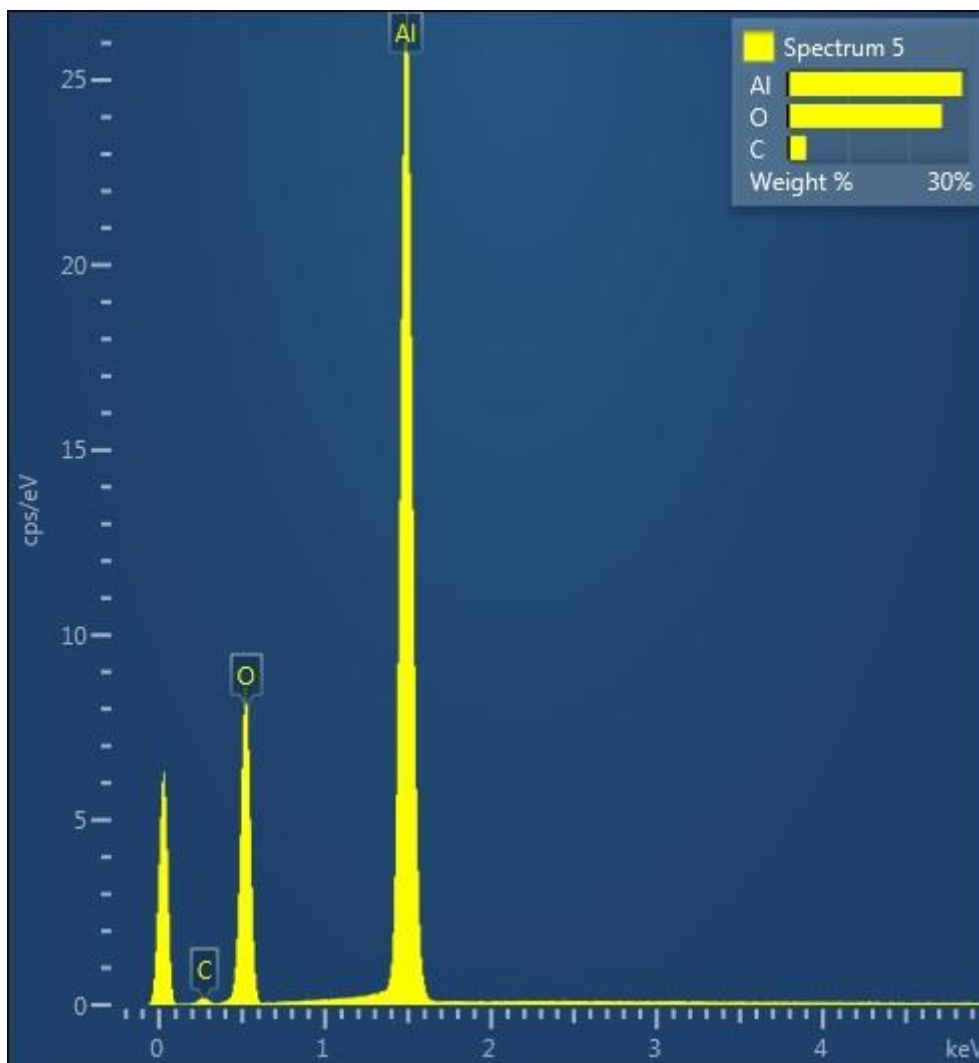


Electronic supplementary information



Element	Line Type	Apparent Concentration	Wt%	Atomic %
C	K series	0.36	3.11	8.86
O	K series	26.53	25.52	54.57
Al	K series	28.86	28.83	36.56
Total:			57.47	100.00

