Ammonothermal Bulk GaN Substrates for Power Electronics

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GaN-on-GaN power devices are beginning to demonstrate significantly better performance (specific on-resistance versus breakdown voltage) than corresponding SiC-on-SiC or GaN-on-Si power devices, in agreement with theoretical predictions. Bulk GaN substrates grown by vapor-phase techniques have been in routine commercial use for GaN-based laser diodes since 2006 and are now being used for GaN-based LEDs. However, these substrates are pseudo-bulk by virtue of being grown on non-GaN substrates such as sapphire or GaAs, have defect densities that are undesirably high, have limited availability above 2 inch diameter, and are expensive. Soraa has developed a novel ammonothermal approach for growth of high quality, true bulk GaN crystals at a greatly reduced cost. Soraa's patented approach, known as SCoRA (Scalable Compact Rapid Ammonothermal) utilizes internal heating to circumvent the material-property limitations of conventional ammonothermal reactors. The SCoRA reactor has capability for temperatures and pressures greater than 650 °C and 5000 atm, respectively, enabling higher growth rates than conventional ammonothermal techniques, yet is less expensive and more scalable than conventional autoclaves fabricated from nickel-based superalloys.

SCoRA GaN growth has been performed on *c*-plane and *m*-plane seed crystals with diameters between 5 mm and 2" to thicknesses of 0.5-4 mm. The highest growth rates are greater than 40 μm/h and rates in the 10-30 μm/h range are routinely observed. These values are significantly larger than those achieved by conventional ammonothermal GaN growth and are sufficient for a cost-effective manufacturing process.

Two-inch diameter, crack-free, free-standing, n-type bulk GaN crystals have been grown. The crystals have been characterized by a range of techniques, including x-ray diffraction rocking-curve (XRC) analysis, optical microscopy, cathodoluminescence (CL), optical spectroscopy, and capacitance-voltage measurements. The crystallinity of the grown crystals is very good, with FWHM values of 15-80 arc-sec and average dislocation densities below 1×10^5 cm^{-2}.