-exclusive licence opens up the market for the patented invention to several companies – including you as the patent owner. This approach enables you to fully capitalise on a large market which you would not be able to fully exploit yourself.

A licence may be limited by, for example, geographical area, field of use or duration, and may also include or exclude the right to sub-license. In this way, you can limit each licensee's rights and maintain overall control of the exploitation of your patent. The amount of revenue derivable from the patent will depend on numerous factors, including the nature and value of the patented product or process, the strength of the patent, the breadth of the monopoly provided by the patent claims, the scope of the acts permitted by the licence, and whether it is exclusive or non-exclusive.

Patent acquisition

A patent is a form of property and has a value dependent on its strength and the commercial significance of the monopoly it provides. The commercial significance may be judged on the basis of the benefit derived by having a monopoly position or by the amount of licensing income actually or potentially derived from the patent. A patent can be used as leverage in commercial negotiations and clearly forms an important asset, which can be realised by way of sale (either on its own or along with the company), by way of a mortgage of the patent to raise capital or by way of attracting investment in the company.

Further detailed information is available in the Knowledge Bank or by contacting a Partner at D Young & Co LLP. Both can be found at dyoung.com Alternatively, email the author at cjm@dyoung.com

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Building in security from the start

The benefits associated with the IoT derive from greater connectivity, but without proper security mechanisms, the entire connected pathway is vulnerable. By Adrian Caceres.

Security remains the top concern for designers, builders and marketers of products for the Internet of Things (IoT) – and for good reason. When previously unconnected products join the IoT, they – and their users' data – become subject to hacking, compromise and mischief.

Most of the 'things' that make up the IoT are produced by companies that have never thought about connectivity security. How are manufacturers of home appliances supposed to know what a good connected version of a refrigerator or coffee maker should be?

The benefits of the IoT derive from connectivity: for consumers, it might mean receiving an alert at work or while watching a football match that there's a problem with their domestic heating, lighting or security system. Or it may help them to improve their health and fitness by tracking various biometric values, from heart rate to blood sugar levels. For manufacturers of connected products, it means gathering valuable data on how people are using their products – when, where, what features and how frequently.

But the pathways that deliver the benefits also introduce security risks. Without the proper security mechanisms in place, data traversing the public Internet is vulnerable to hackers. Manufacturers of IoT connected products need to not only address the security of products themselves, but also the entire connected pathway. If they're doing business in the EU, they also need to abide by the strict regulations about the sharing of personally identifiable information.

IoT security must extend seamlessly from the connected product to the cloud and to the web or mobile application that controls the product.

Starting in the platform

IoT security must extend seamlessly from the connected product to the cloud and to the web or mobile application that controls the product. This means that manufacturers that lack expertise in disciplines such as network security suddenly must figure out which protocols and standards to use, how to balance access with security, and how to integrate handoffs at all steps along the IoT pathway.

In most cases, a wiser approach for manufacturers will be to choose a ready-made IoT platform that provides comprehensive, end-to-end, integrated technology. For example, a good IoT platform will embody the standard Authentication, Authorisation and Accounting (AAA) approach to security that arose in IP-based networking realms.

The three A's of AAA security are:

- **Authentication**, which determines who or what you are. It's the process of identifying an individual person, usually based on a username and password. It's based on the principle that each user has unique information that can distinguish him or her from all other users.
- **Authorisation**, which determines what you are allowed to do and see. It's the process of granting or denying a user access to network resources after the user has been authenticated with a username and password, using the authorisation level to determine what information and services the user has access to.
- **Accounting**, which determines what you did while connected. It's the process of tracking a user's activity while accessing the network's resources. It can include the amount of time spent on the network, the services accessed, and the amount of data transferred during a given session. Accounting data can be used for trend analysis, capacity planning, billing, auditing and cost allocation, as

New security threats are bound to proliferate and a properly designed end-to-end IoT platform should evolve and respond to these changes.

Applying and co-ordinating the AAA approach

An IoT platform can apply and coordinate the AAA approach all the way from connected product to cloud to control application. Ideally, an IoT platform lets manufacturers of connected products:

- Protect the privacy of their end-user customers' data, for compliance with regulations and to protect the manufacturer's brand reputation;
- Encrypt all user-identifiable information to protect data in transit to or from the cloud;
- Manage access (authentication), authorisation and accounting for all users and all of a manufacturer's connected products;
- Prevent distributed denial of service attacks;
- Prevent devices from other manufactures from accessing their connected products' data;
- Handle lost or stolen products, including the ability to remotely wipe out all or some data or disable products' connectivity.

well as for security reasons.

