HiPERFORM

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Volume 2

Newsletter M24

Reliable and energy efficient drivetrains

HiPERFORM stands for High performant Wide Band Gap Power Electronics for Reliable, energy efficient drivetrains and Optimization through Multi-physics simulation.

The research work in HiPERFORM investigates advanced production processes and methods for GaN based switch technologies for the application in automotive domain and aims to enable a long-term cost reduction of 40% in comparison with existing samples of these innovative switches. Regarding the high reliability requirements, which are expected to be fulfilled with SiC-switches, HiPERFORM performs research work to close the gap for GaN-switches. The project HiPERFORM researches and develops architectures for switching topologies and controllers with SiC and GaN switches that support switching frequencies of up to 500 kHz and have 30% less energy losses in comparison with existing architectures, enabling energy efficiencies of up to 98% in power train applications.

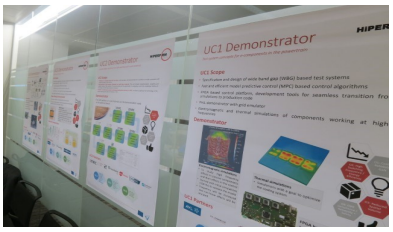
Figure 1: Project Consortium

In HiPERFORM, 31 partners from 8 European countries are cooperating for more than 3 years to pave the way for a decarbonized transport system. From the manufacturer of semiconductors as well as power modules through suppliers of development methods and tools to the system and ultimately the vehicle manufacturers. The integration of academic partners with a high-level of competence in these domains completes this approach.

Inside this issue

Facts & Figures

Partners: 31
Countries: 8
Budget: 41 Mio €
JU Funding: 12 Mio €
Project Start: May 1st, 2018
Duration: 36 months
Coordinator: AVL List GmbH



Two Years of HiPERFORM

New materials and power switches

The HiPERFORM project is entering year 3. Some very promising results are already available and activities are running very well. However, the COVID-19 crisis has also hit the partners very much and new ways of cooperation have to be found instead of meeting physically. The results obtained during the second year and the ongoing work of the partners are presented in the next pages of this newsletter issue.

The second project year was very successful and brought many new results that were presented and discussed during the 4th General assembly meeting (this time a virtual meeting, which was originally planned in Dresden at Fraunhofer FEP) and also presented at 19 international conferences in 2 journal papers.

The main project achievements in Y2 were in the field of new GaN power devices. IMEC presented a new generation of GaN HEMTs on poly-AlN substrates. Infineon and OnSemi also presented a new generation of power GaN HEMTs that are now available for partners and will be used in demonstrators.

The third period will strongly focus on the finalization of the demonstrators: high efficient on-board and off-board chargers based on WBG devices for EV and also new control, simulation and testing equipment. A short description of the newly developed vECU-CAR and High-level charging management can be found in articles on pages 3 and 4.

"31 automotive, semiconductor and academic partners working towards one goal."

Use-Case Progress

- UC1: The electrical design of the test systems was further developed and is now in a final stage. Moreover, the mechanical design of the test systems is in advanced stages and prototypes are under construction.
- UC2: Test bench results are used to monitor and to benchmark the first pGaN HEMTs on poly-AlN wafers. These devices went through the discrete wafer level test bench at imec and currently are tested by STUBA and NanoD.
- UC3: Since the start of the project, the use-cases content was updated and increased in scope from one demonstrator to two demonstrators. The specifications for these two hardware demonstrators have clearly been defined and reported as part of the public Deliverable 1.1 .
- UC4: The main goal of use-case 4 is to develop an electric drive system (double inverter plus two electric machines) and control conceived with capabilities of WBG materials and two in-wheel motors. The involved partners have worked together to identify a suitable interface between components and requirements for the dual-inverter and in-wheel motors.
- UC5: The optimal design of on-board charger, as well as hardware implementation of the first-stage converter (AC/DC) have been completely achieved and the final integration will take place in the upcoming period.
- UC6: To show the positive contribution of SiC devices on volume reduction, efficiency increase and safety improvement in the world of off-board chargers as a test vehicle, a 175 kW charger is going to be build including the total test environment.