Fig. S1 EDX analysis of bare sapphire substrate without any surface treatment

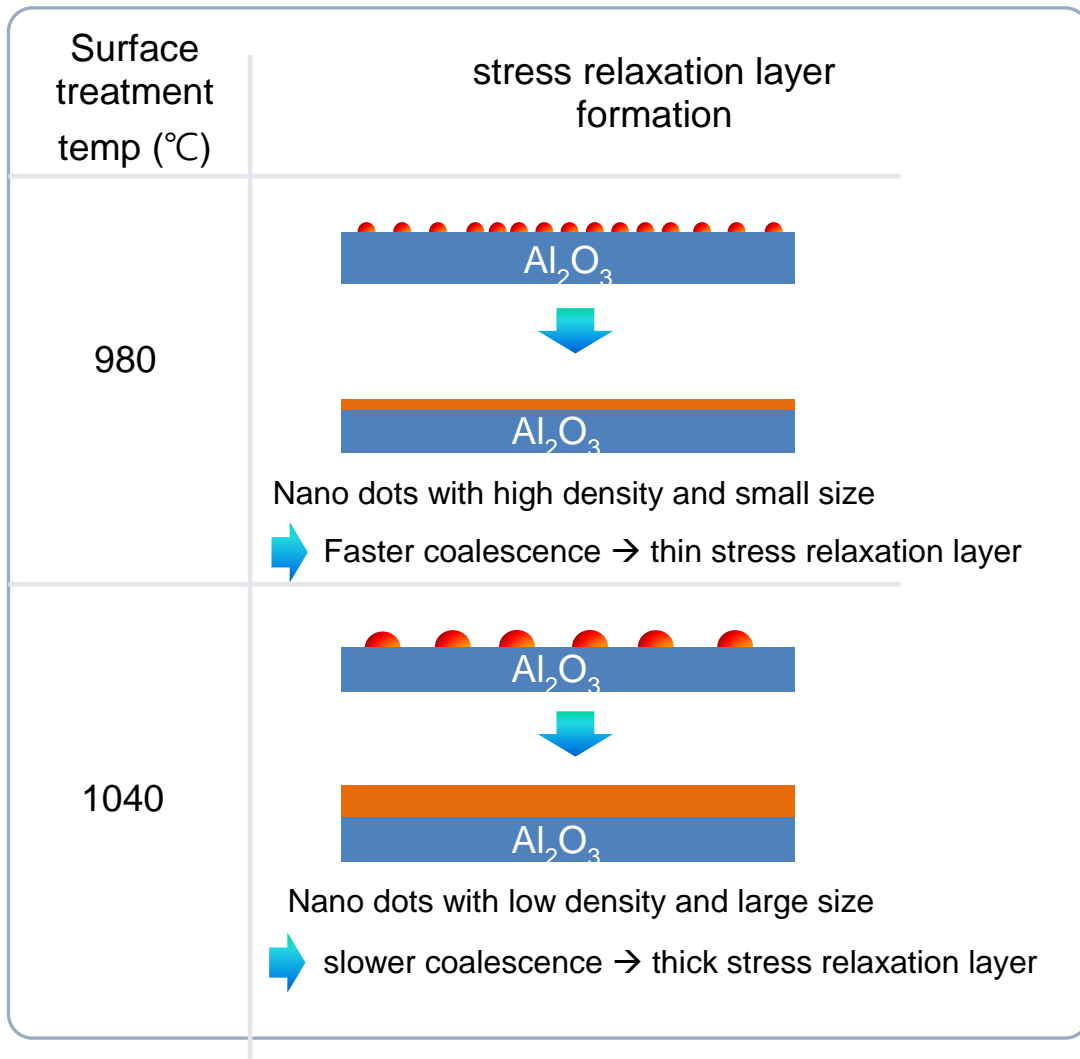


Fig. S2 A schematic diagram of stress relaxation layer formation as a function of surface treatment temperatures.

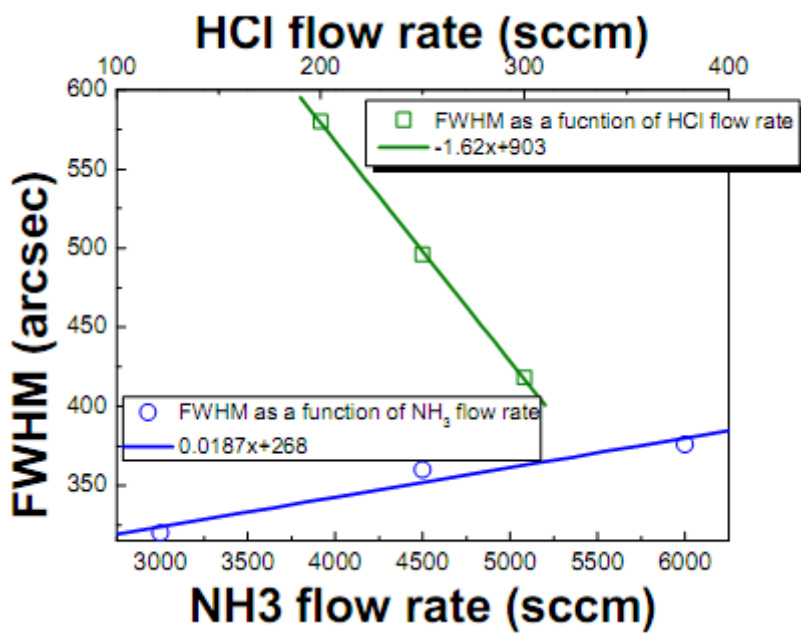


Fig. S3. The FWHM of X-ray rocking curves for thick GaN on Al₂O₃ substrate as a function of HCl and NH₃ flow rate during surface treatment at 980 °C.