CALL 2012-1

Project profile

E²COGaN

Energy Efficient Converters using GaN Power Devices

Highly efficient power conversion is at the heart of the worldwide effort for a green economy, requiring devices with improved capabilities, feasible by replacing the silicon basis material with compound materials with a wide band-gap such as gallium nitride (GaN). The ENIAC JU project E²COGaN will demonstrate the benefits of GaN devices in micro-grid interfacing circuits for photovoltaic power generation and in grid-connected chargers for high voltage batteries for electro-mobility, establising a pan-European GaN power electronics ecosystem and competence.

Area

- Automotive and Transport
- Energy Efficiency
- Equipment, Materials and Manufacturing

Objectives

Efficient power conversion systems are at the heart of the worldwide effort for a green economy, since they can minimize losses and save energy, contributing thus to a better CO_2 balance sheet. Semiconductor power devices are the central components of any power conversion circuit that transforms voltages, e.g. from 220V AC mains to 12V DC for an end-user appliance or, reversely, from a car battery supplying DC to the AC required by an electric motor. Optimized power conversion is essential for the systems relying on batteries or on limited renewable energy sources. The market success of full electric vehicles depends critically upon highly efficient power switching devices.

Over the past 30 years, silicon has been successfully used for high voltage (>400V) power switches, thanks to major breakthroughs in device architectures (IGBT, super-junction). However, due to the intrinsic properties of the material (relatively low bandgap, limited thermal conductivity etc.), the rate of progress slowed down. Further performance improvements and higher efficiencies will become more and more challenging and cost-intensive to achieve, making disruptive power device technologies based on Wide-Band Gap (WBG) materials like GaN and SiC increasingly attractive because of their potential to achieve higher performance at equivalent cost.

Both SiC and GaN present a band gap of about 3.3eV and an associated critical field of about 3 MV/cm – 10 times higher than in Si – enabling to decrease considerably the total chip area at equivalent high voltage and on-state resistance. The current designs mainly rely on unipolar structures (FET-based switches and Schottky-barrier diodes). The very low switching losses and practically no reverse recovery energy allow higher switching frequencies and a massive reduction of the passive components. The WBG-based devices perform intrinsically better in harsh environments under high temperatures, making them a strong contender for the automotive market. SiC diodes are for instance commercially available, with the first switches being currently introduced. SiC power electronics is however still hampered by a severe cost penalty of the SiC starting material.

Boosted by the widespread use of GaN in optoelectronics – GaN is the starting material for blue and green emitting (laser) diodes – researchers started building devices for radar and RF for military and aerospace applications, but recent advances in the challenging epitaxy of GaN on silicon substrates bear the promise to significantly reduce costs down to silicon levels, triggering investigation on GaN use for high volume markets among which the power conversion. We foresee a dominant position of this technology by the end of this decade in power converters for electrical vehicles and photovoltaic systems.

Work and consortium

E²COGaN will demonstrate GaN-on-Si as a disruptive High Voltage (HV) technology. Devices like Schottky Barrier Diodes (SBD) and High Electron Mobility Transistors (HEMT) shall be developed and introduced through the whole value chain up to demonstrators with high industrial, societal and environmental relevance. The plan is to start with 600V, 10A GaN power devices developments, concentrate in the early stages on applications below 10kW, and then gradually explore voltages up to 1500V and currents up to 100A.

Special attention will be paid on reliability issues and parasitic effects that will be investigated through a combined approach based on advanced electro/optical measurements and electro/thermo/mechanical TCAD simulations to understand and identify the Safe Operating Area and to develop a robust and reliable GaN-on-Si power device technology platform.

Another important topic is the development of suitable packages / modules allowing high frequency and/or high temperature operation together with the design and implementation of the associated gate drivers.

The consortium provides a common and global, industry-relevant approach involving the whole GaN power electronics value chain from the substrate provider, GaN device manufacturer, assembly house to the end user. It is completed by top academic institutes and other tool or service providers (simulation software, measurement tools, etc.).

Expected results

The project demonstrators will focus on two application domains with strategic relevance:

Firstly, on photovoltaic (PV), where the use of GaN will be explored in micro-grid interfacing circuits evaluating an overall gain in system efficiency and operating cost over incumbent Si- or competing SiC-based solutions.

Secondly, on automotive, where the benefit of GaN will be investigated in grid-connected chargers for high voltage batteries, as found in new hybrid and full electric vehicles. Power conversion for interfacing to lower voltage levels will also be investigated. Main motivations are gain in efficiency, weight, footprint, and – related to the expected high temperature operation capacity – ease in the heat and cooling management.

Moreover, the project will include a pre-study in aeronautics with specific high temperature (250°C) mission profiles as well as the atmospheric radiation constraint.

Impact

Among the foreseen potential societal and environmental impact of this project are the establishment of a pan-European GaN power electronics technology ecosystem and competence ensuring the autonomy of Europe on strategic and disruptive semiconductor and power conversion technologies, the contribution to higher efficiency in both energy generation and usage and last, but not least, a significant step towards a knowledge-based, resource efficient, low carbon European industry and economy.

Automotive and Transport

Partners

- AUDI AKTIENGESELLSCHAFT
- AZZURRO Semiconductors AG
- BITRON SPA
- CIRTEM
- CISC SEMICONDUCTOR GMBH
- COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES
- CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LA NANOELETTRONICA
- EPIGAN NV
- EUROPEAN AERONAUTIC DEFENCE AND SPACE COMPANY EADS FRANCE SAS
- FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V
- Microwave Characterization Center SAS
- NanoDesign, ltd.
- NXP SEMICONDUCTORS NETHERLANDS BV
- NXP SEMICONDUCTORS UK LIMITED
- NXP SEMICONDUCTORS BELGIUM NV
- ON SEMICONDUCTOR BELGIUM BVBA
- ROBERT BOSCH GMBH
- SCHNEIDER ELECTRIC INDUSTRIES SAS
- SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE
- STMICROELECTRONICS SRL
- SYNOPSYS SWITZERLAND LLC (*)
- TECHNISCHE UNIVERSITEIT EINDHOVEN
- UNIVERSITAET KASSEL
- UNIVERSITY OF BRISTOL

Project co-ordinator:

- Frederik Deleu, ON Semiconductor Belgium BVBA

Key project dates:

- Start: 01.04.2013
- Finish: 31.03.2016

Countries involved:

- Austria
- Belgium
- France
- Germany
- Italy
- The Netherlands
- Slovak Republic
- Switzerland
- United Kingdom
- Spain

Total budget:

- € 26.3 million

The ENIAC Joint Undertaking, set up in February 2008, co-ordinates European nanoelectronics research activities through competitive calls for proposals. It takes public-private partnerships to the next level, bringing together the ENIAC member states, the European Commission and AENEAS, the association of R&D actors in this field, to foster growth and reinforce sustainable European competitiveness.

Details correct at time of print but subject to possible change. Updates will be included in the project summary at the end of the project.

ENIAC Joint Undertaking • Brussels • Belgium
Tel : +32 2 221 81 02 • email: eniac@eniac.europa.eu • website: www.eniac.eu