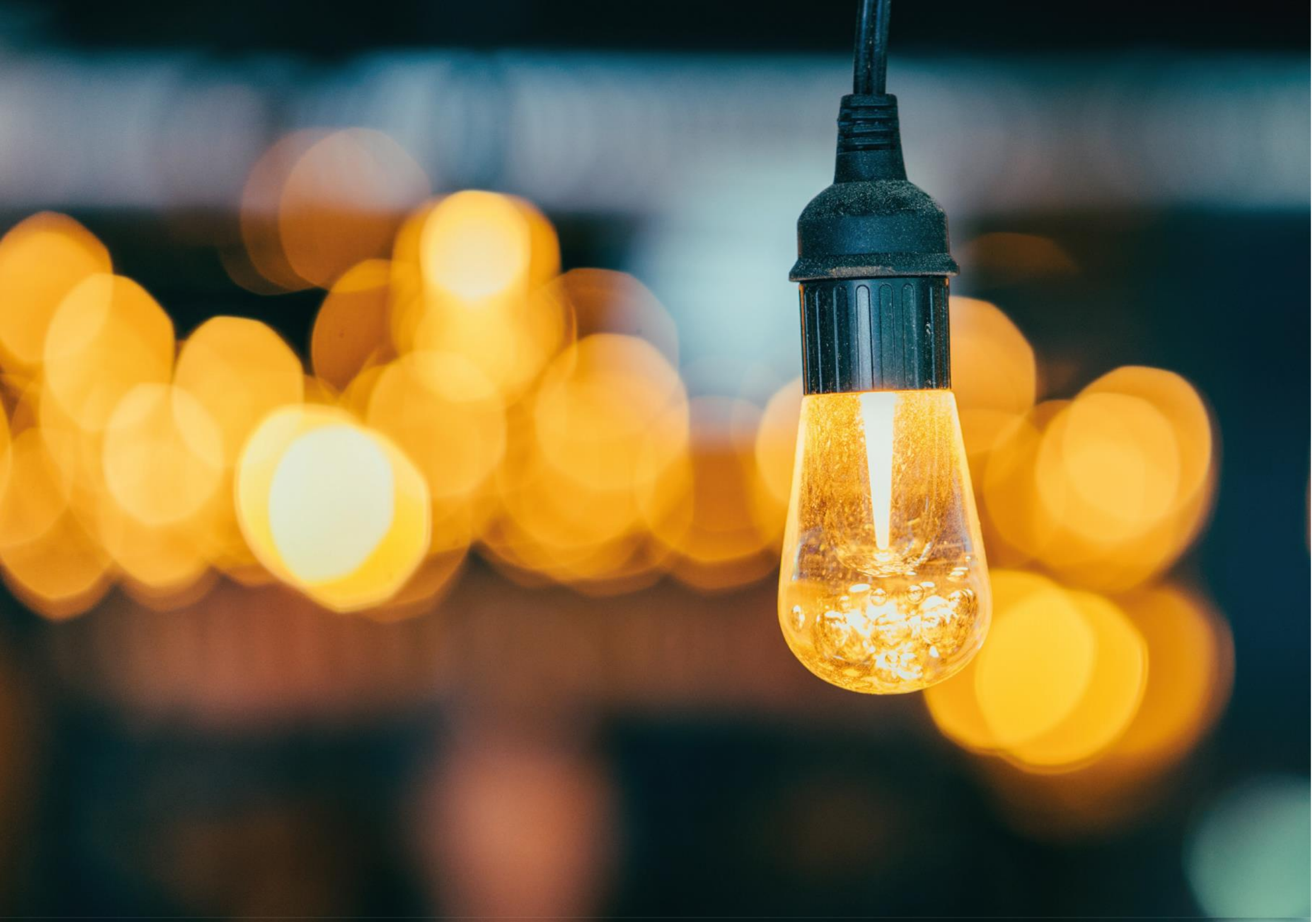


Powergan:
Creating a French industry

Professional seminar

15/03/2022

IRT SAINT EXUPÉRY

NANOELEC.

INSTITUT VEDECOM

Foreword

Power electronics covers a vast range of applications, from personal electronics to the electrification of private and public transport. Gallium nitride (GaN) and other wide bandgap materials can considerably reduce the energy losses that occur during voltage transformations. For the 100-650V range, GaN-on-silicon (GaN/Si) technologies are supplementing the current possibilities offered by silicon carbide and silicon components. They enable compact and efficient, low-cost conversion systems to be envisaged, designed to meet the wide range of society's electrification needs.

At a time when the technology is mature enough for industrialisation, the Nanoelec and Saint Exupéry IRTs and the Vedecom ITE propose bringing the academic and industrial GaN community together, for discussions on the following topics:

- Structuring an industrial sector, at the initiative of STMicroelectronics, and the contribution of the dedicated IRT Nanoelec programme
- Application prospects and R&D aspects
- Institutional initiatives

[Strategy]

2017 – 2021:
the Powergan programme

Over the period 2017-2021, the R&D programme at IRT Nanoelec dedicated to GaN helped structure the national GaN value chain, with a research strategy based on disruptive GaN/Si power devices, using 200mm technology and co-design tools and techniques for GaN compatible power converters. The programme is being extended with the "650V transistor" technology transfer to STMicroelectronics and the development of a proof of concept for a digital twin dedicated to GaN components.

