

Explore an approach towards the intrinsic limits of GaN electronics

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Supplementary Information

Sample A was prepared using the classic two-step approach by a low pressure MOVPE system, namely, after an initially high temperature annealing process under ambient H₂, a 25-nm-thick GaN nucleation layer was grown at a low temperature of 550 °C, followed by the growth of a 1.5 μm GaN buffer layer, and then a 1 nm AlN spacer and finally a 25 nm AlGaN barrier (20% Al composition) all grown at 1110 °C, respectively.

Sample B to E were grown by using our high-temperature AlN buffer approach, namely, ammonia (NH₃) pre-flow was conducted on sapphire for nitration after an initially high temperature annealing process under ambient H₂ as usual. A 500 nm AlN buffer layer is subsequently grown at 1180 °C, followed by the growth of a 1.5 μm GaN buffer layer, and then a 1 nm AlN spacer and finally a 25 nm AlGaN barrier (20% Al composition) all grown at around 1110 °C, respectively. The details of the growth conditions are given below

Table 1. A summary of growth parameters for Sample B – E up to GaN buffer layer

		Temperature (°C)	Pressure (Torr)	NH ₃ Flow Rate (sccm)	TMGa Flow Rate (sccm)	TMAI Flow Rate (sccm)
Sample B	GaN buffer	1100	225	5840	65	-
	HT AlN buffer	1180	65	300	-	180
Sample C	GaN buffer	1110	225	5840	65	-
	HT AlN buffer	1180	65	300	-	180
Sample D	GaN buffer	1120	175	5840	65	-
	HT AlN buffer	1180	65	200	-	180
Sample E	GaN buffer	1130	175	5840	65	-
	HT AlN buffer	1180	65	150	-	180

Fig-suppl-1 (a) and (b) show the atomic force microscopy (AFM) images of the standard GaN and the GaN on HT AlN in a larger scanning area, respectively. Fig-suppl-1 (a) exhibits features with parallel and straight terraces but without any dark spots, indicating a typical 2D layer-by-layer growth mode, while Fig-suppl-1 (b) is a typical AFM image for standard GaN, showing spiral features with dark spots due to screw dislocations as a result of 3D growth. Detailed RMS data show a RMS value of 0.35 nm for the GaN on HT AlN, and a RMS value of 0.47 nm.

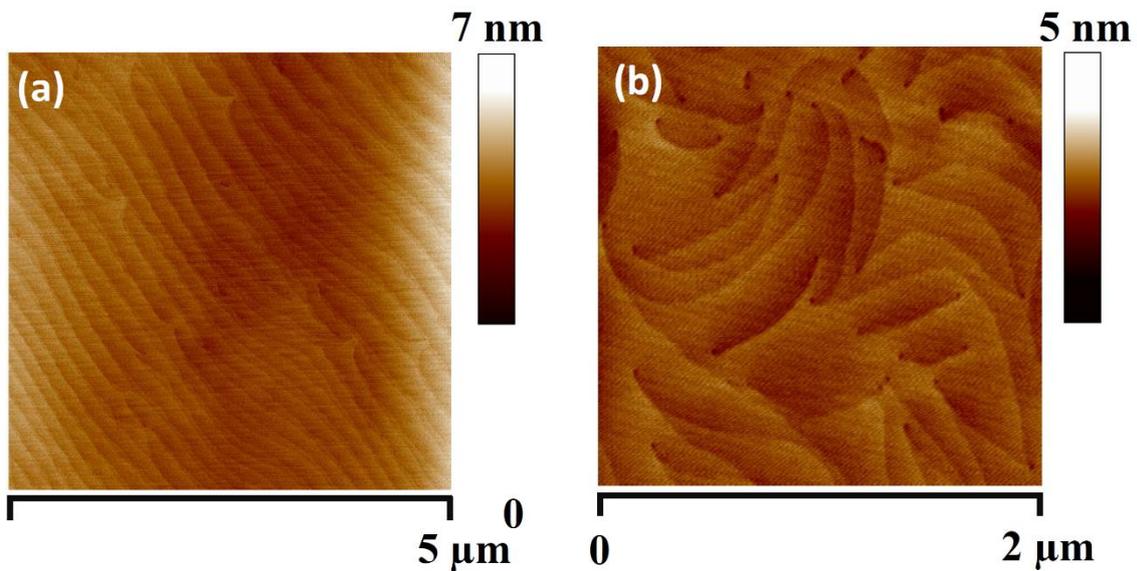


Fig-suppl-1 (a) and (b) show the AFM images of the standard GaN and the GaN on HT AlN in a larger scanning area, respectively.

Fig-suppl-2 (a) shows the XRD rocking curve of the standard GaN measured along the (002) direction, showing the full width half maximum (FWHM) is around 280 arc sec, which is often observed (the XRD rocking curve of the GaN on our HT AlN buffer with a FWHM of 100 arc sec was also included as a reference). The Inset shows the XRD rocking curve of the standard GaN measured along the (102) direction, showing a FWHM of 350 arc sec, which is also often observed. Fig-suppl-2 (b) shows the photo-luminescence (PL) spectra of the standard GaN measured at 18k using a 325 nm He-Cd laser, exhibiting a strong GaN band edge emission at 357 nm without any yellow band emission at 550 nm.

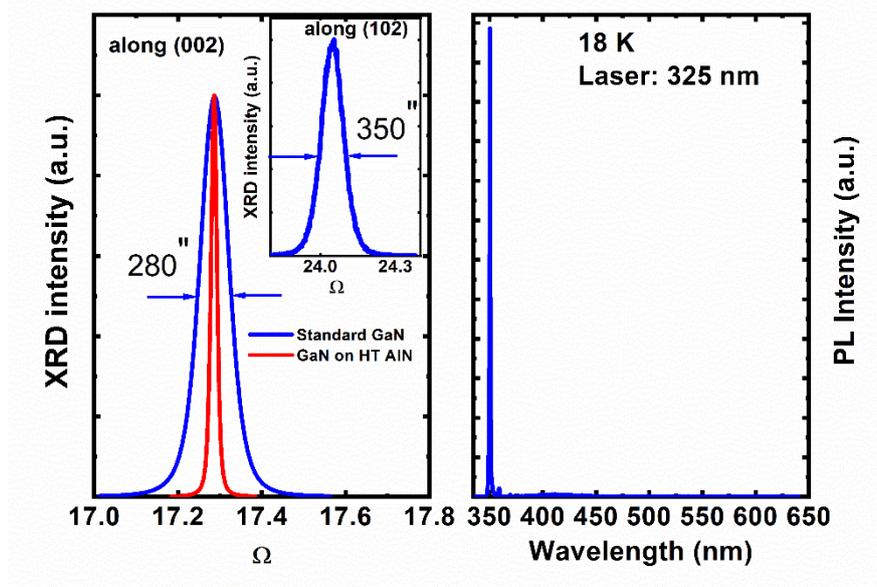


Fig-suppl-2 (a) and (b) the detailed XRD rocking curves of the standard GaN measured along the (002) and the (102) directions and the PL spectrum of the standard GaN measured at 18 K, respectively.