Electronic Supplementary Material (ESI) for RSC Advances.

Bow-free Freestanding GaN Wafer

Jae-Hyoung Shim,[1] and Jea-Gun Park[1*]

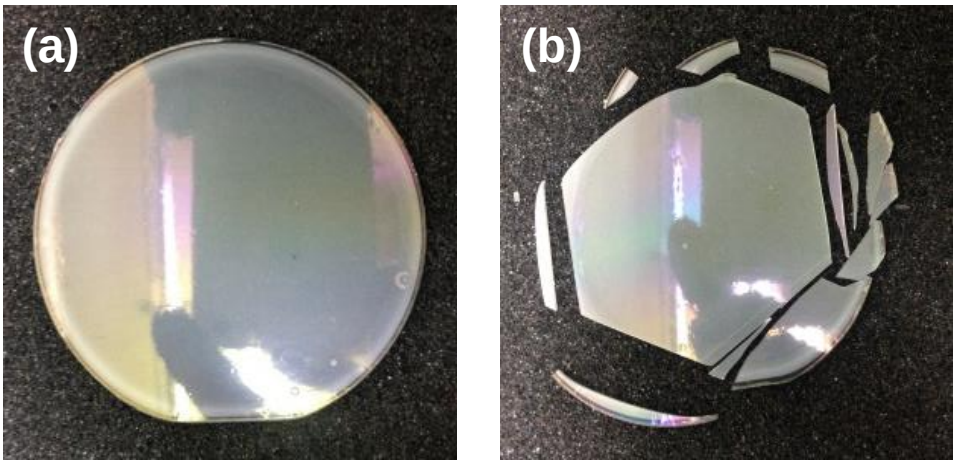


Figure S1. Images of as-grown HVPE GaN layers grown on 2-inch sapphire substrates with the GaN layer thickness of (a) 297 um and (b) 330 um. The GaN layer thickness of 297 um grown on a sapphire substrate showed no crack with a wafer bow of +865 um, while the GaN layer thickness of 330 um grown on a sapphire substrate cracked due to very high bow induced by the stress between GaN layer and sapphire substrate.

