1. Crystal quality and surface morphology of AlN buffer on Si substrates

The crystal quality of AlN buffer on Si substrates was characterized by HRXRD measurements. The results are shown in Fig. S1. The full width of half maximums (FWHMs) for (002) and (102) reflections are 1229 and 1737 arcsec, respectively. The surface morphology of 200nm AlN buffer on Si substrates was characterized by atomic force microscope (AFM). The root-mean-square (RMS) roughness value over 10 × 10 μm^2 is 0.36nm.

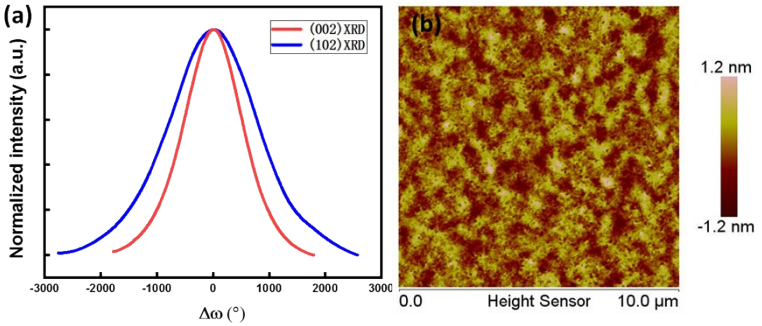

Fig. S1. (a) XRD rocking curves of AlN buffer on Si substrates at (002) and (102) reflections, (b) AFM image of the AlN buffer on Si substrates.

2. Surface morphology of 3.5 μm GaN epilayers

The surface morphology of GaN epilayers was characterized by AFM. The RMS roughness value of GaN epilayers with and without CNT mask over 3 × 3 μm^2 are 0.125nm and 0.314nm, respectively. The Fig. S2a exhibits a smooth surface with long, uniform and well-arranged steps, while the atomic steps are disordered and discontinuous in Fig. 2b.

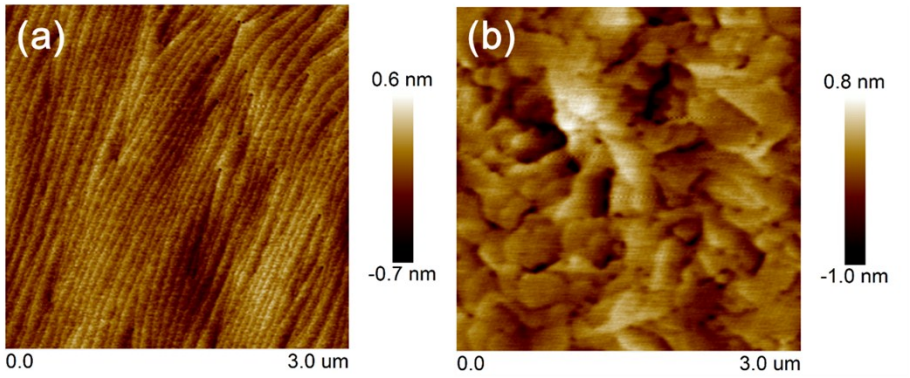

Figure S2. AFM images of GaN epilayer with (a) and without (b) CNT mask.