TECHNICAL INNOVATIONS

vECU_CAR

vECU_CAR (virtual Electronic Control Unit Car) is a powerful, flexible, real time simulation environment for the design, development and validation of complete vehicle systems or subsystems.

vECU_CAR can be used throughout the entire design process, allowing model and software in the loop for preliminary tests, and hardware in the loop for real-time testing of electronic control units (ECUs) and powertrain components.

Technical Characteristics

Multibody and chassis models

vECU_CAR includes a real-time vehicle multibody dynamics simulator (named DYNACAR®), which has been developed by Tecnalia. DYNACAR® incorporates detailed theories to accurately model tire and road contact in order to obtain the lateral and longitudinal forces acting on the vehicle, as well as complex component models for powertrain and suspension systems. It allows manual (Driver in The Loop) or automated tests.

Powertrain models

Powertrain components (Vehicle Control Unit, Powertrain Control Unit, Battery Management System, Battery pack, Power Converter, Electric Machine, Hybrid Control Unit, etc.) are developed in simulation environments (commonly Matlab/ Simulink, LabVIEW, C, Fortran) aiming to define the electric / electronic architecture of the vehicle target.

Powertrain models can be substituted by the physical components, reducing costs and time spending during the test stage (see Figure 2).

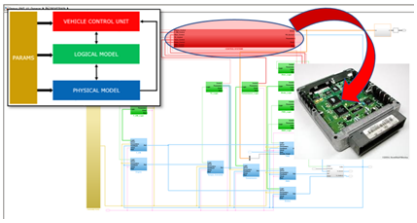


Figure 2: From virtual ECU to physical components.

"vECU_CAR can be used throughout the entire design process (SiL, MiL), allowing the rapid prototyping, implementation and real-time testing (HiL)."

vECU_CAR: Application in HiPERFORM

vECU_CAR including DYNACAR® vehicle dynamics simulator is used in HIPERFORM project. The main objective is to develop a Hardware in the Loop (HiL) environment in order to assess representative conditions for the target vehicle (see Figure 3).

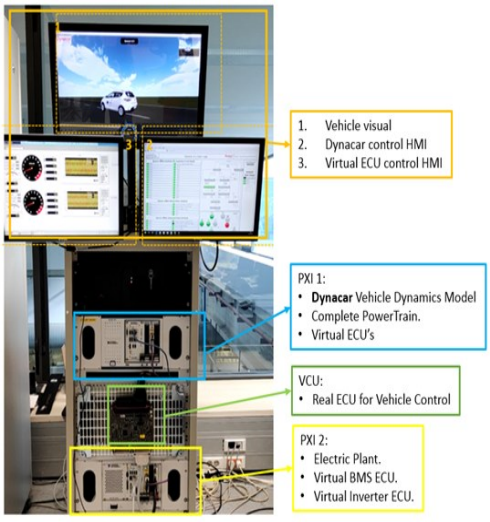


Figure 3: HiL simulator integrating vECU_car.

The HiL simulator includes two real time PXI devices (powerful Real Time Platform by National Instruments). One PXI executes at 1ms the vehicle dynamics model (DYNACAR®) as well as the virtual powertrain components developed in the project. The other PXI device includes the virtual electric plant of the vehicle target (power converter, e-drive and battery pack), the virtual Battery Management Unit and the virtual Inverter Control Unit. The execution time of this device is more critical, being set at 1µs (20-30 times faster than the related controller).

Three screens provide users information about the simulation scenario (vehicle moving on a road, following a defined trajectory); the DYNACAR® commands and requests, and the virtual Electronic Control Unit commands. In this particular application, the virtualized Inverter Control Unit can be easily replaced by the real target, as shown in Figure 3.

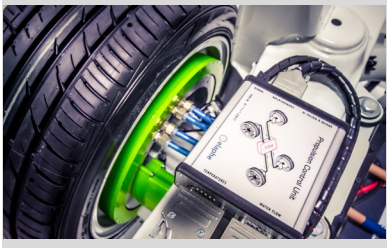
About the author

Dr. Elena Trancho received the first M.Sc. degree in automatic and electronic engineering from the University of Deusto, Bilbao, Spain, in 2011, the second M.Sc. degree in electrical engineering from the Institut Nationale Politechnique, Toulouse, France, in 2012 and the Ph.D. degree in control engineering from the University of the Basque Country, in 2018.

