Invited Paper

Power Electronic Devices Based on Bulk GaN Substrates

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Fast switching power semiconductor devices are the key to increasing the efficiency and reducing the size of power electronic systems [1]. For the last three decades, silicon power devices (MOSFETS, IGBTs, and diodes) have dominated the power device market. During this time there have been tremendous improvements in silicon power device performance. However, these devices are now approaching the physical material limits of silicon. Alternative wide-band gap semiconductor materials, such as silicon carbide (SiC) and gallium nitride (GaN) are enabling a new generation of power devices that will far exceed the performance of silicon-based devices. Wide band-gap semiconductors enable continued improvement of the efficiency and reduced system size of power electronics. SiC diodes have already been commercialized and they are increasingly utilized in applications that demand higher efficiency and reliability. However, there is great interest in developing GaN-based power devices because the fundamental material based figure-of-merit of GaN is much higher than either SiC or Si.

This presentation will provide an introduction to wide-bandgap power electronic devices. Subsequently, the power-device figure-of-merit [2-4] governed by the physical properties of the semiconductor material will be derived for Si, SiC, and GaN. It will be demonstrated that the full potential of the GaN material system can be realized by fabricating vertical devices growing epitaxial GaN layers on bulk GaN substrates by MOCVD (metal organic chemical vapor deposition). Published results from Si and SiC devices along with lateral (horizontal) GaN power devices fabricated on SiC or silicon substrates are compared with the True GaN™ approach. Record device performance results will be shown for devices with breakdown voltages of 600 to 3700 V and current levels approaching 100 A. Temperature characterization data, switching behavior in a boost circuit, and results from reliability testing will prove that applications such as server farms, inverters for solar and wind, solid state lighting, motor drives, and hybrid/electric vehicles will all benefit from the development of devices based on bulk GaN substrates.

References:

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