

Supplementary information:

**Compressive Stress Management for Hillock-Free AlGaN
Epitaxy on HTA-AlN Templates Using Low-Al-content
Interlayer**

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The surface morphology of the AlN grown on templates

The surface morphology of the AlN grown on the unannealed PVD AlN templates (unannealed template) and high temperature annealing AlN (HTA-AlN) templates are shown in Figs. S1(a) and S1(b), respectively. The surface of both the AlN epitaxy layers show excellent step surface morphology. The root mean square roughness of the AlN grown on the unannealed template and HTA-AlN template are 0.926 nm and 1.200 nm, respectively.

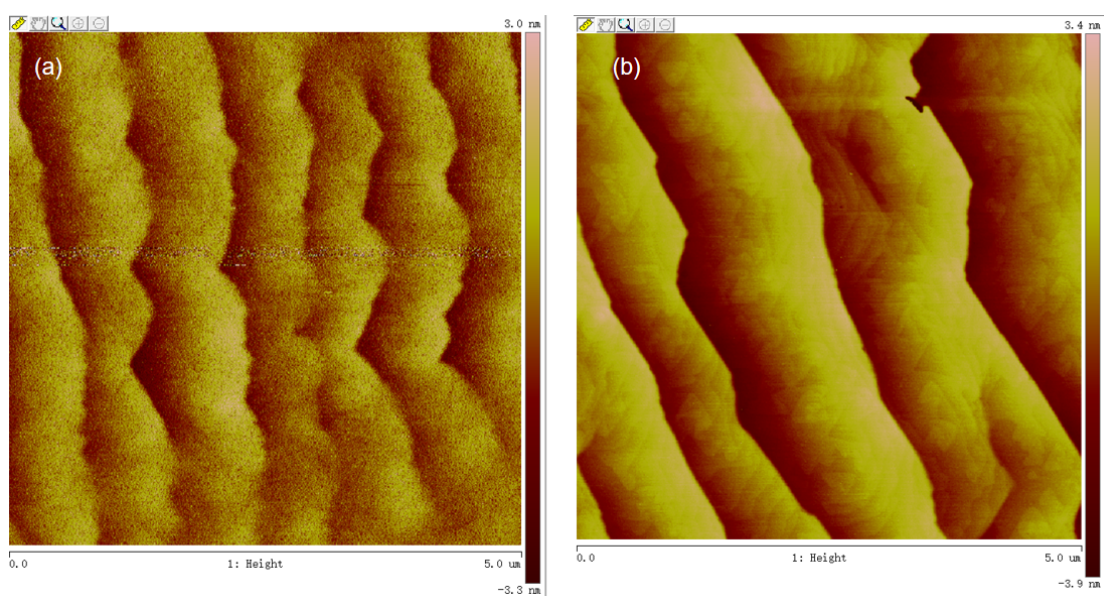


Figure S1. The surface morphology of AlN epitaxy layer grown on (a) unannealed template and (b) HTA-AlN template.

The photo of AlGaN epilayer with GaN interlayer on HTA-AlN template



Figure S2. The photo of AlGaN epilayer with GaN interlayer on HTA-AlN template.

The photo exhibited in Fig. S2 is the sample of AlGaN epilayer with GaN interlayer on HTA-AlN template. The sample had already been cracked before we opened the reactor. After collecting the sample fragments, we pieced them together and took the photo.