From 2012 to 2014, she worked as an Advanced Flight Control Researcher in Toulouse, France. In 2014, she joined Tecnalia Research & Innovation, Industry and Transport Unit, Bilbao, Spain, where she works in advanced drives control. Her research interests include electric and hybrid vehicles, variable-speed drives, advanced control strategies, and fault-tolerance techniques.

Use-Case 4: In-wheel electrified powertrain

Demonstration of a complete powertrain conceived with capabilities of WBG materials, featuring high power density and high efficiency double SiC inverter.



TECHNICAL INNOVATIONS

Development of an optimization algorithm for a high-level charging management system

As a part of UC6, a high-level charging management strategy (real-time scheduling and optimization algorithm) is developed for an off-board charger. Novel charging strategies are necessary to cover the expected increase of the EV fleet. The proposed strategy considers user demand related information (e.g., when the charging process needs to be finished, how much energy that is needed during charging, etc.) and information from the charging point operator, i.e. timed-based electricity tariff table and grid constraints. With this information, the optimization algorithm computes a time schedule for the entire charging process representing the optimal / maximal current allowed to be withdrawn from the charging unit. This schedule can be changed according to the real-time situation.

Figure 4: High-level charging management system.

About the author

Dr. Ir. Mohamed Abdel-Monem is a head of Products Innovation & Systems Verification (PI&SV) team at Powerdale. Doctor in engineering sciences with more than 30 scientific publications, the first author of a patent application. He has 8 years of experience in national and European funded projects in the field of vehicle-to-grid (V2G) and second-life battery systems, power electronic converters, electric vehicle charging methodologies, energy management strategies (EMS), battery management system (BMS), and testing, characterizing and modelling of various rechargeable battery storage systems.

"Novel charging strategies are necessary to cover the expected increase of the EV fleet."

Use-Case 6: SiC Off-board charger

This use-case explores the technological possibilities for high power conversion electric vehicle chargers (up to 150kW), as opened up by the future availability of WBG power devices.

Link for video

https://youtu.be/md4rvRy6Kqo

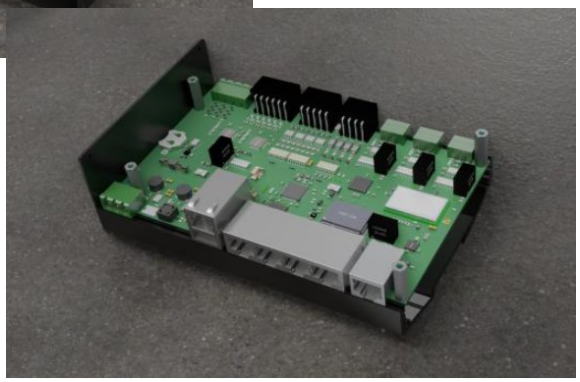


Figure 5: High-level charging management system — internal view.

TECHNICAL INNOVATIONS

Demonstration of process chain: from bare poly-AlN to fully integrated pGaN gate HEMT

Imec demonstrates the use of poly-aluminum-nitride (poly-AlN) as a substrate material, on which GaN power technology is processed. The coefficient of thermal expansion of poly-AlN is better matched to GaN compared to traditional Si wafers. Theoretically, this allows for the growth of thicker buffer layers, yielding increased device performance, robustness, and reliability.

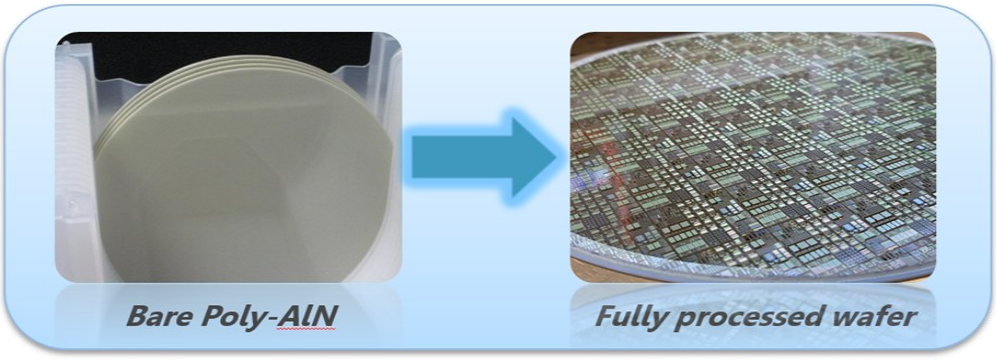


Figure 6: From bare poly-AlN to fully processed GaN-on-poly-AlN wafer with power electronic devices.

