IGaN's 200mm GaN-on-Si epi to optimize cost in power switching

Commercialization in mid-2019 to advance next-generation high-speed, high-power devices.

As gallium nitride (GaN) is a wide-bandgap semiconductor material that is suitable for the next generation of high-speed and high-efficiency power devices, Singapore-based IGSS GaN Pte Ltd (IGaN) has developed high-quality gallium nitride on 200mm silicon substrates for power electronics applications. In collaboration with its tool vendor, IGaN has developed the epitaxial wafers for a 200mm CMOS-friendly GaN fab process that they will make available by mid-2019.

"We believe that 200mm is the way to go to achieve mainstream adoption of GaN in new power electronics," says president George Wong. "With 200mm you potentially save two times of the cost of 150mm solutions, which is the prevalent platform today. It has first been demonstrated by Institute of Materials Research and Engineering (IMRE) Singapore in 2011, where we licensed the technology from," he adds.

"Today, we have achieved even better uniformity and demonstrated higher breakdown voltages. IGaN will be mass-production-ready with our fab partner in second-quarter 2019," says Wong. "We are looking for customers now to take first-mover advantage of our one-stop semiconductor hub solution for 200mm GaN epiwafer and GaN fab process."

The main challenge in manufacturing 200mm GaN-on-Si epiwafers is achieving high uniformity, good crystalline quality of GaN, low wafer warp and bow, low surface roughness, crack-free, and high breakdown voltage. This is mainly due to the thermal mismatch and lattice mismatch between the silicon and GaN. To overcome this, the epitaxial layer must have a buffer layer to mitigate the stress formed during GaN growth. IGaN has been able to optimize the buffer layer to achieve high breakdown voltages of greater than 650V without compromising the crystalline quality of the GaN. Figure 1 shows the typical IGaN GaN-on-Si epiwafer structure for power applications.

Material quality

IGaN used a state-of-the art metal-organic chemical vapor deposition (MOCVD) tool with in-situ thickness measurement capability to grow the GaN on Si<111> substrates. The process used a thick film epitaxial growth technology to meet the >650V breakdown voltage requirements. The key was to optimize the gas flow rates, temperature and pressure at various stages to control the GaN crystal growth. IGaN demonstrated epiwafers that are crack-free, have low warpage of ≤±50μm (see Figure 2) and have low surface roughness of ≤0.3nm (see Figure 3). These characteristics meet the mass-production requirements of an 8-inch fab process for power devices.

Low defect density

IGaN has optimized the process to achieve low dislocation density and high crystalline quality while achieving high breakdown voltage. To analyse the crystalline quality, high-resolution x-ray diffraction (HRXRD) measurements were performed. The XRD omega rocking curves measurement of GaN(002) and GaN(102) reflection are below 400 and 850 arc sec, respectively (see Figure 4).

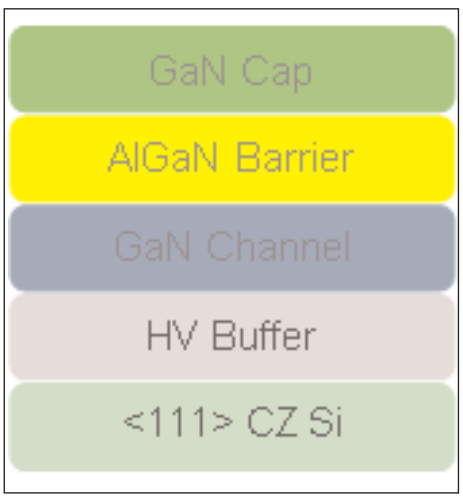

Figure1: Epi structure of IGaN's GaN-on-Si epi for power applications.

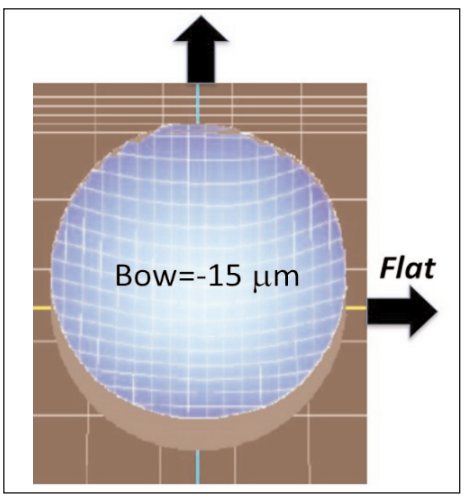

Figure 2: Low wafer bow (<50μm) for 200mm GaN-on-Si epiwafer.

