Supporting Information

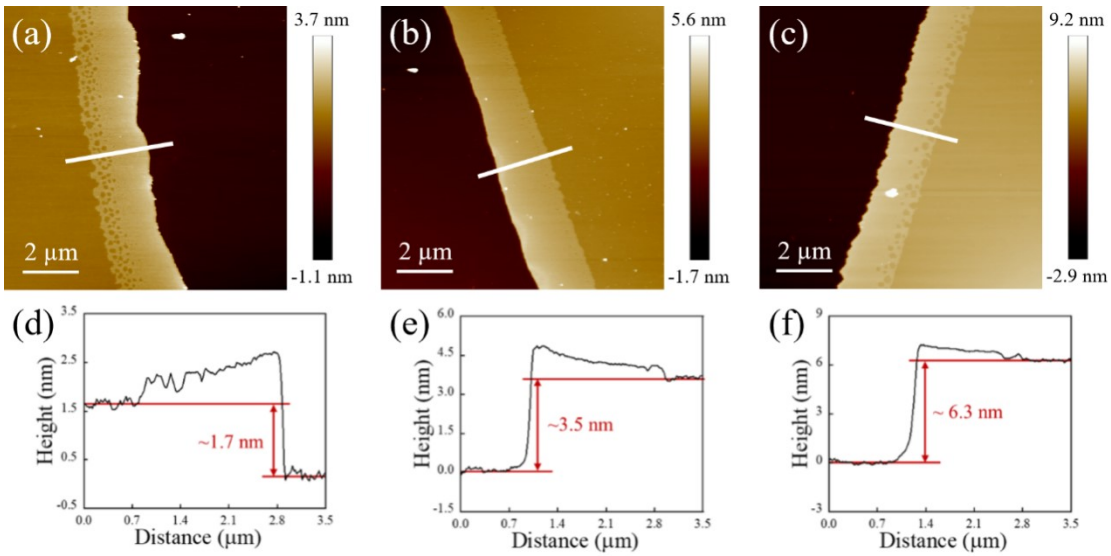

Fig. S1 AFM images of sputtered Ga_2O_3 with sputtering time of a) 25, b) 50 and c) 100 seconds. d) - e) Thickness profiles obtained from images a-c along the white lines.

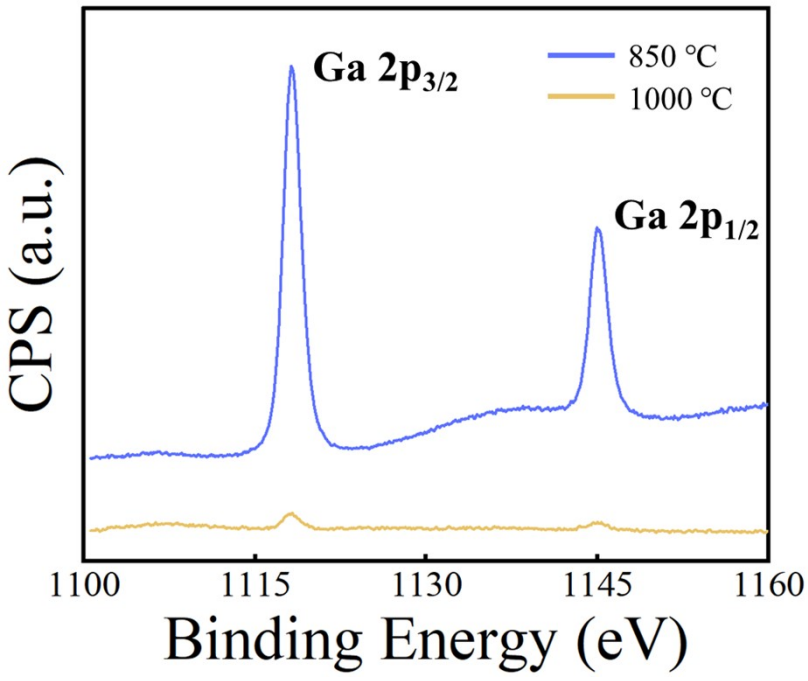

Fig. S2 Ga 2p XPS spectra of 2D GaN with ammonolysis temperature of 850 and 1000 °C.