About the author

Prof. Dr. Benoit Bakeroot received the M.Sc. degree in physics in 1997 and the Ph.D. degree in electrical engineering in 2004 both from the Ghent University, Belgium. Since 1998, Benoit Bakeroot is with imec, where he has been involved in the research on Si and GaN power devices with a focus on Technology Computer Aided Design (TCAD) simulations, compact modelling and device physics. He is author or co-author of more than 60 papers in international scientific journals and conference proceedings. He is currently also part-time associate professor at the Ghent University.

"The buffer performance and the initial results on devices look very promising to achieve 1200V breakdown voltages for GaN."

One of the goals of the HiPERFORM project is to achieve breakdown voltages as high as 1.2 kV for GaN buffer layers. This figure is hard - if not impossible - to meet with traditional GaN-on-Si wafers with large diameter (200 mm), especially with standard wafer thickness. The main challenge is to adopt the epitaxial growth to achieve the set goal. Intermediate results in the HiPERFORM project show the potential breakthrough of GaN -on-poly-AlN: the buffer performance and the initial results on devices (pGaN High-Electron-Mobility transistors) look very promising.

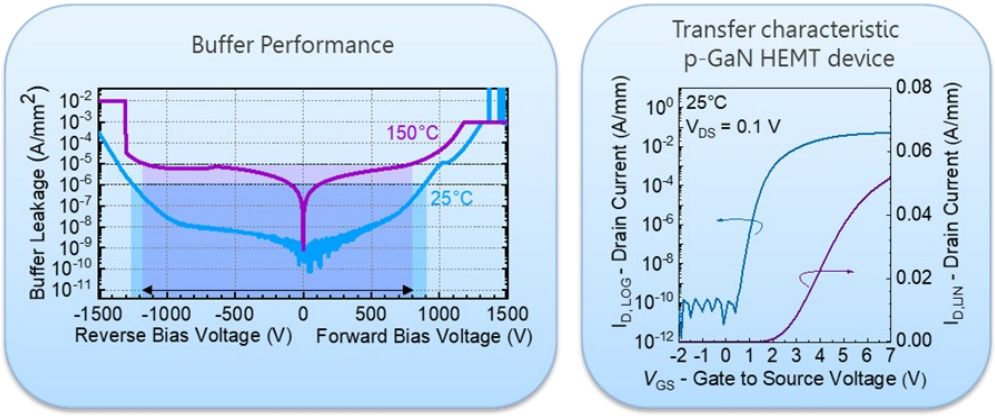


Figure 7: Plot showing high buffer breakdown voltages obtained on poly-AlN substrates (left) and a transfer characteristic of a p-GaN HEMT device on GaN-on-poly-AlN (right).

Use-Case 2: Wafer Test-Bench for GaN

Benchmarking performance of next generation materials for power switches fabricated in GaN using an on-wafer test-bench, assessing performance merits for use of these materials in power subsystems for automotive applications.

Public Deliverables available at www.hiperform.eu

The HiPERFORM project web site was launched in October 2018 and provides a lot of information about the project and the partners. In the "News" section, public Deliverables of the project can be found and easily downloaded. Currently there are seven public Deliverables available. In total, the project will generate 20 public Deliverables.

Examples of Deliverables:

D1.1 Specification for use-cases for inverters, test systems and chargers - Develop clear specifications for each use case with the involvement of all relevant stakeholders for the single use cases.

D3.1 Design optimization of switching topologies - document presents results of design optimization and selected topologies for power-electronic systems of the drivetrain.

D3.3 Assessment of control algorithm for electronic systems with WBG technologies - document presents the results of developments of control strategies and control algorithms

D5.6. Report on the design of off-board charger systems for electric vehicles - description of design of the converter used in the off-board charger.

https://www.HiPERFORM.eu/

EVENTS & NEWS

1st Annual Review Meeting, Brussels

The 1st annual review meeting took place in Brussels from June 25 to 26, 2019 at the ECSEL JU premises. The review meeting was well organized and the technical presentations were of high scientific quality and were appreciated by the reviewers.

