CALL 2009

Project profile

MERCURE

Micro- and nanotechnologies based on wide band gap materials for future communication and sensing systems

The ENIAC JU project MERCURE is developing advanced semiconductor materials to provide functionality not available before with silicon-based micro- or nanoelectronics. It will enable future ambient intelligence systems to achieve autonomous and self-reconfigurable operations with real-time and efficient self-optimisation of performance. Key applications will include the future wireless communications market which will expand to higher frequencies as new applications and frequency bands are allocated. This will require an always-connected, multi-standard, multi-service communications environment.

Sub Programme

- Nanoelectronics for Communications

Future smart systems will have to be autonomous and self-reconfigurable for real-time and efficient self-optimisation of their performance. Such systems must not only overcome the design trade-offs that current analogue components endure but also realise new and more efficient circuits with reduced size, weight, power and cost.

Two technologies are emerging to enable such performance. Wide band gap (WBG) materials such as gallium nitride (GaN) and aluminium nitride (AlN) are expected to play a fundamental role in the development of future smart systems, while RF micro-electromechanical system (MEMS) and nano-electromechanical system (NEMS) switches appear as complementary technologies to achieve the reconfigurability required for future smart systems.

WBG semiconductor materials demonstrate unique physical properties with unprecedented power handling and robustness that make them attractive for microwave and millimetre wave applications. They are also ideal for the creation of a new generation of sensing devices capable of working in harsh environments at temperatures above 600°C. This is particularly appealing for automotive, aeronautics and aerospace applications and for intelligent energy control sensors.

Merging technologies

The ENIAC JU project MERCURE is setting out to merge these technologies and functions to enable the reconfigurability of high power systems. This involves the integration of advanced microwave functions using WBG monolithic microwave integrated circuits (MMICs) – IC devices that operate at microwave frequencies from 300 MHz to 300 GHz – and sensors together with RF MEMS and RF NEMS active interconnections.

The four main objectives are to:

1. Integrate WBG devices and RF MEMS switches;
2. Integrate WBG devices and RF NEMS switches based on carbon nanotubes;

3. Realise and optimise WBG-based sensors and develop the technology necessary for their monolithic integration with WBG MMICs and RF MEMS; and
4. Display the integration of these technologies in four demonstrators.

A variety of materials

A variety of materials are being studied. Silicon and silicon carbide (SiC) are the most likely substrates. GaN/AlGaN layers will be grown epitaxially on these substrates to obtain the electronic structures in line with design rules specified at nanometric scale and will be processed according to micro- and nano-scale dimensions for the gate-control electrode.

Metal and dielectric technology will be employed for the MEMS switches, with carbon nanotubes grown using plasma-enhanced chemical-vapour deposition (PECVD) employed for the NEMS switches. GaN will be structured with nanometre precision and treated with various metallic catalytic materials.

Micron- or submicron-scale thick GaN and AlN membranes will be fabricated using silicon micromachining technologies for use as for piezoelectric acoustic devices for high Q resonators. Selective GaN and AlN etching techniques will be employed for the integration of the resonators with the high electron mobility transistor amplifier.

Mixed-technology systems

While the basic principles of the micro- and nanotechnologies involved have been addressed individually in the past, future smart micro and nano systems require exploration of their integration capabilities. MERCURE will validate the compatibility and integration possibilities of components and functions, such as GaN-based MMICs.

The technology proposed will allow the demonstration of mixed-technology systems that address integrated micro- and nano-system applications. GaN-based MMICs will meet the needs for high-frequency, high-power and low-noise applications. These will be combined with passive and active devices realised with micro and nano features. Actuating, interfacing, sensing and power controlling are all functions that the MERCURE chip will be capable of performing.

Knowledge sharing

The resulting smart systems will have a major socioeconomic impact, demonstrating new and improved functions in fields including:

- Environment where sensors for intelligent energy control will reduce electrical energy consumption; and
- Improved and safer transport and mobility through sensors, car radar systems and enhanced communications systems with sensor-based adaptive capability.

Demonstration of such multifunctional chips will show that it is possible to achieve fast reconfigurable communications systems optimally connected anywhere and anytime. New generation aerials will be developed based on the proposed approach. These will include smart aerials and modules for fast transmission and reception.

The realisation of MERCURE's ambitious objectives will enable Europe to achieve technological leadership in its targeted domains.

Nanoelectronics for Communications

Partners:
- AGH University of Science and Technology
- Foundation for Research & Technology – Hellas (FORTH)
- National Institute for Research and Development in Microtechnologies (IMT)
- SHT Smart High Tech
- Thales Research & Technology
- Thales Systèmes Aéroportés
- TopGaN
- University of Warsaw
- VIA electronic

Project co-ordinator:
- Afshin Ziaei, Thales

Key project dates:
- Start: February 2010
- Finish: January 2013

Countries involved:
- France
- Germany
- Greece
- Poland
- Romania
- Sweden

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- €3.3 million

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