The thickness of AlGaN epilayers

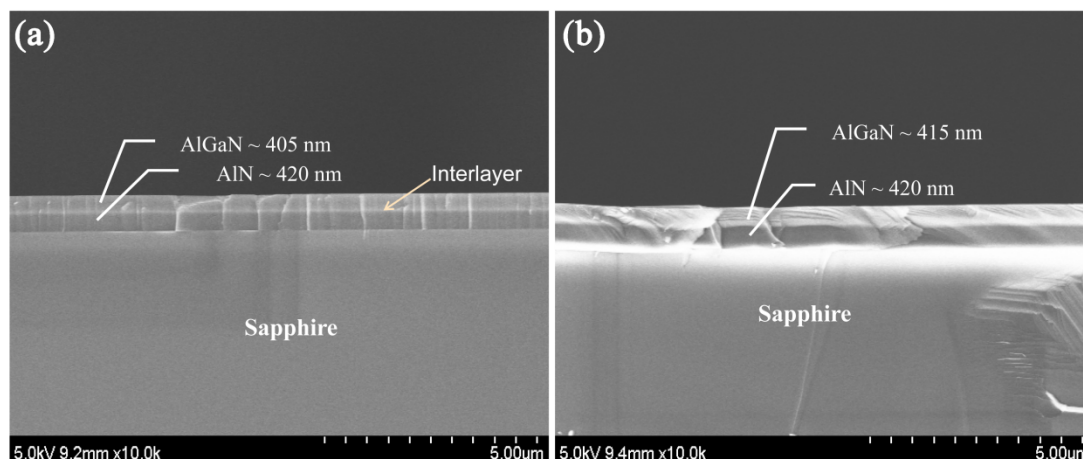


Figure S3. The cross-sectional SEM image of the AlGaN grown on the HTA-AlN template (a) with interlayer and (b) without interlayer.

The cross-sectional SEM images of the AlGaN grown on the HTA-AlN template with/without interlayer are shown in Fig. S3. It can be extracted that the thickness of the regrown AlGaN epilayers are similar. The low-Al-content AlGaN interlayer can be seen in the Fig. S3(a) with higher brightness compared with that of the AlGaN layer grown on it.

Analysis of the stress state of AlGa_N epilayer with IL

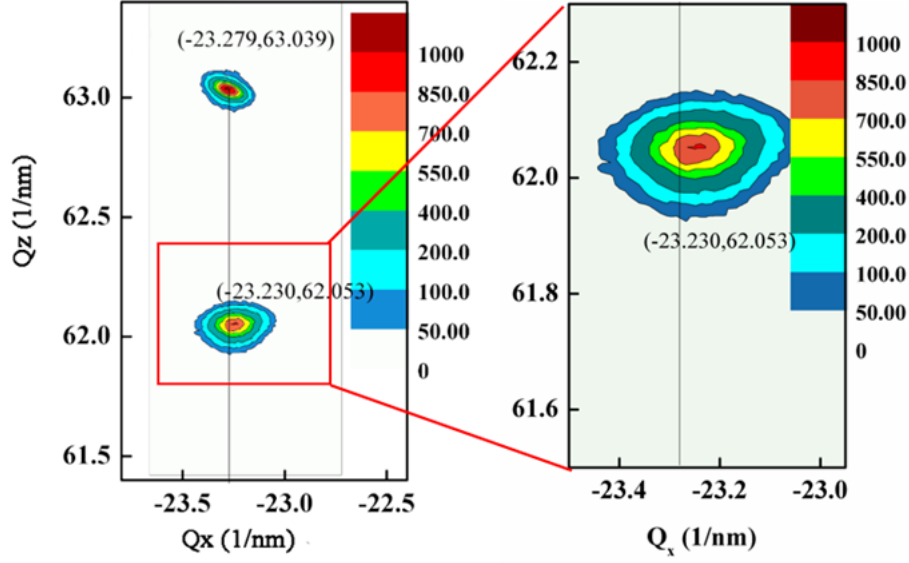


Figure S4. The RSM of AlGa_N with IL and the enlarged AlGa_N RLP

The RSM of AlGa_N exhibits only one primary RLP corresponding to AlGa_N as shown in Fig. S4. It appears to consist of two closely overlapping RLPs, both close to but distinctly offset from the fully strained reference line. This overlap can be attributed to the comparable compositions of the interfacial layer (IL) and the AlGa_N epitaxial layer (~60% vs. ~63%). The proximity of the RLP to the fully strained reference line indicates that the in-plane lattice constants of both the AlGa_N IL and the epitaxial layer are close to that of the AlN template. These observations suggest that the IL has a relatively low degree of relaxation.

It is also worth noting that, due to the considerably greater thickness of the epitaxial layer, its diffraction signal dominates the overall RLP profile. This is the basis on which we assign the RLP coordinates primarily to the AlGa_N epitaxial layer.