Based on the review evaluation report we can say that the project has achieved most of its objectives and milestones for the reported period with relatively minor deviations and has delivered exceptional results with significant immediate or potential impact.

Figure 8: 1st Annual Review Meeting in Brussels.

"HiPERFORM has delivered exceptional results with significant impact in Year 1."

General Assembly Meetings, Bratislava , Oudenaarde, WebEx

The 2nd General Assembly meeting of the HiPERFORM project was organized from April 29 to 30, 2019 in Bratislava, Slovakia and was hosted by the Slovak University of Technology in Bratislava.
The first part of the meeting was dedicated primarily to review the status of the project, where the use-case leaders presented the major achievements reached in the first year and informed the partners about the next steps in their respective use-cases. In the evening partners came together for a common dinner at Dunajsky Pivovar. The second day was dedicated to WP presentations, dissemination and exploitation topics.

The 3rd General Assembly meeting of the HiPERFORM project was organized by On Semiconductor Belgium from October 15 to 16, 2019 in Oudenaarde. The meeting had a strong focus on the use-cases, presenting significant progress for all 6 topics.
The 4th General Assembly meeting was strongly affected by the current COVID-19 crisis. The meeting was supposed to take place at Fraunhofer FEP in Dresden. However, due to travel restriction all over Europe, the partners had to make the meeting virtually. This allowed the partners to discuss all necessary topics and share the latest progress in all WPs and use-cases.

Figure 9: 2nd General Assembly Meeting in Bratislava.

Figure 10: 3rd General Assembly Meeting in Oudenaarde.

HiPERFORM @ ECSEL JU Symposium, Bucharest, 2019

HiPERFORM project was presented at the ECSEL JU Symposium in Bucharest in June, 2019. In the poster session the scope, objectives and the key facts of the project were presented.

HiPERFORM @ EFECS, November 2019

EFECS is the international forum with a focus on 'Our Digital Future' along the Electronic Components and Systems value chain in Europe. The organizers of this event, AENEAS, ARTEMIS-IA, EPoSS, ECSEL Joint Undertaking and the European Commission, in association with EUREKA, brought all stakeholders together on 19-21 November, 2019.

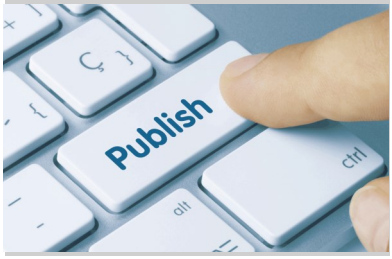
EFECS provided numerous opportunities to learn more about the latest developments, cooperation and funding possibilities in the ECS Community.

The HiPERFORM project was presented with an own booth by the coordination team of STUBA and AVL, where videos of innovative demonstrators were shown.

Figure 11: Project booth at EFECS in Helsinki.

Scientific publications

HiPERFORM as a research project is generating a lot of scientifically interesting information, that are presented by project partners on international conferences, in journals and also as book chapters. A full list of scientific publications can be found on the project website in the "Publications" section. Currently there is a list of 20 publications. A pdf copy of some publications can be directly downloaded from the web site.



"HiPERFORM brings new solutions for electrical and hybrid vehicles."

HiPERFORM in Numbers

1 Review Meeting

4 General Assembly Meetings

20 Project Steering Board Meetings

24 Months of Successful Project Team Work

31 Partner Organizations Working Towards One Goal

37 Submitted Deliverables to the ECSEL-JU

Dissemination Activity	Plan Y2	Real Y2
Organisation of a Workshop/Conference	1	2
Flyer	1	1
Social Media	1	2
Participation to a Workshop	1	1
Other	1	1
Scientific Publications - Journals	5	2
Participation to a Conference	11	19
SUM	**21**	**28**

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Upcoming Events

8-11 June, 2020: ADEPT Conference, Nový Smokovec, High Tatras, Slovakia

28 June, 2020: International scientific symposium on co-simulation and solver coupling, Ferrol

14 July, 2020: ViF Seminar

7 September, 2020: EPE'20 ECCE Europe Conference on Power Electronics & Applications, Lyon

21 September, 2020: SafeComp and Workshop at SafeComp by ViF

11-14 October, 2020: ASDAM Conference 2020, Smolenice Castle, Smolenice

24-26 November, EFECS 2020, Berlin

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