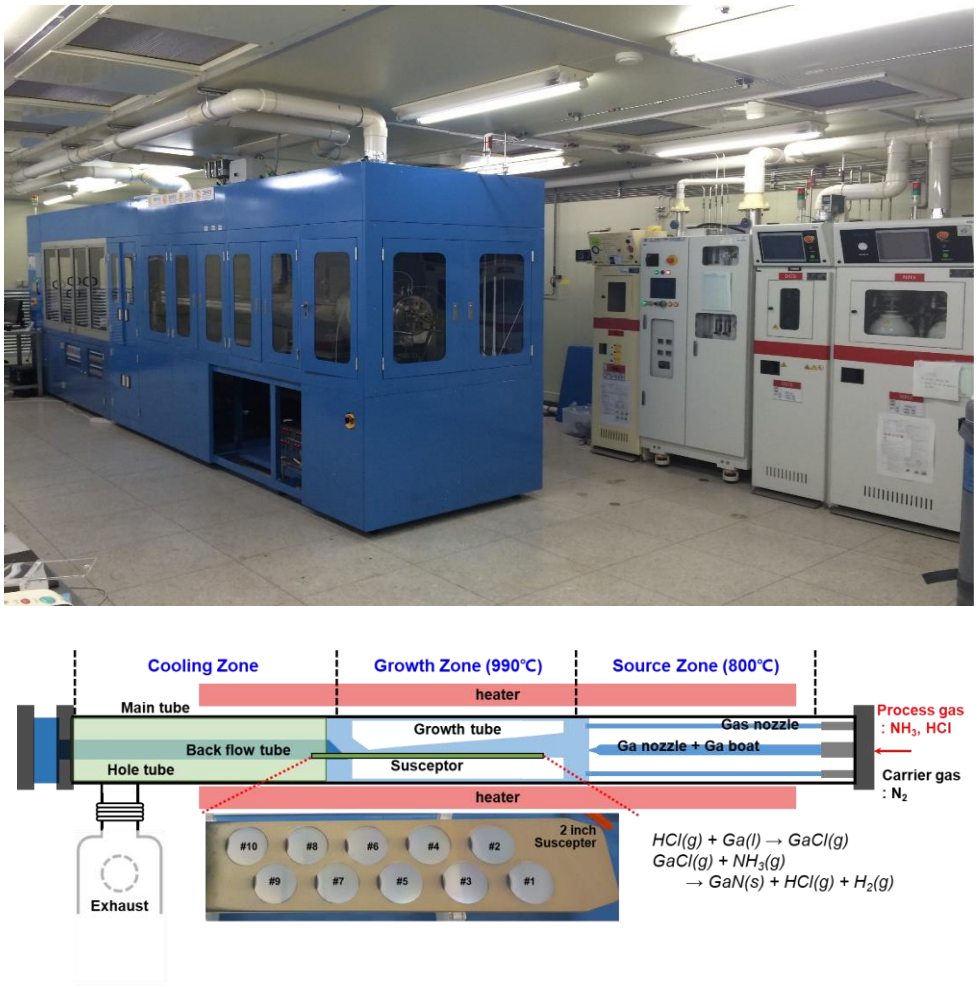


Figure S2. HVPE GaN growth and gas supply system used in the experiment. HVPE GaN growth system has source, growth, and cooling zone for the GaN on sapphire growth. For GaN growth, NH_3, HCl, purified N_2 gas flew into HVPE reactor.