The optical microscope results and the XRC FWHM of the AlGa_N epilayers

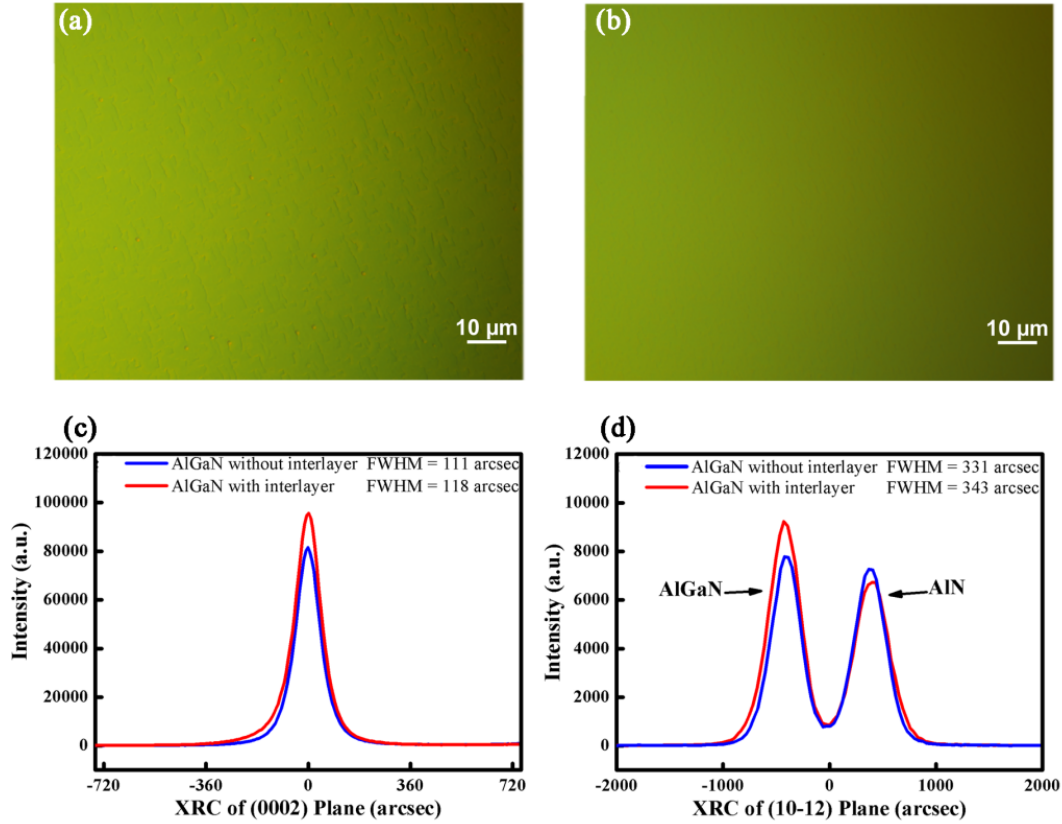


Figure S5. The surface morphology characterized by optical microscope for (a) AlGa_N epilayer without low-Al-content AlGa_N interlayer and (b) with low-Al-content AlGa_N interlayer. (c) The (0002) plane XRC and (d) the (10-12) plane XRC of AlGa_N with/without low-Al-content AlGa_N interlayer.

The surface of AlGa_N without low-Al-content AlGa_N interlayer shows obvious fluctuations with hexagonal structures as exhibited in Fig. S5(a), and the surface of AlGa_N with low-Al-content AlGa_N interlayer is smooth.

The full width at half maxima (FWHM) of XRD rocking curves (XRC) have been measured to characterize the crystal quality of AlGa_N. The FWHM of (0002)/(10-12) plane XRC are 111/331 arcsec for AlGa_N without low-Al-content interlayer and 118/343 arcsec for AlGa_N with low-Al-content interlayer. The FWHMs of the AlGa_N with and without low-Al-content interlayer are similar, which means that the dislocation density is similar for the two samples.