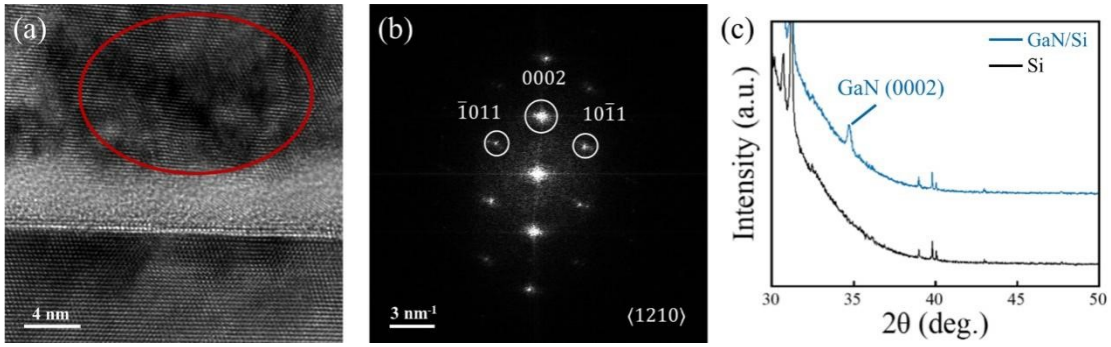

Fig. S3 a) HRTEM image of thick GaN synthesized *via* two-step method and b) the corresponding SAED pattern. c) XRD patterns of as fabricated GaN/Si heterojunction and Si substrate.

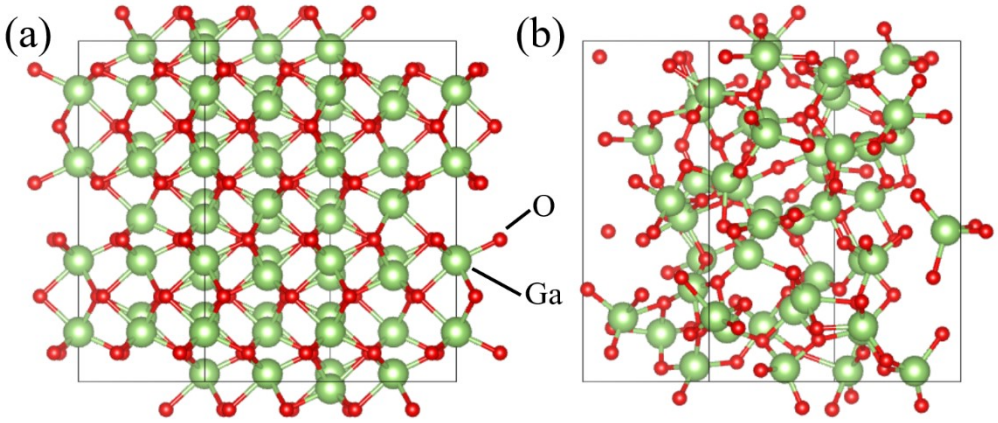

Fig. S4 Illustrations of a) γ-Ga_2O_3 and b) amorphous Ga_2O_3.