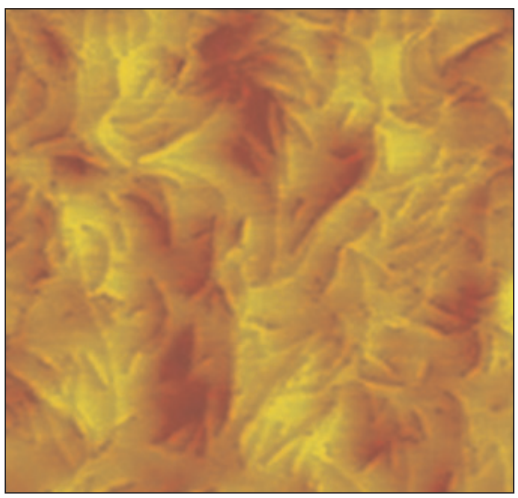

Figure 3: Typical surface roughness of 200mm GaN-on Si epi 0.25nm.

Material uniformity

IGaN's epiwafers exhibit excellent material uniformity. The thickness and the aluminium composition distribution uniformity are typically better than 1% (see Figures 5 and 6), translating characteristics to high-yielding epiwafers during GaN device fabrication.

High breakdown voltage

IGaN's GaN-on-Si epiwafers can withstand high breakdown voltage. Typical measurements exhibit a lateral breakdown voltage of greater than 800V at 1μA/mm with 15μm space (see Figure 7) and a vertical breakdown voltage of greater than 650V at 1μA/mm^2 (see Figure 8).

Forward conduction characteristics

IGaN's epiwafers have good forward conduction characteristics. The two-dimensional electron gas (2DEG) concentration is more than 8x10^{12}cm^{-2} and the 2DEG mobility is better than 1500cm^2/V·s. The resistance is less than 500Ω/sq.

Conclusion

IGaN's 200mm GaN-on-Si epiwafers have achieved excellent performance and uniformity for GaN power devices fabrication. The firm aims to continue to innovate and contribute to driving the adoption of GaN by providing high-quality GaN-on-Si epiwafers and GaN fab processing.

IGaN also supplies GaN-on-silicon epiwafers in both 100mm and 150mm diameters. ■

www.igssgan.com

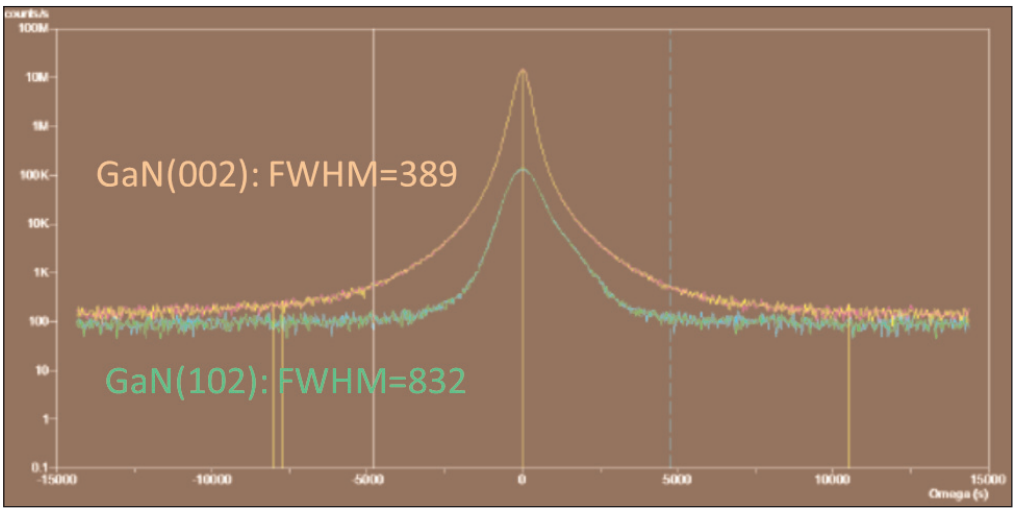

Figure 4: XRD omega rocking curves of GaN (002) and GaN(102) reflection for IGaN's 200mm GaN-on-Si epiwafer giving a measure of tilt and twist in such a large area.

