MICRO- AND NANOELECTRONICS

FASTER, FASTER, NICE AND SMALL

We are awash in a sea of microelectronics — not just in our smart phone and laptop, but embedded in so many everyday objects, from gas boilers to borrowed library books. Since the first integrated circuit, industry has never ceased to find new uses for electronics. European research continues to come up with novel applications — and is shrinking the dimensions of chips down into the nanoworld.

Microchips are yesterday's technology. Well, almost. In 1965 Gordon E Moore, cofounder of Intel, noted that the number of transistors you can fit into an integrated circuit appeared to double about every two years. Since then this output of faster-yet-smaller electronics components has been relentless.

And, with each iteration, industry has found exciting new applications for electronics. Back in the days when a computer was the size of a room, they were gadgets for scientists and serious number-crunchers. Then they shrank. Smaller chips effectively created personal computing.

Families and businesses could afford computers for work, play and more recently communication, shopping and entertainment thanks to the internet.

Still the electronics shrank. As engineers came up with clever designs and laser-based silicon wafer etching got more precise and accurate, we found that powerful, low-power chips could be used for mobile phones and laptops. Computing went palm-sized.

Within the Sixth Framework Programme (FP6), micro- and nanosystems in Europe got their big break with six calls for proposals netting a total of 79 projects worth EUR 500 million — EUR 300 million from the European Commission.

These projects have brought together researchers and industries with end-users and suppliers from some 500 different organisations across the Union. The projects covered diverse subjects, from technologies and systems development (e.g. microelectromechanical systems or MEMS, radio frequency microsystems, as well as plastic and organic micro-nanosystems), to product innovation and new manufacturing processes.

The use of microsystems to support applications, such as health and biomedicine, food chain management, displays and robotics also came under this umbrella research effort.

In 2008, chip manufacturers commercially launched 45 nanometer (nm) chips and 32 nm versions are just around the corner. According to the industry's agreed International Technology Roadmap for Semiconductors, 16 nm chips could become available by 2018.

But in a world dominated by names like Intel, IBM and AMD, where does Europe fit in? Although Europe may not boast such big names in chip fabrication, since the Fifth Framework Programme (FP5) for research it has built up significant expertise in chip design and innovative manufacturing processes.

This research effort is complemented by other national and international programmes, such as a string of Eureka cluster programmes in nanoelectronics dating back to 1989. The investment is paying off as European firms now find they are world leaders in chip mastering and manufacturing tools, with several major specialist clusters, such as Dresden in Germany and Grenoble in France.

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Although this field of research appears highly technical, and far removed from the gadgetry of the high street, innovation in component design and manufacturing will soon filter into more powerful and functional ICT hardware and accompanying applications.

After all, the EU is not interested in the pursuit of smallness per se. Tiny chips must serve a purpose, but what could that purpose be? This is a question addressed by countless ICT projects which have exploited the smallest and most powerful chipsets of their day for exciting new applications.

European-funded research has pioneered the application of radio frequency identity tags (RFID), for instance, in many business spheres, especially track and trace solutions in transportation and logistics operations.

R & D projects funded through Framework Programmes have been complemented by several policy frameworks, legislation and more commercially focused technology pilots under the aegis of the eTEN programme and the more recently launched 'Competitiveness and innovation programme' (CIP).

Next-generation RFID tags and nanochips will lead to the 'internet of things', a topic of great interest among European researchers funded through FP7. Numerous projects are looking at applications in healthcare, smart cars, public transport and even domestic appliances.

The internet fridge which orders milk and eggs from the supermarket may sound ridiculous, but seriously smart fridges that may communicate with the electricity grid and your central heating control are probably only a few years from the market. ■

PROJECTS IN FOCUS

European research plays a central role in the international effort to push the dimensions of electronic components to just tens of nanometres. And as the speed and power of microprocessors increases and their efficiency improves, scientists are also developing many exciting new ICT applications.

Industry analysts have predicted the collapse of Moore's law for years, but thanks to unprecedented levels of internationally coordinated industrial and public-funded research, chip manufacturers continue to squeeze more onto their silicon wafers.

But it has taken some innovative thinking and the development of entirely new approaches to chip design and fabrication.

The 'More Moore' project developed technologies for an approach called extreme ultra violet (EUV) lithography. Partner ASML subsequently produced two industrial prototype EUV machines that incorporated several components from other European SMEs. In 2010 ASML delivered its sixth EUV machine for nanochip R & D.

Another boost for Europe's increasing strength in nanochip fabrication was the development of two 'microrobots' in the Nanohand project. Each 2 centimetres robot has a 'microgripper' that can make precise and delicate movements. The 'jaws' open to about 2 micrometres and can pick up objects less than 100 nanometres in size.

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'[It is] really able to grip micro- or even nano-objects. We have handled objects down to tens of nanometres,' says Volkmar Eichhorn of the University of Oldenburg, noting this was a world first.

Project partner STMicroelectronics may want to use the 'pick-and-place' Nanohand technology to insert carbon nanotube connections on its microchips. These tiny carbon wires dissipate less heat than copper and allow circuits to be packed more densely.

Today chip manufacturers even build up chips by stacking elements in three dimensions. Unfortunately, when you pack everything in so tight, just like people, they all get rather hot and bothered.

The Nanopack project is exploring various ways to keep these stacked chips cool, for instance by optimising contact between electrical and thermal components, either to prevent energy being transformed into heat, or to help the heat escape more rapidly.

Noise is another hindrance to miniaturisation. 'An increasing fraction of the applied power is converted into non-deterministic signals that add to the ambient noise,' notes Lukas Worschech, coordinator of the Subtle project. 'It is sometimes referred to as the thermal death of electronics.'

But Subtle paradoxically uses the noise to boost the good signal. The project carefully designed chip elements so that feedback from the switches would be amplified by a phenomenon called stochastic resonance.

'These gates work at such low voltages and with so little noise that they are far ahead of the current state of the art in terms of the sensitivity,' Mr Worschech reveals. He thinks they are ideal for sensors, neural networks and quantum computers.

Success etched in MEMS

If you could shrink yourself smaller than a dust mite and explore the innards of modern machinery like cars you would discover amazing microscopic machines. Carefully etched out of silicon wafers are microscale accelerometers to trigger airbags, gyroscopes to detect and correct dangerous yaw in ships and sensors to monitor the build-up of pressure in sensitive machinery.

The automotive industry is one of the biggest consumers of microelectromechanical systems (MEMS). These tiny components marry the worlds of electronics and mechanics. Using the same manufacturing principles employed to produce microchips, it is possible to etch silicon into electrical devices with moving parts.

MEMS manufacturing is extremely complex, involving sometimes hundreds of different steps. Each step may be controlled by a dozen or more parameters, including temperatures, pressures and chemical compositions.

The Promenade project built software that supports the design of MEMS manufacturing sequences. Promenade team members at Cavendish Kinetics and the University of Siegen started a spin-off company, called Process Relations, which has secured investor funding to help with a planned worldwide launch of Promenade's commercial successor, named XperiDesk.