Best PCIM Europe Ever

PCIM Europe 2013 ended on May 16 with a 15 percent increase in visitors up to 7,883 (2012: 6,874), 395 exhibitors (2012: 365) and 87 represented companies (2012: 88). For three days the latest developments and trends in power electronics, intelligent drive technology, renewable energy and energy management have been here on display. The conference was visited by a total of 726 (2012: 744) delegates. PCIM Europe 2014 will take place from 20 – 22 May 2014 at the Exhibition Center Nuremberg.

The Best Paper and three Young Engineer Awards were presented during the opening ceremony of the PCIM Europe Conference 2013. The Best Paper winner was Eckart Hoene of Fraunhofer IZM **(www.izm.fraunhofer.de)** for his paper "Ultra-Low-Inductance Power Module for Fast Switching Semiconductors". He received prize money and an invitation to the PCIM Asia 2014 Conference in Shanghai, sponsored by Power Electronics Europe and Semikron.

The three PCIM Young Engineer (under 35 years old) Awards have been handed over to Radoslava Mitova of Schneider Electric/France for the paper "Half Bridge Inverter with 600 V GaN Power Switches"; Samuel Araujo, University of Kassel/Germany for the work "High Switching Speeds and Loss Reduction: Prospects with Si, SiC and GaN and Limitations at Device, Packing and Application Level", and Daniel Wigger, University of Rostock/Germany for "Impact of Inhomogeneous Current Distribution on the Turn-off Behavior of BIGTs". The three Young Engineer Award winners received prize money of € 1,000 each sponsored by ECPE, Infineon Technologies and Mitsubishi Electric.

The award winning papers were selected from more than 280 papers by the conference directors. The determining criteria were originality, topicality and quality. The awards were presented by the Scientific Advisory Board Chairman, Prof. Leo Lorenz of ECPE, Germany.

Packaging for SiC and GaN

The developments in switching semiconductors have come to a point, were the packaging of the semiconductors becomes a severe influence on switching performance. Especially wide bandgap materials like SiC or GaN switch so fast, that parasitic influences of wire bonds or pins influence the components performance. Furthermore expert knowledge to design a switching cell properly in needed and inhibits the broad use of the superior semiconductor properties.

In the BPA paper "Ultra Low Inductance power module for Fast switching Semiconductors" new strategies and technologies presented to face this challenge. First of all a packaging technology was developed that combines a Direct Copper Bond (DCB) Substrate with Printed Circuit Board (PCB) technologies. Thereby the superior thermal properties of the ceramic is combined with the design freedom of the PCB. These possibilities were then used to create packages with extraordinary electromagnetic properties with the additional feature to be able to directly solder components like capacitors or drivers onto the module. The manufactured module comprises a half bridge with SiC JFETs and a blocking voltage of 1200 V. The DC link inductance was measured to be below 1 nH, which sets the new standard in packaging. The concept of the module is to integrate the critical switching cell into the module including a DC link capacitor. This module concept shows the way to make high-speed switching available to users with less experience in design for high power and speed.

GaN for inverters

The YEA "Half Bridge Inverter with 600V GaN Power Switches" presented by Radoslava Mitova from Schneider Electric also covered the emerging Gallium nitride (GaN) power devices which promise to outperform the legacy Silicon devices

From May 14-16 it was again time for more than 700 PCIM conference delegates and around 8000 exhibition visitors

LEFT: The Best Paper Award was handed over by PCIM Conference Director Prof. Dr. Leo Lorenz (right) to Eckart Hoene of Fraunhofer IZM and PEE Editor Achim Scharf and Uwe Scheuermann from Semikron

and challenge the Silicon Carbide devices in 600 voltage range; thanks to their faster switching speed and low switching and conduction losses. In last few years several device manufacturers have communicated their development on GaN based power devices in the range of 200-600V. This article presents the evaluation of a new 600V GaN High Electron Mobility Transistor [HEMT] in a half-bridge inverter prototype. The static and dynamic characterizations of these devices are presented. Several experiments have been conducted to test the GaN HEMT performances. The results shows that the GaN based devices improves the efficiency of the inverter prototype compared to the Silicon and SiC based devices. The advantage of using higher switching frequency on the size of the inverter output filter inductor was also commented.

Fast switching and loss reduction

The second YEA "Prospects with Si, SiC and GaN and Limitations at Device, Packing and Application Level" presented by Samuel Araujo from University of Kassel covered the prospect of increasing the switching frequency without sacrificing efficiency. This will be mainly achieved through new device technologies, not only relying on WBG materials but also on Silicon, capable of operating at much faster switching speeds and thus with lower losses.