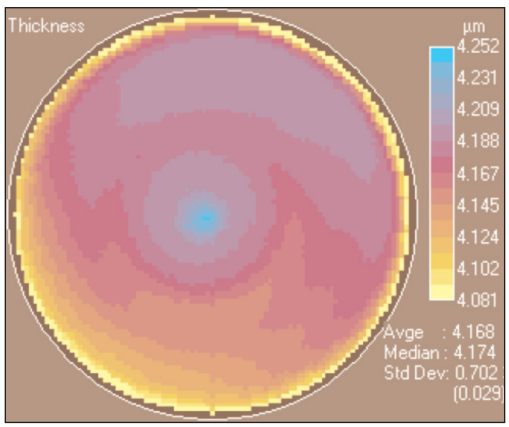

Figure 5: Typical epitaxial thickness uniformity of IGaN's 200mm GaN-on-Si epiwafer.

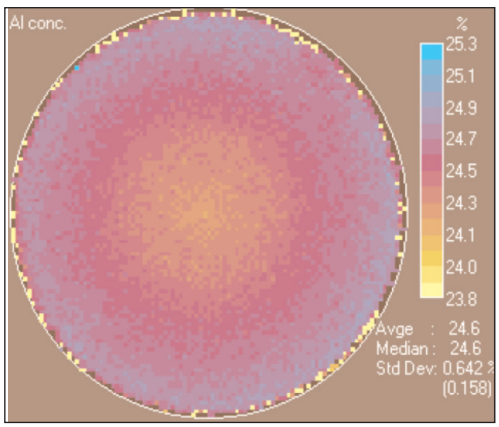

Figure 6: Al composition distribution of AlGaN barrier layer of IGaN's 200mm GaN epiwafer.

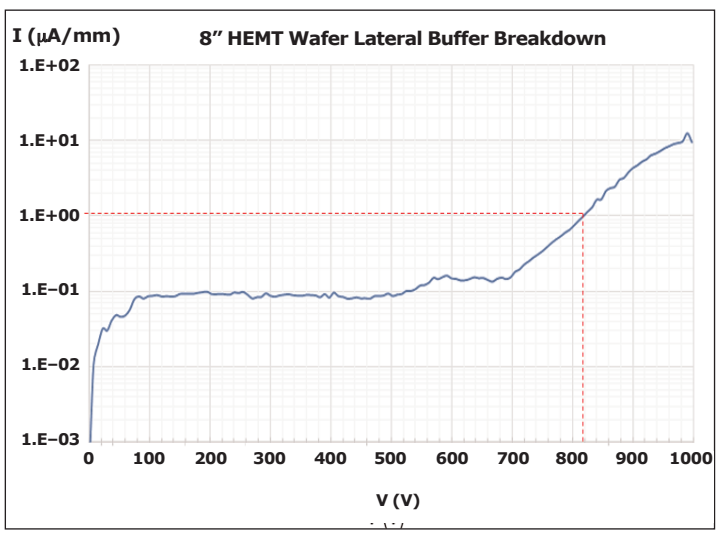

Figure 7: Lateral breakdown voltage characteristics of IGaN's 200mm GaN-on-Si epiwafers with 15μm space.

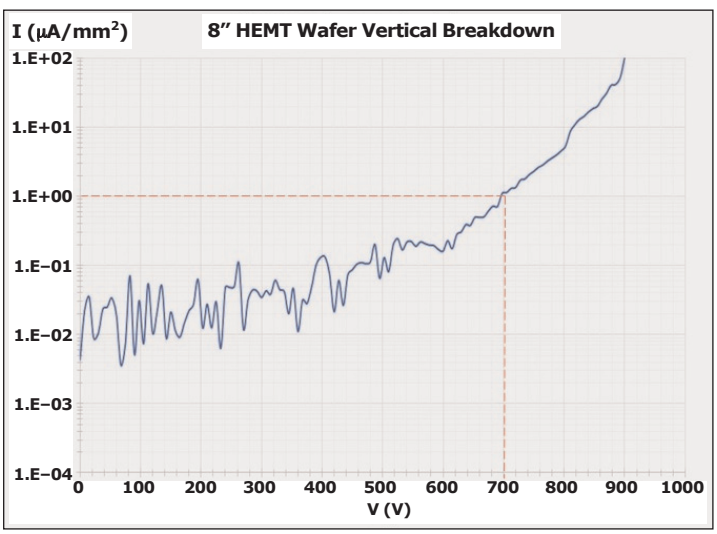

Figure 8: Vertical breakdown voltage characteristics of IGaN's 200mm GaN-on-Si epiwafers.