VISION

Supporting and accelerating the development of a new generation of power components to meet the challenges of the digital and energy transitions.

AMBITION

Contributing to structuring the national GaN value chain with a research strategy based on disruptive GaN/Si power devices, using 200mm technology, and co-design tools and techniques for GaN compatible power converters.

MISSION

Preparing the "650V transistor" technology transfer to STMicroelectronics and establishing proof of concept for a digital twin dedicated to Powergan components.

PARTENAIRES
Partners

CEA, Grenoble-INP, Schneider Electric, Siemens EDA, STMicroelectronics

Very compact and efficient, low-cost power converters

The work of the Nanoelec/Powergan programme is in particular focusing on preparing the next generations of 650V converters.

From smartphones, to household appliances, to electric vehicles, electrical current and voltage have to be processed and controlled by means of a converter, to adapt the voltage levels requires for each specific device. However, power conversion entails energy losses. Gallium nitride (GaN) and other Wide Bandgap materials can considerably reduce these losses. Until recently, these technologies were too costly for use in power conversion applications. But driven by the aeronautical and automotive industries in their quest for highly compact, efficient, low-cost converters, the R&D centres are today pioneering new GaN techniques.

The aim of the Nanoelec/Powergan programme was to reinforce and structure a national industrial and academic ecosystem to help the French and European industrial actors establish themselves in a variety of sectors, ranging from personal electronic equipment to the electrification of private and public transport. The teams taking part in this programme are contributing to the development of GaN-on-silicon (GaN/Si) technologies in order to overcome the technical and economic limitations of the technologies currently available for power components in the 100-650V segment. The programme is based on a disruptive technology using 200mm wafers compatible with mass production. This technology transfer lies at the heart of the GaN/Si pilot line that STMicroelectronics is running in its Tours plant in France.

We are improving the performance and reliability of the first generation of 650V components and preparing for the next generations. In order to drive systems miniaturisation even further, we are working on disruptive converter architectures. We are also developing tools and methods to co-design component and system architectures in order to accelerate technological adoption, in particular in demanding environments such as automotive applications and energy/power conversion.

The work done on the Powergan programme led to significant progress in the performance offered by the next generations of power components, even if R&D efforts will still be needed in the coming years. Each architecture has its own potential, depending on the target application. Over the past five years, the academic and industrial teams working together within Nanoelec have explored a variety of architectures in order to address the need for efficiency at low cost and, perhaps even more importantly, the need for more ecological power electronics.

[Industrial context]

Industrial transfer for a production line in France

STMicroelectronics, a major partner of IRT Nanoelec, took part in the Nanoelec/Powergan programme to develop a disruptive gallium nitride (GaN) technology on 200mm silicon wafers, for power electronics applications. This technology will be transferred to a pilot line in its Tours manufacturing plant in France. For this global electronics player, this is a key element of its ecosystem built around power switching components, as are its collaboration with TSMC and its acquisition of Exagan. With Filippo Di Giovanni, Strategic Marketing Director, a review of innovation and key programmes at the Power Transistors Division of STMicroelectronics in Catania, Italy.

What is the position of STMicroelectronics regarding power switching devices?

We consider that there are many growth opportunities on the markets for power components using both silicon carbide (SiC) and GaN based Wide Bandgap materials and we are investing in order to build solid and reliable supply chains guaranteeing that ST will be a global leader in both technologies. The purpose of the ecosystem we are building is to address the specific needs of the main applications of the power electronics market with the appropriate technologies. ST's GaN on silicon technology is ideal for high-efficiency and high-power applications, notably for on-board automobile chargers, DC-DC converters for hybrid and electric vehicles, wireless charging and IT servers.

In 2020, STMicroelectronics announced an agreement with TSMC, one of the world's leading foundries, as well as the acquisition of the French start-up Exagan. What is your roadmap for GaN technologies?

Our objective with GaN is to reproduce the success we enjoyed with SiC, by rapidly establishing ourselves as leader. We are firmly convinced that this technology will be omnipresent in strategic fields, in particular in energy management (industrial and automotive). This is why we are adjusting our technology platform and our manufacturing strategy.

The collaboration with IRT Nanoelec is a key element in our development strategy for a 200mm power GaN technology platform. Our pilot line on the production site in Tours, France will be the backbone of our development of a complete range of products.

At the same time, we are working with TSMC and Exagan to accelerate the large scale adoption of GaN technology by rapidly growing markets.

The acquisition of the innovative Exagan company brings us broader epitaxy expertise, additional product development skills and extensive knowledge of applications. Exagan is continuing with its product roadmap, and ST is supporting it with deployment.

How do the contributions of the Nanoelec/Powergan programme figure in this strategy?

