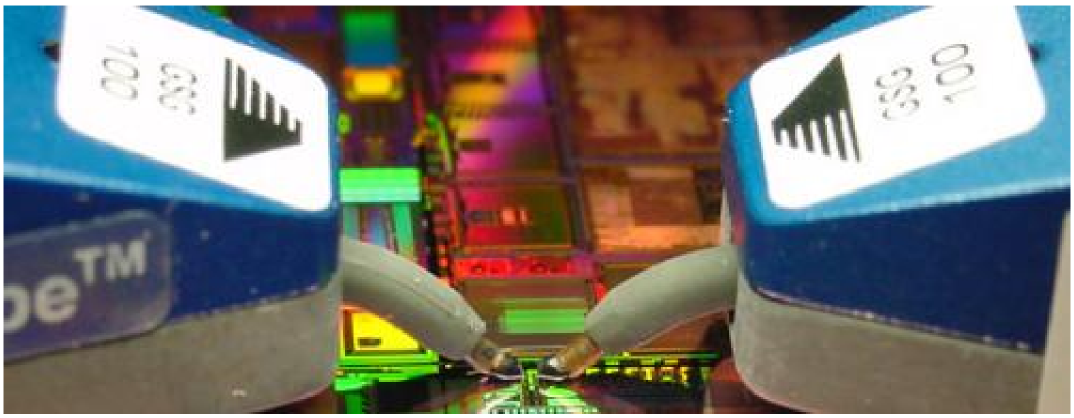
PHYS.ORG

Nanodevices for a 'More than Moore' world

October 4 2013



Credit: NANOFUNCTION project.

Moore's Law - which holds that the number of transistors on an integrated circuit, and hence its processing power, doubles every 18 months - has been the guiding principal of chip design for almost half a century. But with physical limitations to further transistor scaling being reached, Moore's Law may have met its match. We are entering a 'More than Moore' world in which EU-funded researchers are playing an important role.

Since Intel co-founder Gordon E. Moore described his theory in 1965, circuit designers have counted on the steady increase in transistor density to provide greater chip performance in ever smaller packages. Now, however, some of the physical constraints to transistor scaling - such as overheating, energy dissipation and resistance -mean that conventional semiconductor design approaches are unlikely to produce the same rate of progress.

And that is not the only challenge for more powerful and smaller electronic devices to be achieved. Moore's Law only deals with integrated circuits, such as the 'Complementary metal-oxide-semiconductor' (CMOS) chips that live inside your PC, mobile phone or digital camera. A bulky array of additional discrete passive components - such as resistors, capacitors, inductors, antennas, filters and switches - interconnected over a printed-circuit board or two are still needed for your phone to make a call or your camera to take a photo.

For real miniaturisation, a different approach is required: one based on advanced nanotechnology that promises seemingly infinite possibilities and unlimited potential applications. By integrating new functionality using tiny nanostructures such as nanowires and nanomaterials (each tens of thousands of times thinner than a human hair) into CMOS chips, the 'More than Moore' approach means electronics can keep getting smaller, more powerful and more efficient. So small in fact that a computer in pill form could monitor health and deliver drugs inside the human body, or a complete smart home control system could be combined into a package about the size of a credit card.

'Nanostructures and nanowires have received much attention for future CMOS in recent years. Nowadays activities devoted to using nanostructures, especially nanowires, to create innovative "More than Moore" products are very promising,' says Dr Francis Balestra, the Director of the Sinano Institute of France's Centre National de la Recherche Scientifique (CNRS) and a researcher at INP-Minatec in Grenoble.

Devices on the nano-scale

In the 'Beyond CMOS nano-devices for adding functionalities to CMOS' (NANOFUNCTION) Network of Excellence, Dr Balestra and a team of researchers from 15 academic and industrial partners in 10 European countries worked on how nanostructures can be integrated with CMOS chips to add a vast array of new functionality on a tiny scale. Supported by EUR 2.8 million in research funding from the European Commission, the consortium focused particularly on ultra-sensitive nanosensors capable of detecting signals in molecules; nanostructures for harvesting energy for the development of autonomous nanosystems; nanodevices for spot cooling of integrated circuits; and nanodevices for radio-frequency (RF) communication.

'These nanodevices will be needed in the future for very low power or autonomous nanosystems for many applications, including health and environmental monitoring and the "Internet of Things",' Dr Balestra explains.

Nanoscale systems-in-package (SiP) or system-on-chip (SoC) devices, integrating processing power with sensors, RF communication and a range of other functionalities, for example, could be used to detect all manner of substances, toxic and benign, including chemicals in the environment, in food, and in the human body.

In the NANOFUNCTION project, the researchers advanced the current state of the art, developing a low-cost and highly efficient nanowire sensor array, which contains more than 1000 silicon nanowires and integrates different sensing elements to simultaneously detect various molecules. To test the array, the team designed effective functionalisation techniques for DNA grafting - a cutting-edge and highly experimental process in which a segment of DNA is removed and replaced by another form of the DNA structure.

The team further showed how nanostructures, as well as acting as sensors, can also provide critical improvements to existing sensor technology and other electronic applications. Working in an area known as 'cooltronics,' the team proved that huge performance enhancements or new regimes of operation are enabled when critical components in an electronic circuit are cooled to ultra-low temperatures. Their approach relies on a new type of 'electron cooler' that uses strained silicon (sSi) in combination with a superconductor, and which has so far been tested on terahertz (THz) radiation sensors - an emerging technology operating in the frequency range between microwaves and infrared light waves, which has many potential uses, including medical imaging, security and space applications.

Similarly, the consortium took a cutting-edge approach to using nanostructures for RF communications, exploring the potential for nanowires to be used as highly efficient RF interconnects and antennas - technology that could lead to much smaller communication devices.

Nano-power

But where would such a tiny device draw power from? Conventional batteries are still a long way from reaching the nanoscale. The NANOFUNCTION researchers therefore investigated innovative ways to power nanoscale devices from their immediate environment, drawing energy from vibrations, movement, heat or solar power and storing it in active materials that can act as nano-batteries. The development paves the way for fully autonomous nano-devices able to power themselves.

'These nanotechnologies will be combined and integrated in future autonomous nanosystems, which will be needed for many applications. The main challenges are the development of CMOS-compatible technologies and the reduction of the energy consumption of sensors, computing and RF communication, as well as increase in the energy harvested from the environment,' Dr Balestra says.

He notes that in the NANOFUNCTION project many challenges have been overcome, and that the team's work is helping open the door to further miniaturisation of devices.

'Miniaturisation remains a major enabler for price reduction, functionality multiplication, and integration with other electronics. In addition, nanoscale structures can improve devices' intrinsic performance or enable new functionality, such as ultra-high-sensitivity detection,' he explains.

In advancing the current state of the art and carrying out extensive dissemination activities among the European and international nanotechnology community, NANOFUNCTION's work constitutes an important benchmark in the field.

'It will benefit European industry and society by preparing long-term integration, which Europe can rely on to underpin research on advanced technology development in this strategic "More than Moore" field - in which Europe already has a strong position,' Dr Balestra says.

He notes, nonetheless that it is likely to be 10 to 20 years before such advanced nanodevices make their way into commercial applications.

'For commercial exploitation, additional research will be needed in order to optimise these nanocomponents for very important applications for European economy and society,' he says.

More information: www.nanofunction.eu/nanofunction/

Provided by CORDIS

Citation: Nanodevices for a 'More than Moore' world (2013, October 4) retrieved 27 April 2024 from https://phys.org/news/2013-10-nanodevices-world.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.