In the path towards such development it is thus interesting to identify the true limitations for each device technology based on inherent properties and also on properties of the freewheeling path. Several enhancements in the field of packing are also still necessary in order to fully exploit the referred power devices' capabilities. In addition to this, other issues at application level concerning EMI, driving and also the influence of transient speed at inductor losses still need to be addressed. This paper presented an overview of these issues based on experimental results and literature research in order to assert future development trends. In addition a benchmarking of different SiC switch technologies based on a new figure of merit has been performed.

These awarded papers demonstrated very obviously the impact of wide bandgap devices and in particular GaN for future power electronic designs, which was also the aim of PEE's Special Session "Power GaN for Highly Efficient Converters".

LEFT: Winners of the Young Engineer Award and sponsors (in the back) Radoslava Mitova (Jörg Malzon-Jessen/Infineon, left), Daniel Wigger (Gourab Majumdar/Mitsubishi), and Samuel Araujo (Thomas Harder/ECPE)

Turn-off behavior of BIGTs

The impact of Inhomogeneous Current Distribution in the BIGT has been presented by the third YEA Daniel Wigger, University of Rostock. ABB's **(www.abb.com/semiconductors)** BIGTs are a new type of power semiconductors. In opposite to a conventional IGBT/diode module, this device includes the functionality of the diode and the IGBT. An advantage of the device is the softness of the turn-off behavior in the IGBT-mode compared to a conventional IGBT. The reason for this is the inhomogeneous current distribution in the BIGT.

The BIGT has a different chip design, compared to an IGBT. The BIGT chip contains the pilot-IGBT with a conventional design and the RC-IGBT with the shorts on the collector. The pilot-IGBT is needed to prevent the snapback effect. Due to the lack of the shorts the p-emitter efficiency is higher in the pilot area. As a reason of that, the plasma concentration during the on-state is higher in the pilot-IGBT, as in the RC-IGBT. The inhomogeneous charge carrier distribution will have an influence on the turn-off behavior in the IGBT mode. This behavior has been investigated at different current levels and compared to a state-of-the-art IGBT. At low current the BIGT has a significant higher dvCE/dt and a lower over-voltage. The large hole density in the pilot area causes a high dE/dx and a short space charge region at the same blocking voltage. So there remains a lot of charge in the BIGT, which leads to a large tail current. At high current the high dE/dx in the pilot-IGBT will cause the dynamic avalanche. Due to the dynamic avalanche the dvCE/dt and the di/dt will be limited. Compared to the IGBT the inception voltage of this effect in the BIGT is significantly smaller, that's why the device is softer than the conventional IGBT.

More awards from Semikron

Also the SEMIKRON Foundation **(www.semikron-stiftung.de)** and the ECPE **(www.ecpe.org)** jointly honored the team of Michael Eberlin, Florian Reiners, Olivier Stalter, Sebastian Franz (all of Fraunhofer ISE, Freiburg) and Frank Seybold (KACO new energy) with the Innovation Award 2013 for their "Innovative Power

LEFT: The SEMIKRON Young Engineer Award has been handed over to Jordi Everts by ECPE President Leo Lorenz

Electronics for the next generation village energy supply" concept. "The researchers have developed power electronics components for a complete off-grid solar energy supply system", said Bettina Heidenreich-Martin, member of the Semikron Foundation Board, during the award ceremony. "The innovation is considered a holistic approach to off-grid PV supply for larger consumers, such as villages and businesses, particularly in emerging countries."

The SEMIKRON Young Engineer Award has been handed over to Jordi Everts, PhD student and research assistant at the Catholic University of Leuven (KU Leuven) in Belgium, Department of Electrical Engineering (ESAT), for his concept of a "Bidirectional Isolated ZVS DAB DC-DC Converter with Ultra Wide Input and/or Output Voltage Range, being Applied in a Single-Stage PFC AC-DC Electric Vehicle Battery Charger". With these awards, the SEMIKRON Foundation and the European ECPE Research Network honor outstanding innovations in projects, products, prototypes, services and innovative concepts in the field of power electronics. In total, there were 19 applications and submissions for the two SEMIKRON awards, 5 of which have been nominated for the Young Engineer Award as well. Prof. Dr. Leo Lorenz, President of ECPE, presented the awards on behalf of the SEMIKRON foundation.

"One of the key objectives for the ECPE European Centre for Power Electronics is to foster and support research and education in the field of power electronics", said Lorenz. "The ECPE network, with its 70 members, currently includes 70 European universities and research institutes as so-called Competence Centres. I welcome the support for young researchers in the field of power electronics, and want to express my thanks to SEMIKRON Foundation for issuing the awards".

