1. The strain state of the GaN in the initial high electron mobility transistor (HEMT) template and on sapphire template

Figure s1 shows XRD 2theta-omega scans of the GaN (002)-plane in the initial HEMT and on sapphire substrate. The peak of GaN (002)-plane diffraction grown on sapphire is 34.56° while it shifts to 34.61° for that in the AlGaN/GaN-on-Si HEMT structure. In comparison to the standard diffraction peak of the GaN (002)-plane located at 34.5692°, the out-of-plane lattice constant *c* of the GaN in the HEMT structure is smaller. Since the strain in III-V nitride semiconductors is typically biaxial, the in-plane lattice constant *a* should be larger. Thus, the GaN channel in the HEMT suffers from a tensile stress. It is little strange as the thickness of GaN channel is only 200 nm, which might be induced by the wafer bowing or thermal mismatch. On the other hand, the GaN layer grown on the sapphire substrate is nearly the same to the standard one, indicating little residual strain.

In addition, the crystalline quality of the GaN layers on the two templates are characterized by the XRD rocking curves. The full-width-at-half-maximum (FWHM) value of the GaN (002)-plane RC is 1033 arcsec, which is much higher than that of the GaN on sapphire substrate (~280 arcsec). The poor crystalline quality of the GaN layer in the HEMT is the reason for the poor quality in the following InGaN epilayer.

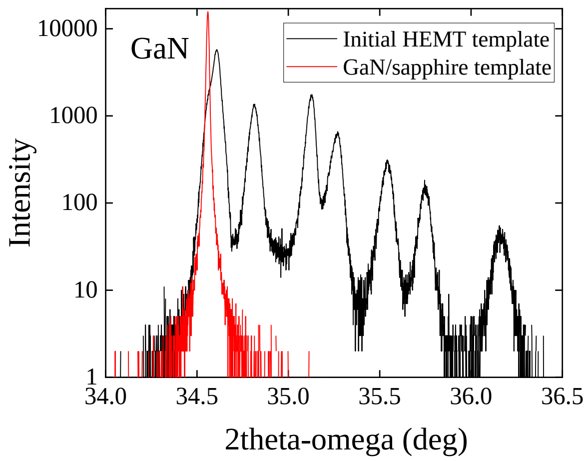

Figure S1. XRD 2theta-omega scan of the (002)-plane for the initial high electron mobility transistor (HEMT) template and GaN/sapphire template.

2. Photoluminescence (PL) spectrum of the InGaN/GaN on HEMT templates grown at different temperatures

The PL spectra of the InGaN/GaN heterostructures grown on HEMT templates grown at different temperatures are shown in Figure S2. Compared to the PL spectrum of the InGaN/GaN on the HEMT template grown at 760 ℃, an improved crystalline quality is displayed for the InGaN/GaN grown at 780 ℃. The peak at ~365 nm is from the GaN near-band-edge (NBE) emission, and that at ~385 nm is corresponding to the NBE emission from the InGaN. The yellow band luminescence (YL) at ~550 nm is usually considered to be originated from the nitrogen vacancy related defects in the structure. The ratio between the NBE and YL (I_{NBE}/I_{YL}) can be a reflection of the quality of the epitaxial film. It is shown that the I_{NBE}/I_{YL} for the InGaN grown at 760 ℃ is 1.41, and it is enhanced to 1.83 for the InGaN/GaN grown at 780 ℃. This indicates an improved crystalline quality at the elevated temperature.

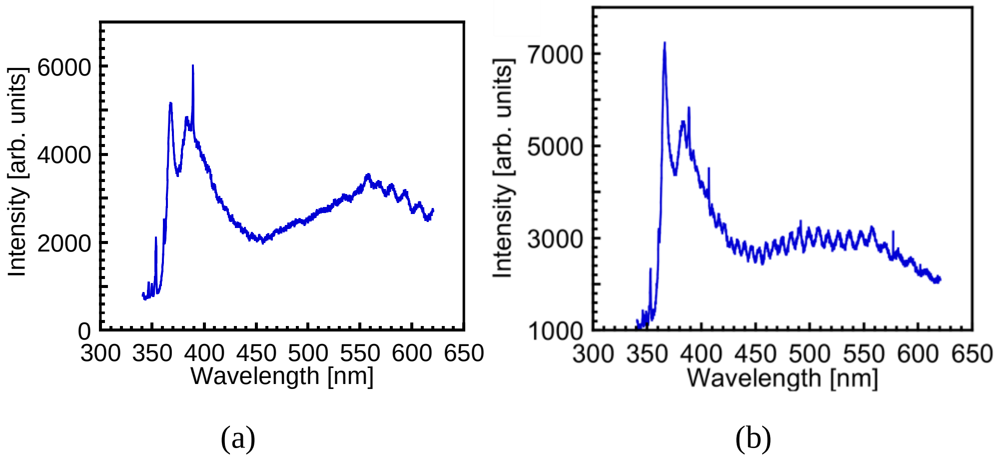

Figure S2. PL spectrum for InGaN/GaN heterostructures grown on HEMT templates at the temperature of (a) 760 ℃ and (b) 780 ℃.