From 2017 to 2021, Powergan was the framework for a fruitful collaboration which took us towards the next generations of GaN power components. The currently ongoing developments on 200mm wafers, advanced 650V transistors and Schottky diodes based on the MIS Gate Recess approach, are enabling us to initiate transfer to our pilot line in Tours. Based on our experience with silicon or SiC power components, we know that GaN power components will improve significantly in the future. This IRT Nanoelec programme brought together the multidisciplinary industrial and academic expertise needed to take the devices to the theoretical limits of the GaN material, while at the same time designing additional "smart" and high value-added functions for the end users.

[Morning programme]

Powergan: creating a French industry

National symposium

8h30	**Reception**	
9h	Opening	Hughes Metras, IRT Nanoelec Director Sandrine Maubert, IRT Nanoelec Deputy Director
9h15	[Overview] The GaN markets	Claire Troadec, Power & Wireless Division Director at Yole Développement
9h45	[Reference viewpoint] Status of wide bandgap technologies, ST strategy and structuring of the French GaN sector (Powergan challenges)	Filippo Di Giovanni, Strategic Marketing, Innovation and Key Programs Manager at ST Microelectronics
10h30	Coffee break	
10h45	[Round-table] GaN application prospects for energy transition	Moderated by > Fabio Coccetti, Head of “Component Modelling and Reliability” Department Competence Centre – “More Electrical Aircraft” at IRT Saint Exupéry > Roch El Khoury, Head of Electrification department at ITE Vedecom With > Laurence Allirand, Component specialist Active ICs, Wide Band Gaps & Supply Security at Vitesco Technologies > Marc Marin, HO EEE Parts Engineering and Radiation-France at Airbus Defence and Space > Eric Moreau, Products and Applications Director / Director of the Exagan-STMicroelectronics site in Toulouse > Miao-Xin Wang, Advanced Power Electronics, Schneider Electric > Jean-Sylvio Ngoua Teu, Power Electronics Engineer, Safran
12h30	[Buffet and poster sessions] Overview of scientific production of Powergan	Presentation by Raphael Salot, Nanoelec/Powergan programme Director & Major Accounts Manager at CEA-Leti, with the project managers: René Escoffier, Charley Lanneluc, Romain Gwoziecki, Léo Sterna (CEA-Leti) and Jean-Luc Schanen (G2ELAB: UGA/G-INP/CNRS)

[Afternoon programme]

Powergan: creating a French industry

National symposium

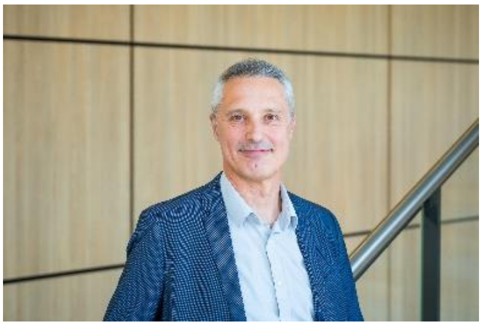
13h30	[Reference viewpoint] GaN for Automotive Powertrain: Current situation and perspectives	Jean Philippe Mercier, HEV System & e-motor Expert Leader, Groupe Renault
14h15	[Round-table] Scientific obstacles and technological challenges: vision and areas for research for the sector players (academic and industrial)	Moderated by Marc Plissonnier, Head of the "Energy Electronics & sensor systems" department at CEA-Leti with > Véronique Souza, Head of the "Power Semiconductor Devices" laboratory at CEA-Leti > Sébastien Houivet, Product Technical Director ELVIA Group > David Trémouilles, researcher at CNRS-Laas, > Jean-Luc Schanen, Lecturer at G2ELab (Grenoble-INP/UGA) > Pascal Bolcato, Engineering Director Analog & Mixed-Signal at Siemens Digital Industries Software
15h30	Coffee break	
16h	[Overview] Institutional initiatives and ongoing projects	Raphael Salot, Nanoelec/Powergan programme Director & Major Accounts Manager at CEA-Leti.

[Introduction]

A national symposium for gallium nitride-based power electronics

By Hughes Metras, Director of IRT Nanoelec and Sandrine Maubert, Deputy Director of IRT Nanoelec

9h ► 9h15



Hughes Metras has been Director of the Nanoelec technological research institute (IRT) since 1 September 2020. He was previously at CEA-Leti in charge of strategic management of industrial partners in the United States geographical area, a country where he opened the commercial office of the Leti institute in 2011. Before heading abroad in 2011, he was Deputy Director of CEA-Leti, in charge of programmes coordination and sales. Hughes Metras graduated from the Ecole Centrale in Marseille, the IAE (business administration institute) of the Université de Pau et des Pays de L'Adour and holds an MBA from Miami University.