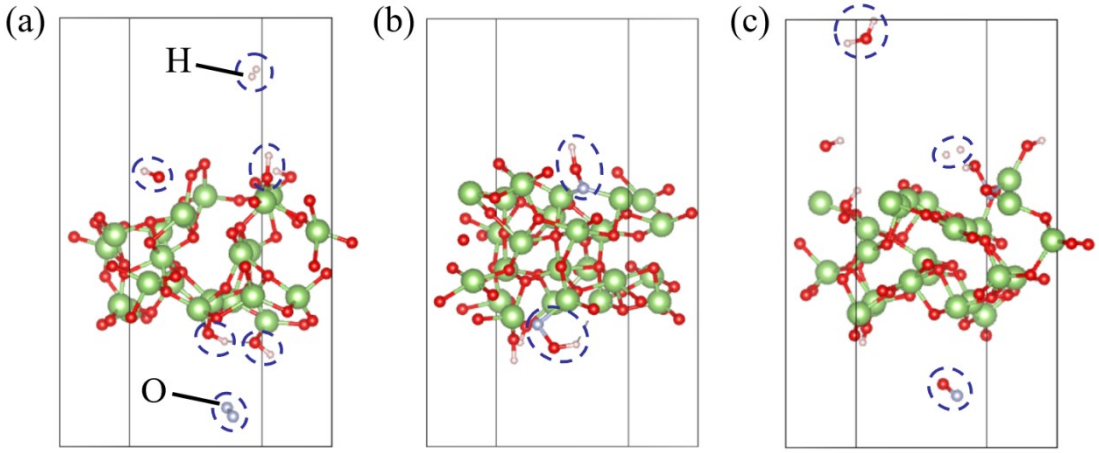

Fig. S5 Atomic models for the calculation results of the reaction between Ga_2O_3 and ammonia.

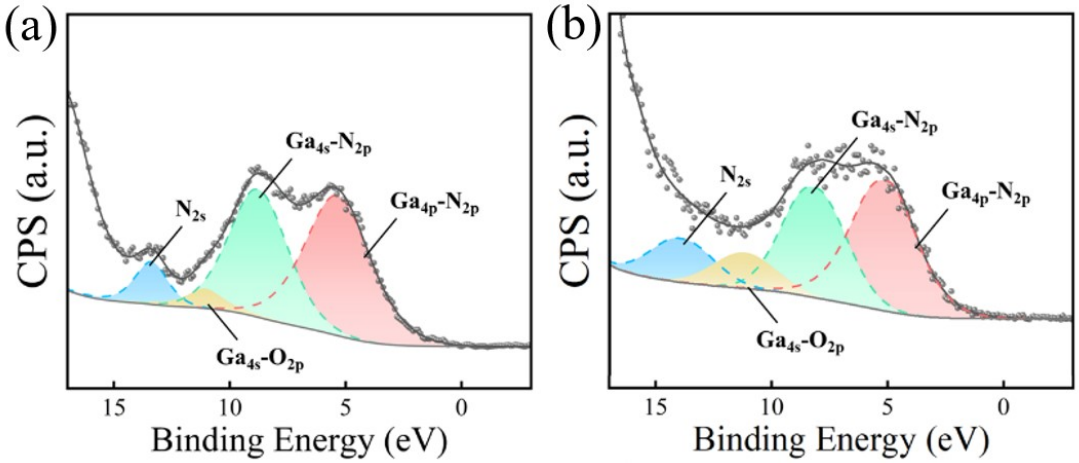

Fig. S6 XPS valence band spectra of a) 2D GaN/Si heterojunction, b) 2D GaN/SiO_2/Si heterojunction.

