

Supplementary Online Material for: “Investigation of AlGaN/GaN high electron mobility transistor structures on 200-mm silicon (111) substrates employing different buffer layer configurations”

H.-P. Lee^{1, 2}, J. Perozek^{1, 2}, L. D. Rosario^{1, 2} & C. Bayram*^{1, 2}

¹Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, USA

²Micro and Nanotechnology Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, USA

*cbayram@illinois.edu

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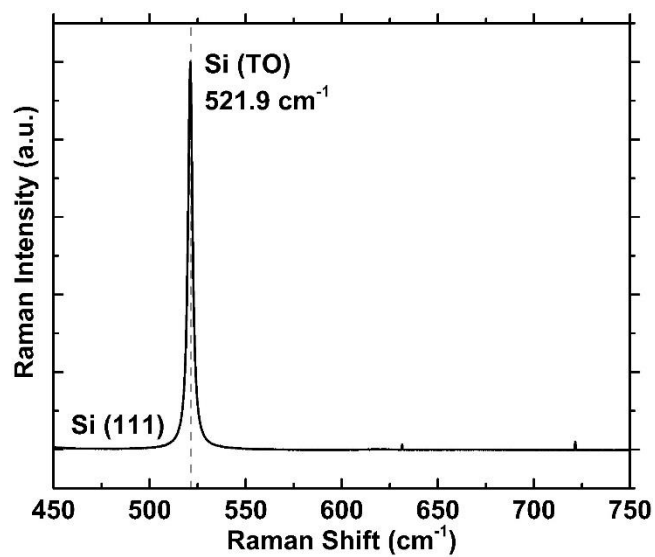


Figure S1. Si (111) Raman spectrum measured by Horiba Raman Confocal Imaging Microscope using 633-nm laser line with a grating of 1800 lines/mm, yielding a spectrum resolution of 1.19 cm⁻¹. A 521.9 cm⁻¹ Si (111) Raman shift was observed.

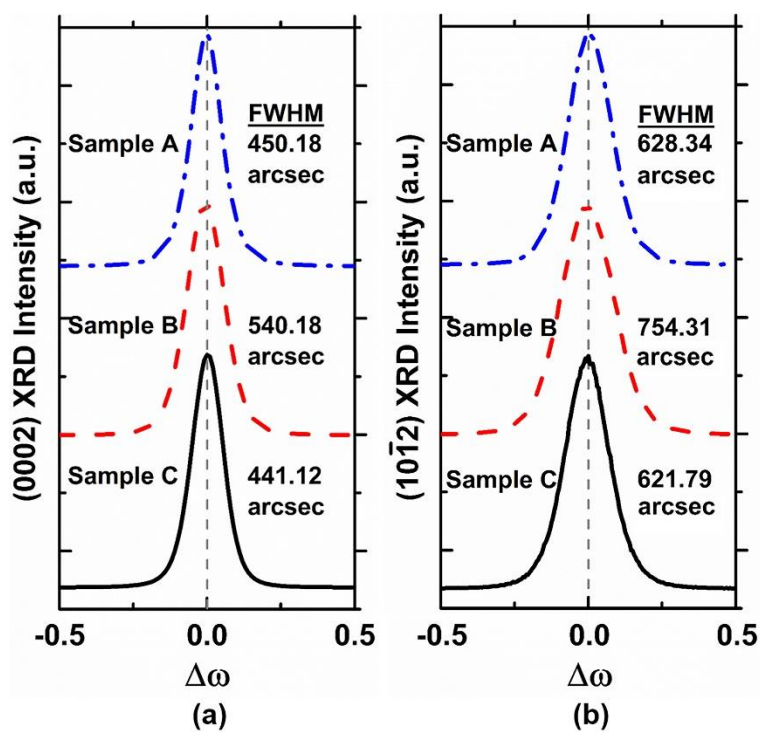


Figure S2. (a) Symmetric and (b) asymmetric ω (rocking curve) scans of (0002) and (101̄2) lattice planes are shown. Symmetric ω scan on (0002) plane is used for investigating the screw-type threading dislocation density and asymmetric ω scan on (101̄2) plane is used for edge-type threading dislocation density investigation (Table 1).