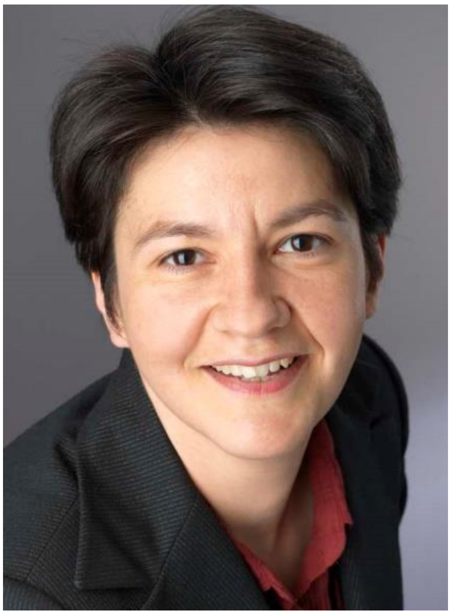
Sandrine Maubert is Deputy Director of the Nanoelec technological research institute (IRT), which she joined in July 2016. She occupied the position of Project Manager for development of medical devices at CEA-Leti as of 2008. For 13 years, she worked in the microelectronics industry. She was in charge of industrialisation of CMOS technology modules at Freescale as part of the alliance in Crolles as of 2003. Before that, she worked as quality monitoring manager on 2 production lines at Motorola in Phoenix, USA. Sandrine Maubert is a graduate of Supelec, and holds a Master of Science diploma in Electrical Engineering from Georgia Tech University in Atlanta (USA).

[Overview]

The GaN markets

By Claire Troadec, Director of the "Power & Wireless" division at Yole Développement.

9h15 ► 9h45



Claire Troadec is Director of the Power & Wireless division at Yole Développement, part of the Yole Group of Companies. These activities cover power electronics, batteries & energy management, compound semiconductors and emerging materials, RF devices and technologies.

Based on her valuable experience in the semiconductor industry, Claire is managing the expansion of the Power and Wireless team's technical and market expertise. Daily interactions with leading companies allow analysts to collect a large amount of data and compare their visions of evolution and technology breakthroughs in various market segments.

In addition, Claire's mission focuses on the management of business relationships with industry leaders and the development of market research and strategy consulting activities inside the Yole Group.

Claire Troadec holds a Master's degree in Applied Physics specializing in Microelectronics from INSA (Rennes, France). She then joined NXP Semiconductors, and worked for 7 years as a complementary metal-on-silicon oxide semiconductor (CMOS) process integration engineer at the IMEC R&D facility. During this time, she oversaw the isolation and performance enhancement of CMOS technology node devices from 90 nm down to 45 nm. She has authored or co-authored seven US patents and nine international publications in the semiconductor field and managed her own distribution company before joining Yole Développement in 2013.

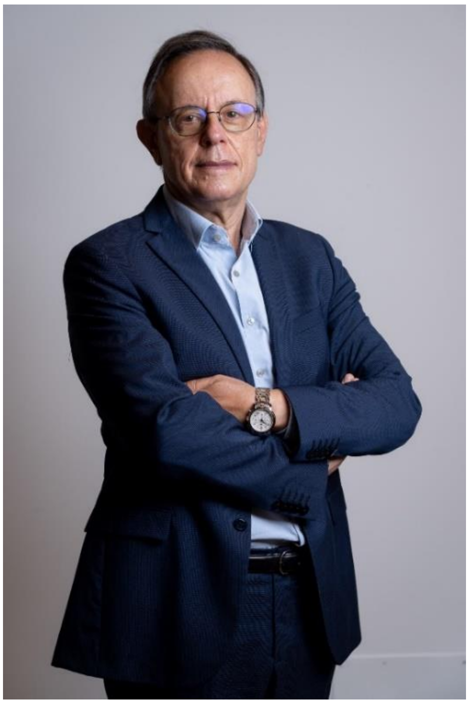
[Reference viewpoint]

Status of wide bandgap technologies, ST strategy and structuring of the French GaN industry (Powergan challenges)

By Filippo Di Giovanni, Director of strategy marketing, innovation and key programmes in the Power Transistors Department of STMicroelectronics in Catania, Italy

9h45 ► 10h30

- Wide bandgap semiconductors address the needs of the decarbonised economy and of the energy transition, helping to systematically improve conversion efficiency
- ST is following a global strategy on wide bandgap products
- Robust presence on the electric vehicles market, thanks to SiC components (MOSFETs)
- Ongoing cooperation with IRT Saint Exupéry: SiCRET. GaNRET shortly. ECSEL: TRANSFORM and GaN4AP
- Complete GaN roadmap
- The GaN sector relies on an ecosystem of industrial expertise and advanced research



Filippo Di Giovanni is currently Director in charge of Strategic Marketing, Innovation and Key Programs for wide bandgap products and power modules at ST Microelectronics Italy.

Mr. Di Giovanni's experience includes silicon power transistors as well as silicon carbide and gallium nitride. The knowledge he has acquired over the years enables him to take part in various technical conferences dedicated to energy conversion. He is also coordinator of various European projects such as TRANSFORM and GaN4AP and a permanent member of a group managing the collaborative development of new technologies with industrial partners.

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[Round-table]

GaN application prospects for energy transition

10h45 ► 12h30

GaN chargers for general public applications are emerging with considerable benefits in terms of performance, weight and size. The mass production effect will enable us to initiate this transition earlier than anticipated, although the power and voltage range will remain limited.