HVDC keynote

Jörg Dorn from Siemens/Germany gave the first interesting keynote on the challenges of power distribution particularly in Germany due to the so-called "Energiewende" or stepping out of nuclear power.

The growing share of power generation from renewable energy sources leads to continuative challenges in the field of electric power transmission. The load centers are often far away from the location of generation and very long transmission distances have to be considered. Requirements, such as low environmental impacts, low transmission losses and high availability have to be fulfilled. In many cases, HVDC (High Voltage Direct Current) transmission it is the only technical and economical solution to cope with these challenges.

Line-commuted converter technology was the unique solution for many decades and is today focusing on bulk power transmission up to 8 GW. Since the introduction of IGBT based modular multilevel converters (MMC) into HVDC transmission, this VSC technology is becoming significantly important. It combines low losses, excellent controllability and failure handling with the capability to build large multi-terminal systems or even HVDC grids in the future.

HVDC will play a dominant role in tomorrow's power transmission systems. In UK, it is planned to connect more than 30,000 MW offshore by HVDC until 2030, in Germany about 20,000 MW until 2020. In Germany, that power has to be transmitted to the load centers.

Since complete new AC transmission overhead lines are critical due to the visual impact, parts of the transmission lines will be realized as cable. As a result, HVDC will have to be used. According to the current status of the network development plan in Germany, three HVDC corridors from the North to the South are planned by the Federal Network Agency, with a total capacity of 8,000 MW. The integration of hydropower – including hydro storage - in Scandinavia and Eastern Europe and solar power from North Africa will also lead to new HVDC systems, which might result in a huge HVDC overlay grid in the future. As a vision, even continents can be interconnected with the possibility to balance power generation and load peaks over the day and night phases.

The second keynote by Alsthom covered the

RIGHT: Jörg Dorn from Siemens/Germany gave an interesting keynote on the challenges of power distribution particularly in Germany due to the so-called "Energiewende"

LEFT: Full house during the PCIM conference sessions

move from IGBTs towards SiC MOSFETs in transportation, the third keynote focused on voltage regulator modules for powering microprocessors.

Special session on gallium nitride

PEE's Special Session "Power GaN for Highly Efficient Converters" on May 16 afternoon attracted some hundred conference delegates. The The third PCIM keynote by Qiang Li, Virginia Polytechnic Institute on this morning, was a perfect introduction to this subject, because it impressively showed how Power GaN technology can optimize the multi-phase voltage regulator (VR) technology that powers almost every Intel processor today. The VR technology is a specialized distributed power system that provides precisely regulated output with fast dynamic response so that energy can be transferred as fast as possible to the microprocessor. Four papers have been presented in this session.

Efficient Power Conversion Corporation (EPC) has been in production with enhancement mode GaN-on-Silicon power transistors (eGaN FETs) for over three years. Much progress has been made improving device performance and reliability. There have also been several new power management applications that have emerged. Two of these applications, RF Envelope Tracking and high frequency Wireless Power Transmission are beyond the fundamental capability for the aging power MOSFET due to the requirements of high voltage, high power, and high frequency. As a result, these are early growth markets for GaN on Silicon devices, as CEO Alex Lidow demonstrated.

Devices based on GaN have emerged and now matured enough to demonstrate higher efficiency in inverter circuits for both solar and motor drive systems. The presentation given by Transphorm's VP Product Development investigated how GaN is making such rapid performance progress and uses test results to illustrate what is now possible using GaN compared to recent SiC transistor performance.

GaN Systems is investing heavily to accelerate the adoption of the new technology by designing CMOS integrated driver solutions onto which the GaN die is mounted directly in a stacked chip assembly combining the switch, its driver, sensors and customized interface circuitry. In solar and wind inverter applications the high voltage operation, embedded galvanic isolation and high speed operation of these devices offer the prospect of higher switching speeds with improved conversion efficiency, lower component count, smaller size and reduced conversion loss, as CEO Girvan Patterson explained.

Experimental results for the use of GaN based power devices in highly efficient high frequency power circuits such as AC/DC power supplies, DC/DC boost and DC/AC motor drive inverters were presented by Michael Briere, also the current status of the development and current performance of the required 600 V rated GaN on Si based devices at International Rectifier, including the development of crack free AlxGayN alloy based epitaxy on standard thickness 150 and 200 mm Si substrates. Results of long term reliability studies of more than 5000 hrs were presented, as well as results for device robustness under standard application conditions. We will publish these papers in this and upcoming issues. **AS**

Literature

"More Power for a Greener World", Power Electronics Europe, April/May 2013, pages 25-27

PEE Special GaN Session speakers Alex Lidow, Girvan Patterson, Michael Briere, and Yifeng Wu at the final podium discussion