The IoT platform developed by Ayla Networks includes embedded virtual agents: software that is embedded onto communications chips and modules from leading semiconductor manufacturers, and run on IoT products or IoT product gateways. These embedded agents incorporate a fully optimised, fully tested network stack along with additional protocols to connect products to Ayla Cloud services.

For example, designers of connected products can choose Ayla-specific versions of communications controllers and modules from a range of companies, including Broadcom, Qualcomm, Marvell, STMicroelectronics and NXP Semiconductors, which all sell products with the Ayla virtual agent embedded on-chip.

Systems with these chips and modules can immediately connect to the IoT platform from Ayla. No further financial or other resources are needed for software or hardware design, and there is no need for a smart gateway to provision and control the device.

Security is built into the chips and modules from the get-go. Security at the chip level starts with encryption to prevent spooking, also known as IP address forgery, in which an attacker masquerades as a trusted host for the purpose of hijacking a browser or gaining access to a network. Chip-level security also includes encryption key transmission protocols such as SSL (Secure Sockets Layer) designed to get data safely to its destination.

Once IoT data reaches the cloud, cloud security must encompass both computer and network security protocols and measures. Cloud security must take into account all the cloud deployment models - private, public and hybrid - as well as issues of virtualization. Importantly for manufacturers doing business in the EU, Ayla operates a European cloud, supported by the AWS EU (Frankfurt) Region cloud infrastructure, that is compliant with EU data privacy policies.

Embedding Ayla agent software into Wi-Fi-based modules enables manufacturers to add cloud connectivity along with wireless connectivity for their IoT products, without doing custom coding. Therefore, manufacturers get to market more quickly and cost-effectively with better-performing and more secure connected products.

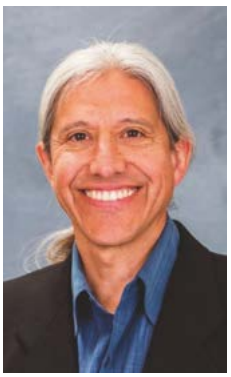
Now and for the future

Delivering IoT security is not a one-time process. Rather, it is an ongoing effort that must respond to new threats as they emerge and handle new technologies as they emerge.

An ideal IoT platform must include enough built-in flexibility to enable manufacturers to improve the level of security they offer with new products. In addition, however, it must also allow manufacturers to update the security of products already deployed in people's homes and workplaces.

New security threats are bound to proliferate, and new IoT solutions will surely come to market. A properly designed end-to-end IoT platform should evolve and respond easily to these changes. It must continue to win end users' confidence that their use of IoT products and applications will not jeopardize their privacy or safety.

An effective IoT platform must also fulfill the crucial benefit to manufacturers of allowing them to learn quickly from their successes and mistakes, using the data generated by their connected products to iterate toward increasingly better versions of their products. And it should do so while maintaining the highest security standards, throughout the entire IoT spectrum.



Author profile:
Adrian Caceres is chief technology officer and vice president of engineering with Ayla Networks

Analog Devices' ADP5301

Mouser Electronics, Inc. is now stocking the ADP5301 high-efficiency, ultralow power step-down regulators from Analog Devices. Part of Analog Device's comprehensive line of power management solutions, the ADP5301 are compact, ultralow-power buck regulators that enable designers to extend their battery life in portable devices with one of the highest ultra-light-load power conversion efficiencies in the industry.

Delivering a 90 percent efficiency rating and consuming only 180 nA of quiescent current, the ADP5301 provides maximum power and battery life for longer periods of time, making these devices an ideal solution for a variety of Internet of Things (IoT) applications.

Analog Devices ADP5301 high-efficiency, ultralow power step-down regulators, available from Mouser Electronics, provide an input start-up voltage range from 2.15 V to 6.5 V, enabling designers to incorporate a variety of battery sources or other power sources and architectures.

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Datamate Coax Multiport 6ghz 50 Connectors

Harwin, the leading hi-rel connector and SMT board hardware manufacturer, today launched a range of standard layout, multiport coaxial Datamate connectors with 6GHz, 50 contacts, suitable for hi-rel applications. Suitable for RG178 cables, the ganged connectors are available from stock with two, four, six or eight contacts.

Based on Harwin's proven high-reliability Datamate connector family, the new coax connectors are designed with a single body moulding to resist extremes of shock, vibration and temperature in challenging application environments such as defence, aerospace, satellites, UAVs, undersea and more. Devices are equipped with hexagonal slotted jackscrews for secure fixing to the PCB, and mouldings are polarised to facilitate quick, error-free mating. Vertical and horizontal orientation styles are available and devices Harwin offers a choice of products to suit two PCB thicknesses, 3.5 and 5mm.

