larger sizes, with extra wide gates up to 150 mm. This calls for MOCVD growth, processing and characterization specific challenges in order to reach the ~1cm^2 area functional devices that are required.

One of the main difficulties in growing GaN-on-silicon is the stress that develops during the growth and the cooling down. That is mostly due to the difference in lattice parameters and thermal expansion coefficients discrepancy between III-N materials and silicon. As a result, the wafer surface uniformity becomes challenging to achieve, especially for growth on large area wafers (6-inch) with extended surface, considering the structural defects that may appear and thus hinder large area device fabrication.

In this work, we report the growth and the fabrication of normally-on, large size AlGaN/GaN HEMTs. High quality and highly homogeneous crack-free AlGaN/GaN structures were grown by metalorganic vapor phase epitaxy (MOCVD) on 6-inch silicon (111) substrates. HEMTs with gate widths ranging from 30 mm up to 150 mm were fabricated, including processing, packaging by an innovative technology and final components electrical characterization. Device packaging based on die embedment in a PCB-like substrate was used to realize the components before characterization.

HR-XRD, SIMS and TEM of HEMT structures will be presented. Devices clean room processing will be described, including the particular actions taken to fabricate the extremely wide gates on the HEMTs (cm^2 sized chips). For HEMTs with a channel length of 9 µm and a width of 150 mm, the saturation current density I_{DS} of 0.4 A/mm with a minimum R_{on} of 8 mΩ were obtained. A high extinction coefficient (I_{DSon}/I_{DSOff}) of 10^{-6} and a low drain leakage current density of 10^{-7} A/mm have been achieved on square-centimeter sized chips.

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Epitaxy of III-V Nitrides with Strain Relief Layers Analysis—TNL EpiGrow Simulator Praveen K. Saxena, P Srivastava and Anshika Srivastava; Tech Next Lab, India

To sustain the worldwide high demand of electrical energy, GaN is a strongly emerging material grown on SiC for RF frequency or on Si for power electronic device applications. However, GaN cost-effective hetero-epitaxial growth suffers with high defect densities. The technology improvements require accurate prediction with an understanding of their formation. The qualitative and quantitative extraction of types of defects is very difficult to accomplish from an experimental point of view [1-2].
TNL-EpiGrow™ simulator provides cost effective solution to replicate the epitaxial growth in a similar manner as real time reactor [3-4]. TNL-Chemical kinetics utility package provides facility to simulate and optimize the gas and surface phase chemical reactions to help a user work efficiently with large systems of chemical reactions. The adsorption, hopping and desorption mechanism rates are computed using in-house developed kinetic Monte Carlo (kMC) algorithms with capabilities to reproduce the real MOCVD reactor based epitaxial growth experiments[3-4].
In present work authors report the growth morphology of buffer layers of AlN on Si (111) substrate via MOCVD reactor equivalent to an AIXTRON CRIUS® close-coupled-shower head (CCS) architecture [3-4]. The growth process steps include epitaxy of (i) AlN, (ii) varying Al composition in $Al_xGa_{1-x}N$ buffer layers. The basic aim of present work is to understand the formation of line dislocations layer by layer. The AlN lattice parameter (a) is taken 3.1258A as compared to Si (111) 3.84 A. The lattice mismatch causes the tensile strain. At the Si/AlN interface the strain will be high. It reduces as growth proceeds for upper AlN layers. Due to high strain, the probability of formation of line dislocation at interfacial AlN layers is high as compared to upper AlN monolayers. The density of line dislocations depends upon thickness of AlN layers. Successively, epitaxial buffer layers of $Al_xGa_{1-x}N$ with x=0.8, 0.5 and 0.2 are deposited. The lattice parameters of ternary compound increases with increase of Ga content in $Al_xGa_{1-x}N$ as compared to AlN and generate the compressible strain. The thickness of various $Al_xGa_{1-x}N$ buffer layers are optimized to achieve overall minimum strain within $Si/AlN/Al_{0.8}Ga_{0.2}N/Al_{0.5}Ga_{0.5}N/Al_{0.2}Ga_{0.8}N$ structure, further used for GaN epitaxy. The thickness of each buffer layer is decided by proper optimization of partial pressures (**Table I**) of various input gases and chemical kinetics to achieve high quality GaN film with minimum dislocation defects. **Table II** depicts the dislocation data and lattice parameters of deposited materials. It is found that dislocation density increases with the increase of Ga content (0 - 50%). However, the decrease in dislocation density is observed with the further increase of Ga content beyond 50% (**Table II**). The dislocation densities data is also justified from the roughness curve where a sudden rise is visible for $Al_{0.8}Ga_{0.2}N$ growth which finally comes down for Ga rich layers. The island-based growth observed and justifies the experimental Stranski–Krastanov (S-K) growth mode.

Table I: input Partial Pressure of Gases

Gases	**AlN**	**$Al_{0.8}Ga_{0.2}N$**	**$Al_{0.5}Ga_{0.5}N$**	**$Al_{0.2}Ga_{0.8}N$**
TMAl	100sccm	97 sccm	94 sccm	80 sccm
TMGa	3 sccm	6 sccm	20 sccm	
NH_3	1 slm	1 slm	1 slm	1 slm
H_2	1 slm	1 slm	1 slm	1 slm

Table II: Extracted Output Parameters

Parameters	**AlN**	**$Al_{0.8}Ga_{0.2}N$**	**$Al_{0.5}Ga_{0.5}N$**	**$Al_{0.2}Ga_{0.8}N$**
Dislocation Density (/cm^2)	$2.5X10^{11}$	$5.65x10^{11}$	$3.03x10^{12}$	$2.625x10^{12}$
Lattice parameter (°A) **a**	3.8332	3.8277	3.8452	3.8861
b	3.8419	3.8489	3.8866	3.8856
c	7.6801	7.6948	7.7127	7.7208