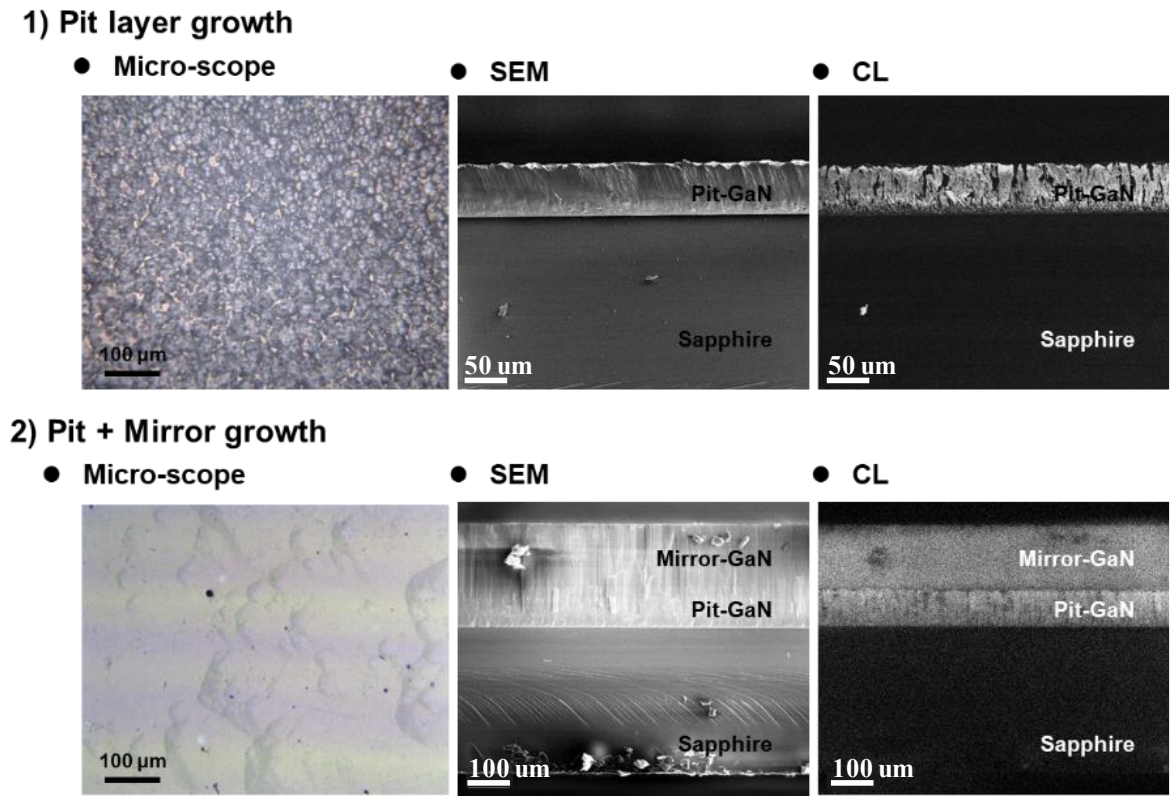
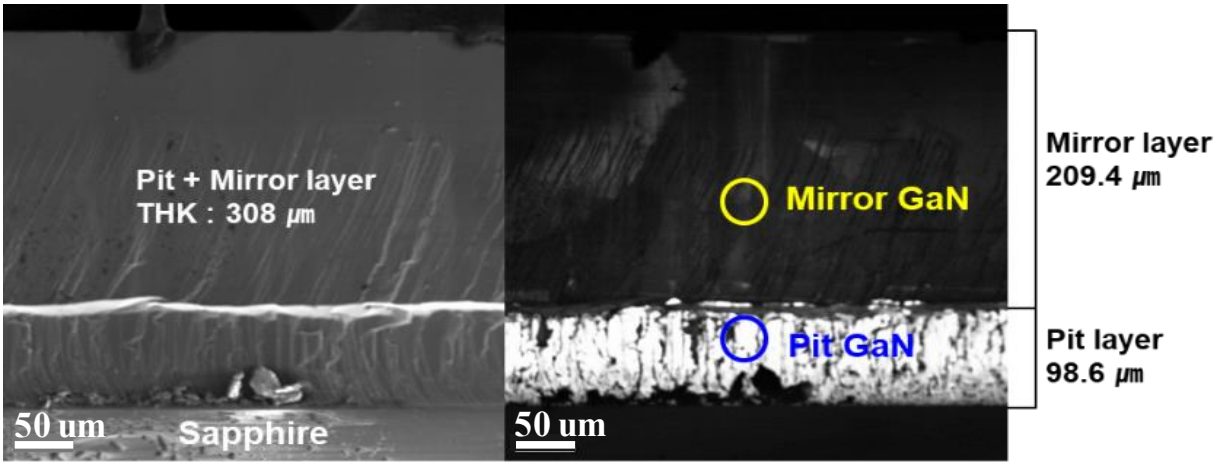


Figure S3. Surface and vertical morphologies. μ-scope, SEM and CL images for (a) the GaN pit-layer grown on sapphire substrate and (b) the GaN mirror-layer after pit layer grown on the GaN pit-layer.



(a) (b)

Figure S4. Cross-sectional SEM image (a) and SEM-CL image (b). A 3D pit-layer was grown at 990 ℃ for 75 min under a flow of HCl (1,800 sccm) and NH_3(19,600 sccm) gases while 2D mirror-layer growth was done at 990 ℃ for 300 min under a flow of HCl (1,000 sccm) and NH_3(2,000 sccm) gases. The GaN pit layer showed a highly porous structure while the GaN mirror layer presented a highly dense structure, as shown in Fig. S4(b).

(a) (b) (c)

Figure S5. Lapping system for GaN surface polishing with diamond abrasive. For the first polishing step, 3-um-diameter sized diamond abrasive and Tin-resin plate were used. After that, pure tin platen was used for fine polish of GaN wafer surface with 0.5-um and 50-nm-diameter sized diamond abrasive.