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ECP5™ FPGA-based Board

Lattice Semiconductor Corporation (NASDAQ: LSCC), the leading provider of customizable smart connectivity solutions, and Mikroprojekt today announced availability of a new ECP5™-based development platform to accelerate system design of communications and industrial applications at the network edge, including HetNet small cells, industrial IoT gateways, and IP cameras.

Mikroprojekt's Kondor AX development platform features Lattice's ECP5 device, a low power, small form factor FPGA with flexible interface connectivity and high-performance DSP for image filtering and data analytics, and a versatile discrete CPU with Linux OS support for system control.

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Electronic Components

Astute Electronics, the leading supplier of electronic components and value added services, has announced that is has gained certification to AS 6081, the SAE Aerospace Standard that addresses counterfeit mitigation which is designed to provide a very high level of protection for companies in the aerospace and defence industries.

Astute is the first British and first European company to gain certification and only the fourth company in the world to achieve this. Astute is also the first company worldwide to have more than one location certified (UK and USA).

AS 6081 standardizes practices and methods to mitigate the risks of purchasing and supplying fraudulent/counterfeit electronic parts. It covers the following activities: Identify reliable sources to procure parts; Assess and mitigate risk of distributing fraudulent/counterfeit parts; Control suspect or confirmed fraudulent/counterfeit parts; Report suspect and confirmed fraudulent/counterfeit parts to other potential users and Authority Having Jurisdiction.

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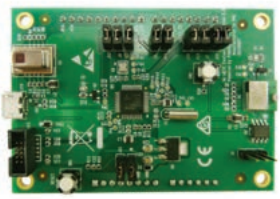
New Grid-Eye Infrared Array Sensor



Integrated "nanopower" Bluetooth Smart module, software and microcontroller enable easy development of new wireless sensor applications within days

Panasonic Automotive & Industrial Systems is launching a Grid-EYE Infrared (IR) Array sensor Evaluation Kit this autumn that combines its "nanopower" PAN1740 Bluetooth Smart module and a microcontroller on one PCB.

By combining its new IR sensor technology with Bluetooth technology and software for IR detection of people and objects on one board, Panasonic enables customers to develop rapid prototypes and quickly build their own wireless sensor "Internet of Things" applications.

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Series Connectors From Amphenol Socapex

Now available in Europe through TTI, Inc., a world leading specialist distributor of electronic components, is the recently extended VAD (Value Added Assembly and Connector Solutions) range for PT/451 series connectors from Amphenol Socapex with Black Zinc Nickel Plating.

Designed for use in harsh environments, e.g. military ground vehicles, marine equipment, oil & gas, as well as industrial outdoor applications, PT/451 MIL-DTL-26482 Series I Black Zinc Nickel connectors can be exposed to salt spray for 200 hours and offer great protection from dust and fluids.

The circular connector range with bayonet locking benefits from several possible contact arrangements, nine shell sizes from 8 up to 24, EMI/RFI protection, and up to 500 mating cycles. The devices are available with four codings, contact sizes 20 and 16 and have been designed for an operating temperature range from -55°C up to +125°C.

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'Spider' Fibre Optic Assemblies

Rugged, reliable and inexpensive

OMC, the pioneer in optoelectronic solutions, is now offering a range of 'Spider' fibre optic cable assemblies which can both split an optical signal from a single source into several outputs as well as combine multiple inputs onto a single output fibre. This can be useful for sensor applications and precise triggering, among other applications.

Previously, designers have been forced to use beam splitters for this purpose, but such devices can be expensive as well as complex to set up. OMC's new 'Spider' fibre optic assemblies, by contrast, are rugged, reliable and much more cost effective. Perhaps the most important feature is that the spider assemblies can be manufactured to suit the customer's application, with customer-specific lengths, connectors and numbers of input/output channels.

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Seminar: Demystifying EMC
Monday 18th January 2016, Reading

Following the successful event in 2015, Rohde & Schwarz is offering a FREE one day Seminar titled Demystifying EMC 2016.

The Seminar will be held on Monday 18th January 2016 at The Royal Berkshire Conference Centre, Reading.
This one day event is designed to cover the fundamentals of Electro Magnetic Compatibility, targeted at Engineers who would like to get a basic appreciation of EMC or brush up on fundamentals once again. This year Rohde & Schwarz will be joined by industry partners who will broaden the topics on offer in various streams.

For more information or to register please visit:
https://www.rohde-schwarz.com/demystifying-emc

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