This round-table explores the prospects for GaN applications as enablers in the energy transition sectors.

As the technological benefits of GaN technology have already been demonstrated, we will explore the opportunities and risks associated with commercial adoption, together with the industrial players.

Each of the participants at the round-table highlights the advantages and complementarity of GaN with respect to SiC, for large volume applications.

With

> Laurence Allirand, Component specialist Active ICs, Wide Band Gaps & Supply Security at Vitesco Technologies

> Marc Marin, HO EEE Parts Engineering and Radiation-France at Airbus Defence and Space

> Eric Moreau, Product & Application Director/ Toulouse Site Director at Exagan-STMicroelectronics

> Jean Sylvio Ngoua Teu, Power electronics research engineer, Safran

> Miao-Xin Wang, Expert in Advanced Power Electronics, Schneider Electric

Moderated by Fabio Coccetti & Roch El Khoury

Fabio Coccetti is head of the "Component Modelling and Reliability" Competence Centre – "More Electrical Aircraft" department of IRT Saint Exupéry

Roch El Khoury, Head Of the Electrification Department at ITE Vedecom

Measurement of heat flux in the component

Proofs of concept for functions that can be integrated onto a chip with a view to developing new components capable of contributing to large-scale adoption of GaN technology by the market. Here we present a study for a heat flux sensor that prevents degradation of the component.

When using a power transistor, its operating state must be known, more particularly its temperature, so that this can be limited, to avoid degrading the characteristics. Operation at too high a temperature leads to an increase in heat losses which can result in reduced performance or even a shortened component lifetime. Managing the thermal parameter generally entails using a temperature sensor which is usually added to the transistor package or, more recently, integrated directly on the same chip.

The approach being studied at Nanoelec/Powergan is not based on the use of temperature sensors, but rather on heat flux sensors. The principle of these sensors is not to measure a single temperature, but two temperatures at different distances on the heating part. This sensor (called a thermoelectric sensor) is based on the Seebeck effect, which can generate a voltage in a circuit made up of two electrically connected materials that conduct differently, for which the connections are kept at different temperatures.

This original solution enables a flux sensor to be integrated, using only the basic building blocks of HEMT transistor manufacturing, with no extra processes being added.

Three sensor geometries were produced in order to study the impact of their shape and position as compared with a central heating element, here consisting of a 10A rating HEMT transistor.

The results show very good sensitivity of the sensors to the heat flux. The sensors' response is between a few millivolts and several tens of millivolts for a power of only 2 Watts (in the heating element). It should also be noted that the sensitivity of these sensors increases as the ambient temperature rises. This is an extremely interesting (although not yet fully understood) property for the high-temperature operation of widegap power components (such as GaN transistors).

Poster presented by René Escofier

René Escoffier is a research engineer at CEA-Leti, focusing on development of transistors and structures on GaN materials, the design of GaN/Si-based components: sensor, protections, limiter circuits and associated digital models.

Partners

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[Poster #2] Scientific contributions of the Powergan programme

Designing a disruptive architecture

A new generation of GaN-based 650V power transistors. Initiation of technology transfer of 200 mm, 650V GaN/Si power components to the STMicroelectronics GaN/Si pilot line in Tours.

The Nanoelec/Powergan programme focuses on the development of a radically innovative architecture for an enhanced GaN transistor, with insulated gate (known as Recessed Gate MIS) which notably enables the transistors to function in "Normally off" (Noff) mode, with low current leakage from the gate, and lesser degradation of the R_{on} (conduction resistance leading to performance losses) at high temperature than the competing solutions. It is thus the ideal response to the needs of the designers, but requires numerous technological obstacles to be overcome, in particular in terms of its gate (stability of electrical characteristics, reliability).

In addition to the technological developments needed to optimise the various blocks and validate a complete manufacturing process, different characterisation and analysis methods have been implemented in order to model the working of the transistors and test a number of architecture variants.

The performance model must be linked to the geometrical and physical parameters of the component (in particular electron gas resistance, contact resistance, mobility in the channel, etc.). Various geometries have been characterised, in order to extract the associated overall R_{on} (conduction resistance leading to performance losses), to evaluate the impact on the threshold voltage and to decorrelate the various contributions.

The impact of the geometries on the blocking voltage withstand capability was also evaluated, notably in order to define the accessible dimension limits. The main architecture-related compromise is that of R_{on} / BV (*Breakdown Voltage*), both of which drop as the gate/drain length (L_{gd}) is shortened.

The second key parameter identified was the length of the channel, which in principle has no impact on the voltage withstand capability, but a significant one on the R_{on}.

Finally, these measurements were able to define a performance model for the R_{on} which acted as the basis for the generation of a new test vehicle designed for improved performance.

The work done in 2021 advanced the maturity of the technology developed under the Powergan programme. At this stage, the broad outlines of the architecture have been validated. The tests identified the initial epitaxy limits in pre-industrial conditions and quantified the divergence from the reference process developed by R&D.

