Power Session

GaN and SiC power device: market overview

M. Rosina
Senior Analyst, Energy Conversion and Emerging Materials
Yole Développement, Power and Wireless,
Villeurbanne (Lyon), France

Abstract
Wide-band gap (WBG) materials, in particular Silicon Carbide (SiC) and Gallium Nitride (GaN) devices have demonstrated the large potential for power electronic applications. According to Yole estimates, the market for SiC and GaN-on-silicon devices in power electronics will reach 10% of market share in five years.
The first commercially available SiC diode has arrived to the market 18 years ago and since then progressively replaced silicon diodes in many applications. SiC MOSFETs has also become commercially available. The 2016-2018 period is crucial for SiC MOSFETs as well as for the whole SiC industry. Actually, SiC MOSFET manufacturers have improved the device reliability and performance. SiC MOSFET is gaining confidence of numerous customers and has penetrated into different applications. The availability of SiC transistor has enabled the realization of full-SiC power modules, providing the strongest benefits compared to silicon-based power modules. The SiC technology market adoption is accelerating. Today, the development efforts have been refocused to the manufacturing issues to drive the cost down: technology transfer to 6-inch wafers, improving manufacturing yield and ramp-up of high volume production.
GaN on Silicon power devices are less mature compared to SiC power devices. But several GaN-on-Silicon power devices suppliers have also entered the mass production phase. The market is driven by low voltage high frequency applications such as Lidar, wireless power, where GaN has its unique selling point as well as consumer power supply market where the weight and size is extremely important. For high voltage industrial applications, the reliability issues are still hindering a larger penetration of GaN devices.
In this presentation, we will give an overview of the market, technology and the industrial supply chain.

Biography
Dr. Milan Rosina is a Senior Analyst for Power Electronics and Batteries at Yole Développement. Before joining Yole, he worked as a Research Scientist and a Project Manager in the fields of photovoltaics, microelectronics, and LED. Dr. Rosina has more than 15 years of scientific and industrial experience with prominent research institutions, an equipment maker, and a utility company. His expertise includes new equipment and process development, due diligence, technology, and market surveys in the fields of renewable energies, EV/HEV, energy storage, batteries, power electronics, thermal management, and innovative materials and devices.

GaN - the future for rectifiers.

O. R. Schmidt
Project director r&d
Eltek A/S, r&d, Drammen, Norway

Abstract

New devices based power converters and systems

Keywords—Wide band Gap semiconductor used in rectifier with focus on GAN transisitor
When dealing with power conversion in a data center, the efficiency and cost-effectiveness is key! Due to the size and capacity of a modern data center, even small efficiency improvements in the power conversion from the incoming AC to the server load have great impact in terms of cost saving.

Over time, Eltek has been exploring wide band gap technology, using GaN transistors instead SiMoS Fets in order to achieve higher efficiency and reliability. Together with Infineon, Eltek have for more than 2 years participated in an EU research program which now has resulted in a new 3kW/48Vdc rectifier with a peak efficiency of 97,8%. The combination of Eltek's proven High Efficiency (HE) technology and Infineon's GaN transistors has enabled a truly cost effective rectifier in the Super High Efficiency range.

With modern silicon devices it is feasible to raise efficiency in the 230Vac-48Vdc conversion step to 98%, but based on the experience from our extensive research we are convinced that this efficiency can better be achieved by utilizing the GaN technology; simpler, more reliable and more cost effective.
In our Super High Efficiency rectifier, we have been using totem pole topology with a lot of different technical issue. The PFC has a peak efficiency of approx. 99% and the rectifier has peak efficiency of 97.8%

Totem pole PFC

This paper will describe how and why GaN is the key to achieve reliable 98%+ efficiency.

Biography

Odd Roar Schmidt(m): R&D Project Director with Eltek. MSc in power electronics from NTNU. He has an extensive experience, 37 years,from industrial R&D and industrialisation of power converters. Formerly, director for Telecom division in Power-One where he was responsible for System, Controller and Rectifier/Converter technology and products. He has also been technical director for Power-One and Eltek.

Design of a 10kW Three Phase PFC with Silicon Carbide

M. Paglia
Application Engineer
ON Semiconductor gmbh, Sales & Marketing,
Munich, Germany

Abstract
A typical On Board battery Charger application for electric vehicles consists of a power factor correction stage (PFC) and a DCDC converter stage, both require the highest efficiency possible in order to deliver as much power as possible to the battery pack. Focus of this work is the 3 phase 10 kW PFC based on Silicon Carbide Mosfet which regulates the output voltage to 700V starting from a nominal input voltage of 230Vrms at 50Hz. Three parameters measure the performances of the system: total harmonic distortion, power factor and efficiency. Ideally they should be zero, one and 100% respectively.
The configuration selected is typically known as inverter, made by 3 half bridges with each central point connected to a dedicated boost inductor, and each high side drain and low side source connected to the bus capacitor. 1200V SiC MOS 80m devices were used together with the recently released ON Semiconductor dedicated SiC gate driver, NCV51705. A digital control has been adopted by means of a mid-range microcontroller. The implemented strategy is based on a field oriented control approach where the rotating DQ domain has been selected aligning the D axes with the input voltage space vector. The selected HW together with the digital implementation represents a bidirectional system, therefore power can flow either ways by modification of the D axis reference current sign. The control strategy works on an interrupt running at 20 kHz using one ADC, 12 bits 1Mbs and one sample and hold. PWM frequency set to 70kHz.
Experimental results demonstrate that the PFC was able to achieve as high as 98.7% at 6.6kW with a consistent efficiency above 98% at higher power output. THD was well below 5% from 3kW onwards and PF is above 0.99 from 4kW. All evaluated at nominal input voltage, 230Vrms.

