8th ECPE SiC & GaN User Forum
Potential of Wide Bandgap Semiconductors in Power Electronic Applications
— Report of Conclusions —

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Overview

Since more than 12 years the biannual ECPE Wide Bandgap User Forum has given advise and support to the introduction and the usage of SiC and GaN devices in power electronic systems. Major progress has been achieved, with today a multitude of SiC diodes and transistors being available and used in series products. For those, special aspects gain importance, such as robustness or qualification when exposed to demanding mission profiles. On the other hand ongoing research and development work is dedicated e. g. to increase voltage and current ratings of SiC devices, to GaN devices including their integration, the respective packaging technology and of course to the applications. Some main topics of this year's ECPE wide bandgap user forum are summarised in the following:

State of the Art and Trends

Several international research programmes and centres have been introduced, contributing to the progress in SiC and GaN devices and systems making use of those. SiC devices have been found to be beneficial for applications in transportation — in particular automobiles with electric drive, and on a higher power level railway — as they permit to increase efficiency and power density. SiC transistors and diodes may serve in traction converters or power supplies there. Photovoltaic inverters constitute another important application. Besides, also special applications have been addressed, e. g. high frequency induction heating — remarkably with resonant switching — or converters in the medium voltage grid as currently investigated as a future option. GaN transistors will mainly be rated up to 650V and used up to voltage levels as supplied by the 230V single phase grid, e. g. for hard switching power factor correction and similar power supply

applications. Obviously the usage of wide bandgap devices requires more than just replacing silicon devices; instead only an appropriate circuit and system design will allow to fully exploit the wide bandgap devices' potential. This e. g. concerns aspects like the cooling concept, partially permitting to replace fluid by air cooling, or the isolation within the converter and beyond, e. g. in an electrical machine, taking into account the applied voltages and their high change rates. Obviously the passives shall be chosen appropriately as well which in most cases seems possible but will not always rely on standard components. Careful parallel connection of relatively small wide bandgap devices may be required to achieve a high current capability.

With regard to SiC, devices and the related packaging technology have been addressed where advanced modules and embedding play an increasing role. Drivers dedicated to the transistors are sufficiently fast and make sure good electromagnetic compatibility taking into account the fast switching slopes and the need to maintain controllability. The devices have reached a high degree of maturity, providing good ruggedness e. g. under surge current or avalanche conditions. Their reliability e. g. with respect to gate oxide stability, humidity and load cycles has been qualified; it should however be noted that the applicable test methods partially differ from what has been established for silicon devices and that the respective device modelling to understand failure mechanisms still is subject to research. With respect to GaN research activities aiming at an optimisation of material and the several types of transistors have been reported. Integration on chip level has been presented as well as hybrid integration and various packaging technologies, ranging from pre-packages e. g. for embedding via chip-scale packages up to more conventional solutions with minimised parasitics. Besides the aspects already mentioned with respect to SiC drivers, GaN drivers need to comply with the different driving conditions or voltages respectively of the devices, maintaining a standard interface towards the control unit. Major progress has been reported considering parasitic effects like dynamic on-state resistance and current collapse, further also considering breakdown towards the silicon substrate in integrated lateral GaN devices.

Conclusion and Outlook

The findings as briefly summarised above illustrate the fast development of wide bandgap power semiconductors. This is beneficial for power electronics as a key technology in various areas, such as energy efficiency, usage of renewable sources for electric energy supply, electromobility or also automation. Both, SiC and GaN devices are available and in particular SiC devices are well qualified and widely applied in commercial products. Nevertheless, research, development and also standardisation are ongoing to further explore the possibilities of wide bandgap devices in power electronics. The European Center for Power Electronics (ECPE) is a stakeholder in this area, bringing together industrial partners and research institutions. After the major interest of more than 300 participants in this year, ECPE will anounce the next SiC & GaN User Forum in conjunction with its annual event in spring 2021, where the progress achieved since today will be reported.