The results obtained on the new dielectric processes opened the door to improved voltage threshold stability after blockage and are integrated into complete electrical packages. This work paves the way for technology transfer with a view to industrial implementation on the STMicroelectronics site in Tours.

Poster presented by Romain Gwoziecki

Romain Gwoziecki is a researcher at CEA-Leti, specialising in electronic power components. After obtaining an engineering diploma at Grenoble-INP and a thesis prepared at Orange, he worked at STMicroelectronics, before joining CEA's laboratories in 2007.

Partners

Reducing electromagnetic interference

The principle of a "sandwich" type 3D layout for lateral GaN components was validated and constructed on a PCB demonstrator, with packaged chips. A concept with shielding by the continuous bus between the semiconductors' floating point and the reference potential (heatsinks) was used and confirmed a reduction in electromagnetic interference. Digital simulation was then utilised.

The notion of active filtering of harmonics is traditionally used for frequencies ranging from 100 Hz to 2 kHz. This entails measuring the network harmonics and reinjecting them in phase opposition onto the line to eliminate them. GaN HEMT components offer the possibility of fast switching at several MHz with acceptable efficiency. They enable the concept to be widely used to reduce disturbances in the frequency ranges usually covered by passive filtering. It is thus possible to envisage compensating conducted emissions in the frequency band ranging from 10 kHz to several hundred kHz (we set ourselves a target of about 500 kHz at the beginning of this study, to be confirmed subsequently) and thus significantly reduce the passive filtering effort and therefore the volume of components needed. However, rapid switching at frequencies this high and with semiconductors such as GaN demands particular precautions to control the disturbances emitted beyond the quench frequency (from a few MHz to several tens of MHz), failing which, the filtering gain on the 10kHz-500kHz part would be cancelled out by that needed for the high frequency part.

At Nanoelec/Powergan, the principle of a "sandwich" type 3D layout for the lateral GaN components was validated and constructed on a PCB demonstrator, with packaged chips.

A detailed analysis of the experimental results obtained on a reference board (without shielding) and on a bard with a shielding layer limiting the common mode, was carried out using simulations performed with tools in the Siemens EDA suite. The different origins of the electromagnetic disturbances were thus brought to light: obviously considerable impact by the power traces, but also a non-negligible impact from the semiconductor package, on which the face connecting to the heatsink is connected to the GaN component source, as is the driver of the "Top" component. The gradual application of shielding has produced interesting results regarding the respective contributions of the 3 common mode origins and highlighted significant gains by shielding the 3 contributors. The methodology is thus perfectly well-known and has been validated, first of all through simulation and then physically.

Poster presented by Jean-Luc Schanen

Jean-Luc Schanen is a lecturer at Enese3, a school of the Grenoble INP group. He heads the power electronics group at G2ELAB (Grenoble Electrical Engineering Laboratory / Univ. Grenoble Alpes, CNRS, Grenoble INP). He ran the GreEn-ER project, which created a world-class innovation hub for renewable energy and resources, in a building meeting the very latest standards in terms of resource frugality, energy independence and environmental footprint management.

Partner

Digital twin

A homogeneous design flow using Siemens EDA software tools was validated by means of different power boards which made it possible for each one to focus on specific elements: compact model, electromagnetic interference, embedded PCB, complex board

Gallium Nitride (GaN) type Wide Band Gap (WBG) components have been emerging on the power market in recent years, for high frequency applications (>>100 kHz) in order to increase the power density of converters. But they are also finding their place in lower frequency applications (<100 kHz) for high-efficiency converters. These two fields of application make maximum use of the performance of GaN components, notably low on-state resistance and switching performance that is today unparalleled.

The integration of GaN type WBG components demands particular attention, notably discrete component integration on PCB. The high transition speeds of these components expand the frequency ranges which had not yet been explored with slower components using classic Silicon (Si) technology. The parasitic elements induced by the PCB, which are not considered to be so with Si technologies, become problematical for operation of GaN components. Their integration has to be optimised, notably minimisation of the switching loop inductances, optimisation of the placement of the decoupling capacitors, the hot point-cold point capacitive couplings, etc.

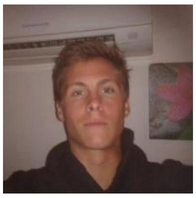
On the one hand, a DUT1 "design under test 1" integrates CEA LETI 650V/30A components on a simple half-bridge in different formats ; TO247-3L-based packaging and a design based on bare die components with glob top. The designs were imported into HyperLynx Siemens EDA in order to extract the parasitic elements from the PCB. Using equivalent PCB models generated, the circuit diagram can be constructed with Xpedition Layout in order to associate the PCB models with their connections to the passive and active components.

Once the diagram is complete, frequency, static and time simulation can be carried out to analyse the behaviour of the circuit, including the parasitic PCB and components. All the results, whether PCB parasitic elements and time waveforms were compared with the experimental results and showed a good degree of coherence.