Sample (Epi thickness)	Layers	Measured lattice constant (a/c) (Å)	Free-standing lattice constant (a_0/c_0) (Å)	In-plane strain/stress (%)/(GPa)	Out-of-plane strain (%)
A (6.315 μm)	GaN	3.1936/5.1827	3.1860/5.1860	+0.2331/+1.0586	-0.0629
	$\text{Al}_{0.33}\text{Ga}_{0.67}\text{N}$	3.1558/5.1275	3.1574/5.1262	-0.0540/-0.2364	+0.0253
	$\text{Al}_{0.60}\text{Ga}_{0.40}\text{N}$	3.1371/5.0730	3.1375/5.0728	-0.0067/-0.0283	+0.0032
	$\text{Al}_{0.82}\text{Ga}_{0.18}\text{N}$	3.1295/5.0176	3.1224/5.0232	+0.2246/+0.9185	-0.1119
	AlN	3.1266/4.9678	3.1120/4.9820	+0.4699/+1.8659	-0.2849
B (2.007 μm)	GaN	3.1873/5.1855	3.1860/5.1860	+0.0340/+0.1544	-0.0088
	$\text{Al}_{0.30}\text{Ga}_{0.70}\text{N}$	3.1567/5.1295	3.1583/5.1283	-0.0487/-0.2140	+0.0228
	$\text{Al}_{0.58}\text{Ga}_{0.42}\text{N}$	3.1365/5.0726	3.1372/5.0720	-0.0250/-0.1059	+0.0121
	$\text{Al}_{0.82}\text{Ga}_{0.18}\text{N}$	3.1290/5.0161	3.1220/5.0217	+0.2254/+0.9218	-0.1124
	AlN	3.1279/4.9674	3.1120/4.9820	+0.5134/+2.0387	-0.2933
C (1.125 μm)	GaN	3.1968/5.1815	3.1860/5.1860	+0.3408/+1.5477	-0.0872
	AlN	3.1283/4.9670	3.1120/4.9820	+0.5181/+2.0573	-0.3004

Table S1. XRD reciprocal space mapping calculations are tabulated. The free-standing lattice constants (a_0/c_0) and elastic constants of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ are calculated using Poisson-Vegard's law with bowing parameter correction.^{1,2}

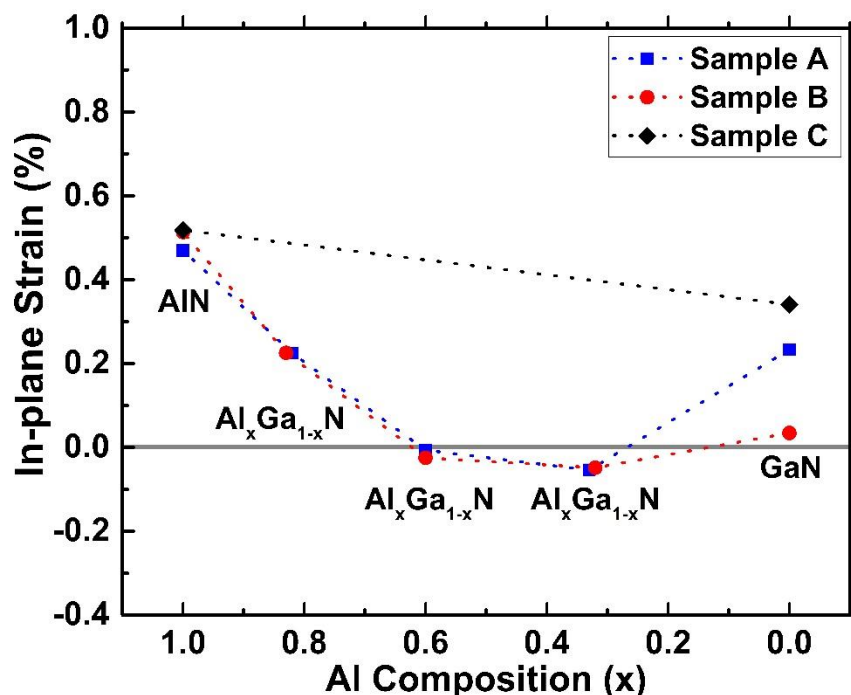


Figure S3. In-plane strain of GaN, $\text{Al}_x\text{Ga}_{1-x}\text{N}$, and AlN obtained from XRD reciprocal space mapping are demonstrated. For sample A and B, from the AlN layer to the $\text{Al}_x\text{Ga}_{1-x}\text{N}$ layer the in-plane strain first decreases from positive (tensile), crossing the zero line (strain-free), and then become negative (compressive). Finally the in-plane strain returns to positive (tensile) due to the growing of the GaN layer. Sample A has a thicker GaN layer than sample B, which results in the higher in-plane tensile strain of the GaN layer. Without any $\text{Al}_x\text{Ga}_{1-x}\text{N}$ buffer layer, the GaN in-plane tensile strain of sample C is investigated to be the largest one.

References

1. Kadir, A., Huang, C.-C., Lee, K. E.-K., Fitzgerald, E. A. & Chua, S.-J. Determination of alloy composition and strain in multiple AlGaIn buffer layers in GaN/Si system. *Appl. Phys. Lett.* **105**, 232113 (2014).
2. Liou, B.-T., Yen, S.-H., & Kuo, Y.-K., Vegard's law deviation in band gaps and bowing parameters of the wurtzite III-nitride ternary alloys. Proc. SPIE 5628, Semiconductor Lasers and Applications II, (20 January 2005).