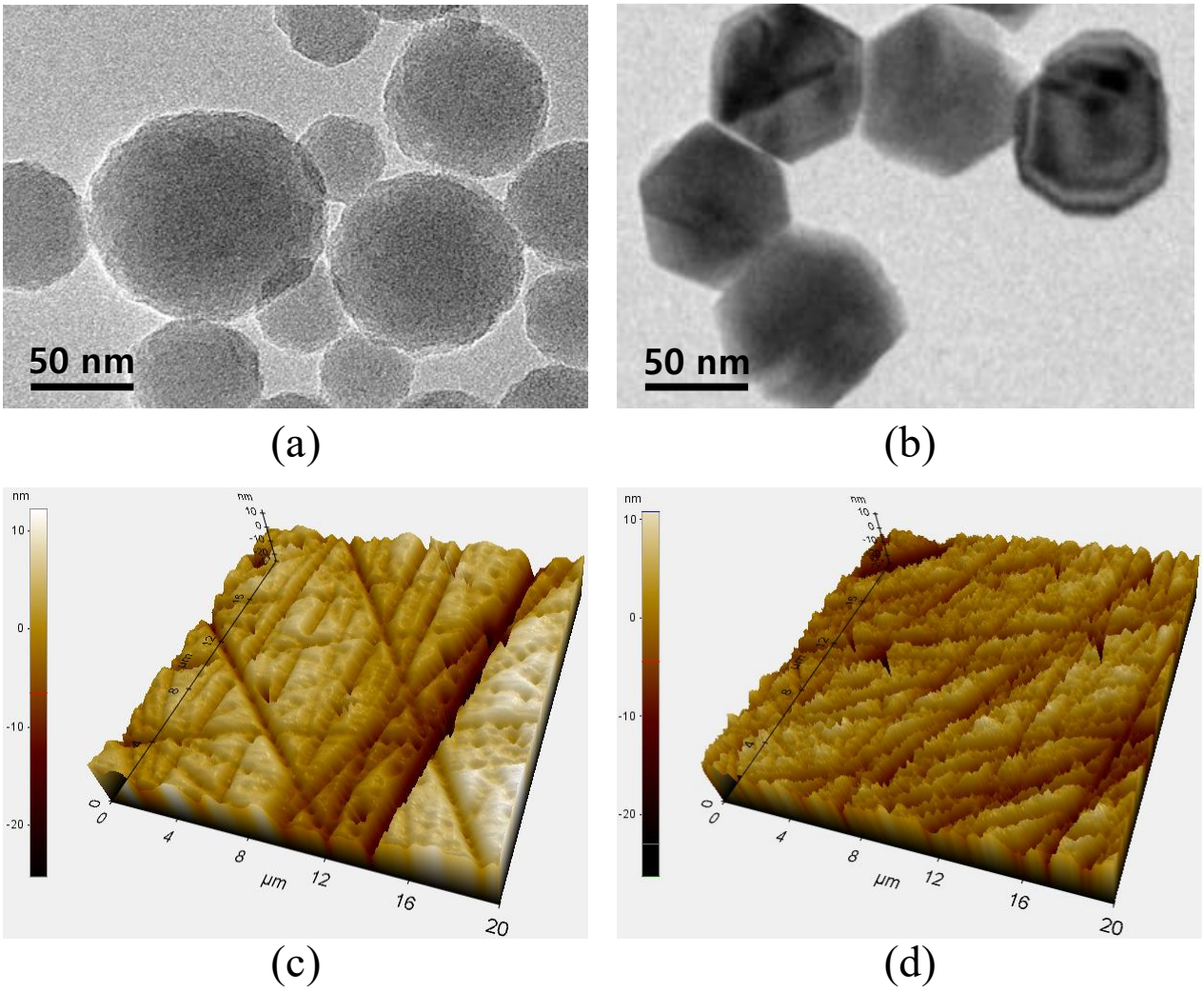


Figure S6. Effect of CMP slurry on surface roughness and scratches. TEM images of (a) colloidal-silica-abrasives and (b) ceria abrasives, AFM images of GaN wafer surface after CMP with (c) colloidal silica abrasives and (d) ceria abrasives.