On the other, a DUT2 integrates off-the-shelf 650V/30A GaN components from the GaNSystem company into a classic half-bridge with capacitive mid-point. This DUT2 was integrated on a bench standardised for electromagnetic compatibility (EMC) tests, notably to measure the conducted common mode noise level generated by the GaN components. As with the DUT1, this design was integrated in HyperLynx to extract the PCB parasitic elements, as well as in Xpedition Layout, to create the schematic around the PCB, but also around the EMC bench (RSIL, probes, common mode inductances, etc.). Each component was meticulously characterised to take account of these imperfections, so that simulation of the discrete elements would be as realistic as possible. The theoretical common mode noise obtained from simulation is consistent with the simulation results, notably with regard to the amplitudes and the transition frequencies.

The quality of the digital model results, in particular with the Siemens EDA suite, is encouraging. There are still notable differences between the laboratory demonstrators and their digital twins, although the trends, the amplitudes, the frequencies, etc., are in line with the experimental results on the two DUTs in question.

Poster presented by Charley Lanneluc



A graduate of Grenoble-IN/Ense3, Charley Lanneluc is a power electronics research engineer and European project manager & coordinator at CEA-Leti.

Partners

[Poster #5] Scientific contributions of the Powergan programme

A 100W AC/DC converter

A new generation of components has been designed. It incorporates a new control method which relies on local detection of the operating quadrant and needs no ultra-fast critical measurement. Simulation results with detailed modelling of the circuits offer very good efficiency prospects.

The action taken aims to overcome the obstacles to the 100W USB Power Delivery application, which requires that a 100W AC-DC power converter be integrated into the authorised volume of a wall power outlet, while meeting the standards for isolation and radiated and conducted harmonic pollution generated by the system on the grid.

In 2019, a first generation of 100W AC-DC converters using Dual Active Bridge architecture was designed and built around high-speed analogue electronics with impedance matching stages. Its inherent advantages are to do away with the multiple conversion stages which limit the efficiency and miniaturisation of the converter.

Tests on a demonstrator show that the ZVS (zero volt switching) driver circuit was significantly improved by comparison with the previous work. The proposed solution thus allows operation at 1 MHz with considerable dynamic ranges. An experimental implementation on a converter cell validated the solution with efficiency levels obtained (losses for 100 W) of 98%.

Efficiency performance at 1 MHz is good but nonetheless insufficient for the final application.

A second generation demonstrator enabled a new control approach to be developed which does not create any control complexity for the user. This control method is based on local detection of the operating quadrant and requires no ultra-fast critical measurement. It can be implemented with low-cost analogue and digital circuits and also has the advantage of offering extensive integration (IC integration possible). SPICE simulation results with detailed modelling of the circuits validated the working of the proposed control and indicate extremely good efficiency prospects.

Poster presented by Leo Sterna

Partner

Leo Sterna is a research engineer at CEA

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[Reference viewpoint]

GaN for Automotive Powertrain: Current situation and prospects

By Jean-Philippe Mercier, HEV System & e-motor Expert Leader, Renault Group

13h30 ► 14h15

Jean-Philippe Mercier is a graduate engineer from the "Ecoles des Hautes Etudes Industrielles" and the "Ecole Nationale supérieure du Pétrole et des Moteurs", and has been working at Renault Group since 1986. From 1986 to 2006, he held various positions, from development Engineer to deputy technical director at Renault Sport & Renault F1 Team. From 2007 to 2012, he was development manager for the new 0.9 l L3 – 1.2l L4 gasoline engines. In 2012 he returned to the Renault F1 Team as Engineering Director. Since 2017, he has been the expert leader in Hybrid Systems and Electrical components.

[Round-table]

Scientific obstacles and technological challenges: vision and research areas for the sector players (academic and industrial)

14h15 ► 15h30

Scientific obstacles and technological challenges remain central to the development of GaN power electronics technology. The round-table offers an opportunity to share the visions of the academic and industrial players in the research fields involved. The participants will more particularly discuss the challenges created by the increase in the frequency of GaN-based power components, the Wide Band Gap – GaN packaging to support this frequency rise, the robustness and reliability of the components related to the specific characteristics of the GaN component and the digital design flow from component to systems.

with

> Véronique Souza, Head of the "Power Semiconductor Devices" laboratory at CEA-Leti

> Sébastien Houivet, Product Technical Director ELVIA Group

> David Trémouilles, researcher in the systems analysis and architecture laboratory (CNRS-Laas)

> Jean-Luc Schanen, Lecturer at G2ELab (Grenoble-INP/UGA/CNRS)

> Pascal Bolcato, Engineering Director Analog & Mixed-Signal at Siemens Digital Industries Software

Moderated by Marc Plissonnier

Marc Plissonnier is Head of the Electronics and sensor systems for energy department at CEA-Leti

