GaNonCMOS

The project

Power electronics is the key technology to control the flow of electrical energy between source and load for a wide variety of applications from the GWs in energy transmission lines, the MWs in datacenters that power the internet to the mWs in mobile phones. Wide band gap semiconductors such as GaN use their capability to operate at higher voltages, temperatures, and switching frequencies with greater efficiencies. The GaNonCMOS project aims to bring GaN power electronic materials, devices and systems to the next level of maturity by providing the most densely integrated materials to date. This development will drive a new generation of densely integrated power electronics and pave the way toward low cost, highly reliable systems for energy intensive applications. This will be realized by integrating GaN power switches with CMOS drivers densely together using different integration schemes from the package level up to the chip level including wafer bonding between GaN on Si (111) and CMOS on Si (100) wafers.

This requires the optimization of the GaN materials stack and device layout to enable fabrication of normally-off devices for such low temperature integration processes (max 400ºC). In addition, new soft magnetic core materials reaching switching frequencies up to 200 Mhz with ultralow power losses will be developed. This will be assembled with new materials and methods for miniaturized packages to allow GaN devices, modules and systems to operate under maximum speed and energy efficiency. A special focus is on the long-term reliability improvements over the full value chain of materials, devices, modules and systems. This is enabled by the choice of consortium partners that cover the entire value chain from universities, research centers, SME's, large industries and vendors that incorporate the developed technology into practical systems such as datacenters, automotive, aviation and e-mobility bikes.

The Partners

Project coordinator: Jean-Pierre Locquet – KULeuven

Partners involved: The GaNonCMOS consortium is composed of 11 recognized key actors on the topics of materials, processing, components and systems for power electronics.

Universities: Katholieke Univeriteit Leuven, University College Cork – National University of Ireland (Tyndall –UCC).

Research centers: Fraunhofer IAF, IHP GmbH – Innovations for High Performance Microelectronics/Leibniz-Institut für Innovative Mikroelektronik GmbH

Industry: EpiGaN NV, IBM Research GmbH, AT&S Austria Technologie & Systemtechnik Aktiengesellschaft AG, RECOM Engineering GmbH & CO KG, NXP Semiconductors Netherlands BV, X-FAB Semiconductor Foundries AG

Consulting: PNO Innovation NV

Achievement in the first 6 month

Work in progress

VRM system-level modeling and design
The work at Voltage Regulator Module (VRM) system-level focused on a number of preparatory but determinative activities. A structured segmentation of the power converter market and applications was executed. Subsequently, existing State-of-the-Art best-in-class regulator commercial solutions were reviewed, analysed and classified for their key metrics such as power density, current density and switching frequency. Then specification targets for converters to be designed for specific future applications were set. Moreover, best-in-class switch technologies, were reviewed and analysed and across five application segments and the three levels of integration, regulator specifications and topology choices were made. Generally, a new trajectory of high phase count solutions with low current per phase is the approach. Finally, key component sources were identified and various discrete and asymmetric monolithic GaN bridge stages were conceptualized.

Materials exploration and development
Concerning materials exploration and development, the activities started with a review of the state of the art and the identification of Copper-Zinc-Tin and Copper-Zin-Tin-Bismuth as starting materials. In addition, also process development has been started up.

Components development and fabrication
The initial activities in this area focused on the production of an embedded inductor complete with switches actives and passives.

For this purpose, the production of a first demonstrator was started, novel magnetic materials were sourced, and first dummy components were received.

Reliability and characterisation
Regarding reliability and characterisation, the main activity was the preparation for the testing of samples and demonstrators. New test equipment was purchased and a concept for the test coupons has been agreed.

Demonstration and piloting
Concerning demonstration and piloting, the work commenced with the definition of requirements for the targeted applications. Different categories of 10 Vendor Relationship Management demonstrators to that could potentially be developed in the project were defined. Subsequently, a list of 10 priority demonstrators was established. Then for each of these demonstrators, a detailed planning of the development, fabrication and iterations was set-up.

Dissemination and exploitation
With regard to dissemination and exploitation, the activities started with the set-up of the project website www.ganconcmos.eu. Moreover, a systematic stakeholder analysis to identify the most important stakeholders within and around the GaNonCMOS value chain was initiated. The analysis relies on a methodology to identify the relevant organisations who could benefit from the results of the project, or have interests or synergy with the activities of GaNonCMOS.