PERFORMANCE, RELIABILITY AND YIELD CONSIDERATIONS IN THE MANUFACTURING OF POWER ELECTRONICS BASED ON SiC AND GaN

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Solar energy and wind energy can meet the future needs of mankind and provide clean energy in the 21st century. From an overall energy efficiency point of view, DC power delivery systems are superior to AC power delivery systems [1]. The use of photovoltaic systems for DC power generation and the delivery and the utilization of DC power can bring clean energy revolution in a manner similar to the role played by low power electronics in the field of global communication. Power electronics based on silicon is not suitable to meet future requirements of power distribution and power utilization. Wide band gap semiconductors, [2] especially silicon carbide and gallium nitride can meet the future needs of power electronics. Significant progress has been made in the last couple of years in SiC and GaN power devices; however the progress is not sufficient to bring the performance and reliability requirements that are warranted for transformative changes in power electronics industry [3].

The performance, reliability, and yield of semiconductor products depend on the defect density [4]. Part of the success of silicon integrated circuit (IC) industry is due to the fact that in the last 50 years, the defect density of the materials involved in Si IC manufacturing has been reduced by more than four orders of magnitudes. Careful examination of the literature shows that bulk defects of SiC and GaN wafers, epitaxial defects and process induced defects are the major roadblocks in achieving the best performance of power devices using these materials. The use of silicon as a substrate provides the ideal platform to build next generation of power electronics based on SiC and GaN. Most of the commercial epitaxial growth systems are using batch processing [5-6]. Silicon IC industry has virtually adopted single wafer processing (SWP) to address the issue of defect density and other manufacturing considerations [7]. The use of advanced process control in SWP allows the control of defect density as well variability of device parameters. In place of conventional thermal processing, rapid thermal processing is used to provide shorter processing time and lower processing temperature resulting in lower defect densities. In addition, the use of high energy incoherent photons in single wafer thermal processing [8] and single wafer chemical vapor deposition [9] provides ultra-high performance devices. Incoherent light sources capable of illuminating a large area (such as 8 inch wafers) with sub 200 nm wavelength are available now and there is an excellent opportunity to develop new processing tools and new processes for ultra-high performance and reliable SiC and GaN power devices and circuits. .

In this paper we will demonstrate that in order to address the defect issues in SiC and GaN based power electronics, new processing tools need to be developed. New process tools should take advantage of the knowledge base that has led to the success of silicon IC industry. Failure to invent and manufacture new processing equipment will be a lost opportunity to develop transformative power electronics based on SiC and GaN semiconductors.

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