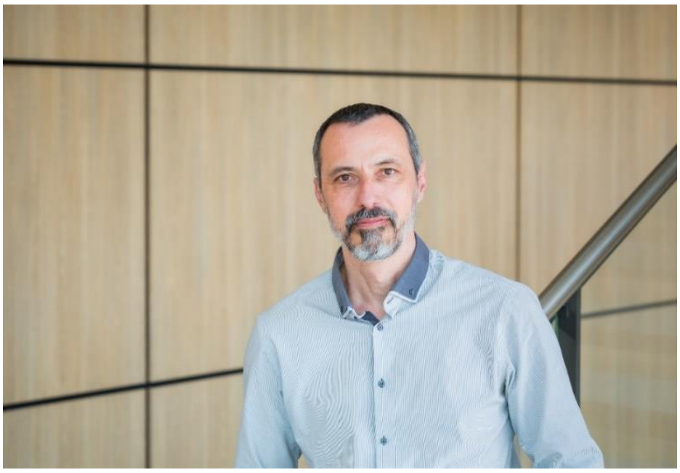
[Overview]

Institutional initiatives and ongoing projects

By Raphael Salot, Director of the Nanoelec/Powergan programme and major accounts manager at CEA

16h ► 16h30

Raphaël Salot has been Director of the Powergan programme at IRT Nanoelec since 2020 and is in charge of several projects in the field of power electronics. He graduated from Grenoble-INP/Phelma and, with a PhD in science of materials and electrochemistry from the Institut polytechnique in Grenoble, he has been working at CEA since 1996 as a research engineer. He was notably in charge of the on-board micro-batteries laboratory at CEA-Leti and was coordinator for major European projects (such as EnSO ECSEL). He is also the author of forty or so patents.



IRT Saint Exupéry

The Saint Exupéry Technological Research Institute (IRT)* is an accelerator of science, technological research and transfer to the aerospace industries, for the development of safe, robust, certifiable and sustainable innovative solutions.

On our Toulouse, Bordeaux, Montpellier, Sophia Antipolis and Montréal sites, we propose an integrated collaborative environment of 350 engineers, researchers, experts and PhD students from industrial and academic backgrounds, for research projects and R&T services backed up by technological platforms in 4 areas: advanced manufacturing technologies, greener technologies, methods & tools for developing complex systems and intelligent technologies.

The GaN activities at IRT Saint Exupéry are concentrated primarily in two areas: characterising and modelling reliability (sustainability and robustness) of commercial off-the-shelf (COTS) components, ranging from discrete components to modules, subject to harsh environmental constraints (thermal, mechanical, cosmic radiation, EMC, etc.). The development of technological and methodological building blocks allowing full utilisation of the intrinsic capabilities of this technology in the field of high-efficiency and high-density on-board power conversion.

**IRT Saint Exupéry is a technological research institute certified by the State under the Investments for the Future Programme (PIA).*

➔ http://www.irt-saintexupery.com

IRT Nanoelec

The Nanoelec technological research institute is a consortium of private and public stakeholders. Its role is to help companies create value and differentiate their products in the digital transition fields. Nanoelec contributes to the competitiveness of the microelectronics sector, in particular in France. It is based in Grenoble, a world-class hub for research, innovation and production in this sector.

From 2017 to 2021, Nanoelec ran a programme called Powergan, together with CEA, Grenoble-INP, Schneider Electric, Siemens EDA and STMicroelectronics. The programme's goal was to help build the national GaN value chain, with a research strategy based on GaN/Si power devices that are disruptive in terms of innovation, using 200 mm technology and technical co-design tools for GaN compatible power converters.

➔ irtnanoelec.fr

ITE Vedecom

The Vedecom energy transition Institute is a public-private partnership foundation devoted to innovative and sustainable mobility solutions, in other words, solutions that are more ecological, more autonomous and more widely shared.

Under the PIA it is tasked by the State with supporting technological innovation and the French industrial sectors involved in mobility of the future. It is built around an unprecedented collaboration between more than 50 players and brings together academic institutions, regional authorities and various private actors impacted by changes in mobility: automotive, public transport and mobility, logistics, road infrastructures, telecommunications, energy, aeronautics and defence, digital services and simulation, insurance.

This key role as trusted third-party enables its members to accelerate innovation and the deployment of new solutions. By focusing on three areas of multidisciplinary R&D - electrification, the autonomous connected vehicle and new mobility and energy solutions - Vedecom offers a systemic vision of the vehicle, its environment and the deployment of new mobilities. Vedecom brings together 100 researchers, engineers and technicians. It has produced nearly 500 publications and 80 doctoral theses, and has trained more than 2,500 people through its training programme.

Via its HiDePE (High Density Power Electronics) project, financed by the PIA in partnership with the manufacturers Renault and Stellantis, VEDECOM is developing new generations of static power converters offering optimal integration of GaN semiconductors. In using these components, the Institute is boosting the efficiency and compactness of DC-DC converters. To do this, the R&D teams are focusing on the study, characterisation and design of passive elements, topologies and cooling solutions optimised for GaN.

➔ www.vedecom.fr

fit | MEMBER

Nanoelec, Vedecom & Saint Exupéry are among the institutes for technological research (IRT) and energy transition (ITE) set up by the French Government and financed by the Investments for the Future Programme (PIA). These institutes bring together academic and industrial players around R&D and innovation projects designed to stimulate the competitiveness of the French economy. They are members of FIT, the association of French technological research institutes.

➔ www.french-institutes-technology.fr/

Your notes