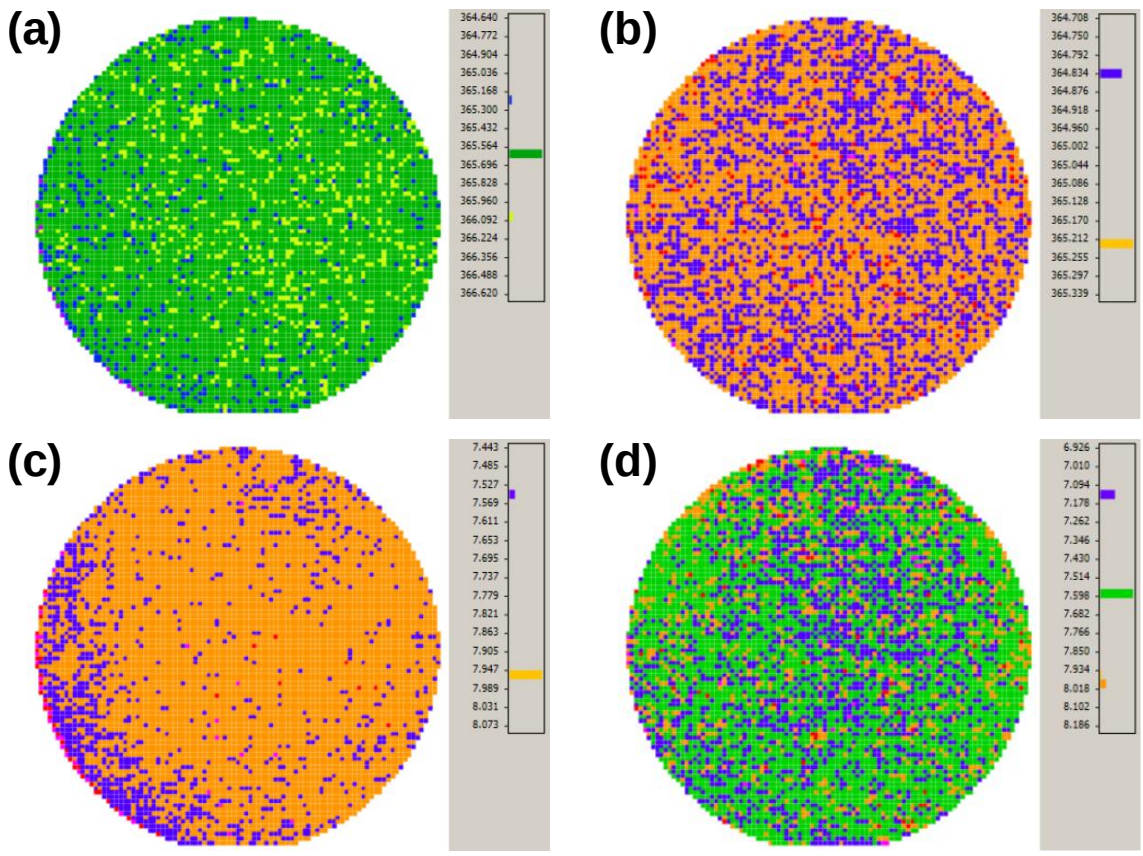


Figure S7. Photoluminescence (PL) mapping of a GaN wafers. PL peak wavelength maps of (a) commercial GaN wafer and (b) our researched GaN wafer. Full-width at half-maximum (FWHM) maps of (a) commercial GaN wafer and (b) our researched GaN wafer. Color mapping is automatically adjusted with color index bar and range. The comparison data is shown in the table below.

Samples	**Peak wavelength (W_p)**	**Energy band gap (E_g)**	**FWHM**
Commercial	~ 365.6 nm	~ 3.392 eV	~ 8 nm
HYU	364.8 ~ 365.2 nm	3.395 ~ 3.4 eV	7.1 ~7.6 nm