Biography
Massimo Paglia received his B.Sc and M.Sc degree in Electrical Engineering from University of L'Aquila in 2004 and 2008 respectively.
From 2009 to 2014 he was with the R&D team at Whirlpool Europe where he worked on the development of 3 phase motor control algorithms.
In 2014 he joined ON Semiconductor as part of the Solution Engineering Center supporting the European Sales & Marketing group. His actual assignment is development of smart algorithms for three phase systems in power applications.

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Senior Analyst, Energy Conversion and Emerging Materials
Yole Développement, Power and Wireless,
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Biography

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Perspectives for disruptive 200mm/8-inch GaN power device and GaN-IC technology

D. Marcon
Sr. Business development manager
IMEC, Leuven, Belgium

Abstract
Today, GaN-on-Si is accepted as a break-through power electronics technology. The favorable materials characteristics and the e-mode lateral HEMT device architecture have led to disruptive device performance. Issues with trapping effects and reliability that plagued early versions of the technology have been addressed and first products are in the market.
Today imec is focused in further increasing the performance and reliability of its 200mm/8-inch GaN-on-Si e-mode devices for 200V and 650V applications. Next to improving GaN-on-Si e-mode technology, imec is also investigating the next generations of GaN technologies that will provide: higher level of integration (GaN-IC), higher performance and larger voltage rating Particularly attention is dedicated to GaN-IC that allows to unlock the full potential of the fast switching GaN-based power devices. Indeed, monolithic integration of a half-bridge, co-integration of the GaN drivers, and free-wheeling diodes offer a way to reduce parasitic inductances, while on-chip temperature sensors and protection circuits increase the robustness. Such power GaN-IC's pave the way for unprecedented compact high-end power systems.
In this talk, imec will review the status of GaN-on-Si e-mode device technology as well as its recent progress on technologies for GaN-IC.

Biography
Denis Marcon received a M.S. degree from the University of Padova in 2006. Subsequently, he received the degree of Doctor in Engineering (Ph. D.) from the Catholic University of Leuven and imec with the thesis entitled "Reliability study of power gallium nitride based transistors" in 2011.He is leading author or co-author of more than 50 journal papers or conference contributions.
Currently, he is a Sr. business development manager in imec, Belgium, and he is directly responsible for the partnerships with imec in the field of GaN power electronics and on dedicated development projects of Si-based device and sensors.

Electroless ternary nickel alloys for under bump metallization (UBM) on power semiconductors for high temperature process conditions or applications

A. Walter
Electroless Team Manager
Atotech Deutschland GmbH, Berlin, Germany

Abstract
The presentation will show benefits and feasibility results for electroless plating of different ternary nickel alloys in comparison to the standard electroless phosphorous-containing nickel for packaging in growing power electronics or automotive industry.

Standard electroless phosphorous-containing nickel for ENEP* or ENEPIG** under bump metallization has the disadvantage that at temperatures above 350°C a phase transition occurs which leads to a layer stress change and may cause cracks in the under bump layer.

Ternary nickel alloys reveal no phase transitions up to 600°C, and are an excellent alternative to the standard electroless medium or high phosphorous-containing nickel for high temperature processing post nickel deposition, and high temperature soldering or applications.

The paper will showcase results of the advanced properties of three different electroless ternary nickel alloys in comparison to a standard medium phosphor and a low phosphor nickel, with regards to thermal behavior, stress shift, and facture toughness.

*electroless nickel, electroless palladium

** electroless nickel, electroless palladium, immersion gold

Biography
Andreas Walter has more than 18 years experience in the semiconductor industry and is currently working as head of application for electroless plating processes for Semiconductor Advanced Packaging at Atotech.

Prior to joining Atotech in 2009, he worked for 3 years as an Senior Engineer at Qimonda for process integration of new memory systems, and for 7 years as a Development Engineer at Infineon, where he was responsible for material development and process integration in 300 and 200mm fab for D-RAM and resistive memories.

Andreas received his Diploma and PhD in chemistry at the Martin Luther University in Halle, where he started as a scientist for synthesis of OLED dyes and organic semiconductors.

SiC Activation and Oxidation Technology and related Production Tools

centrotherm

P. Schmid
Senior Mgr. Process & Technology
centrotherm international AG, Blaubeuren,
Germany

Abstract

Wide Band Gap (WBG) semiconductors such as SiC, GaN, diamond and recently Ga2O3 show superior material properties, which allow operation at high switching speed, high voltage and high temperature, enabling lower conversion losses and smaller converter volumes. Driven by these superior properties and propelled by new volume markets like Electrical Vehicles (EV), WBG semiconductors are today at the doorstep from niche to mainstream. SiC is considered the most advanced WBG semiconductor for power, with main application in the medium to high voltage range (> 600V) followed by GaN with good potential in medium voltage range (< 600V). The success of SiC comes also from its generally high compatibility with Si manufacturing technology and Si production lines. However, due to the different physical and chemical properties of SiC, process steps have to be adjusted. For a few process steps, the requirements are so different that they are out of scope for standard Si tools and require special new tools. For instance, for superior thermal gate oxide formation, temperatures up to 1500°C along with NO gas annealing capability are desirable and for dopant activation in SiC, even temperatures up to 2000°C are required.

The presentation will mainly touch on SiC specific technology aspects related to dopant activation and thermal gate oxide formation followed by a brief introduction of centrotherm´s SiC dedicated tool set.

Biography

Patrick Schmid has over 22 years of experience in semiconductor industry.

For 15 years he was engaged in various technology, R&D and management positions at a leading RTP manufacturing company. When he joined centrotherm in 2011, the scope of his work changed, from Si based logic and DRAM technology, to SiC based power technology, covering positions in technology, R&D, product management and now in Technical Sales.