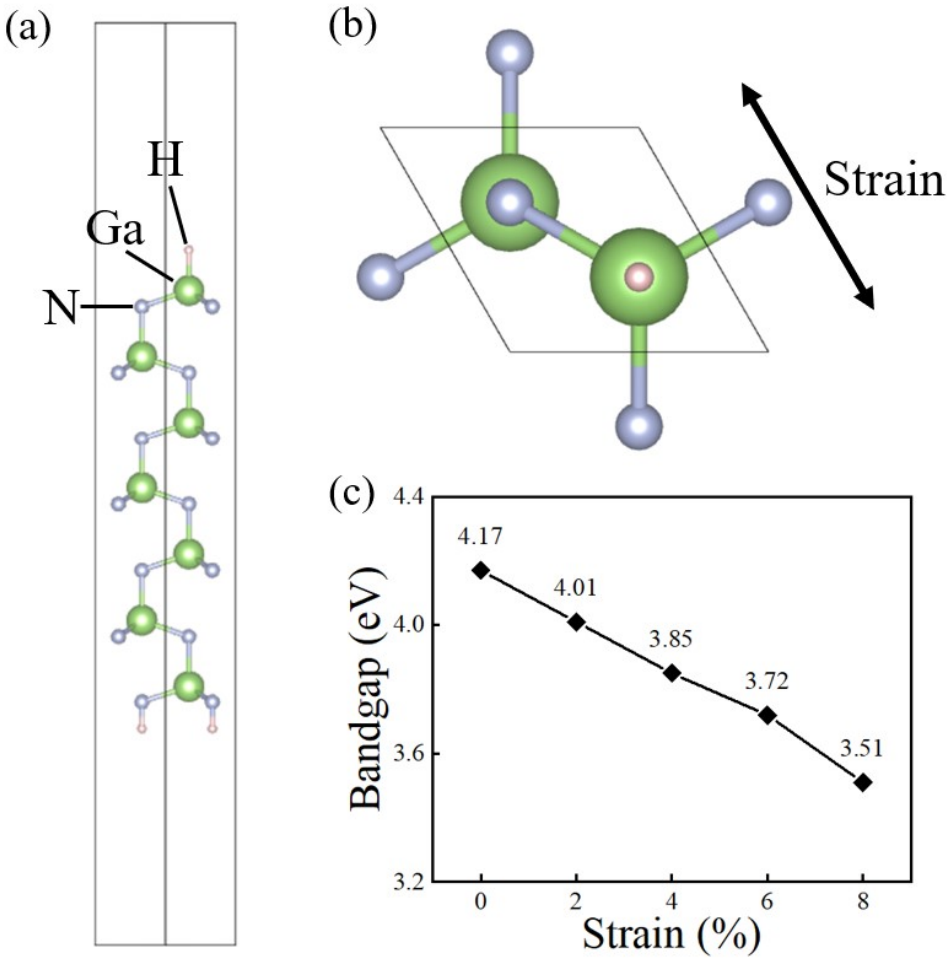

Fig. S7 a) and b) Model of 2D GaN used for DFT calculations. c) Calculated bandgap of 2D GaN as a function of in-plane strain

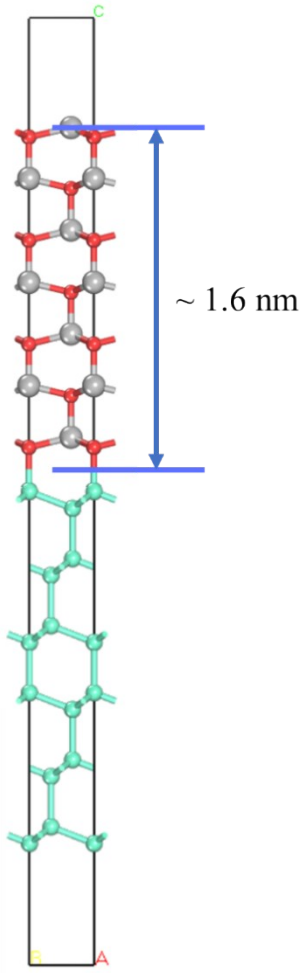

Fig. S8 Model of 2D GaN/Si heterojunction used for DFT calculations.

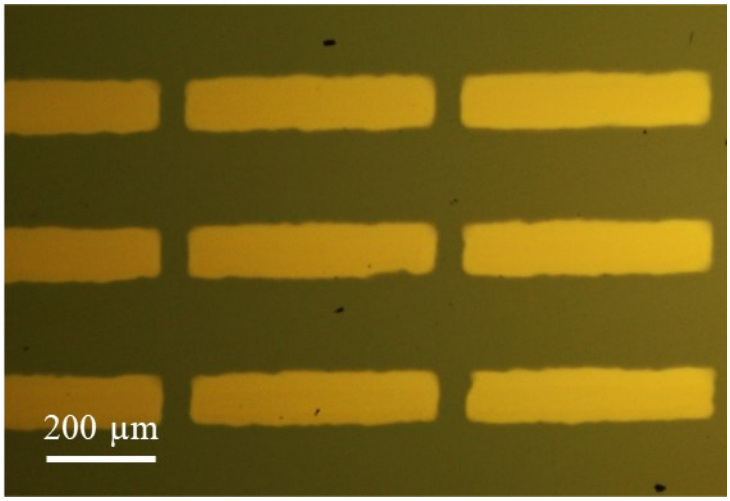

Fig. S9 Optical microscope image of 2D GaN/Si UV-B photodetectors.

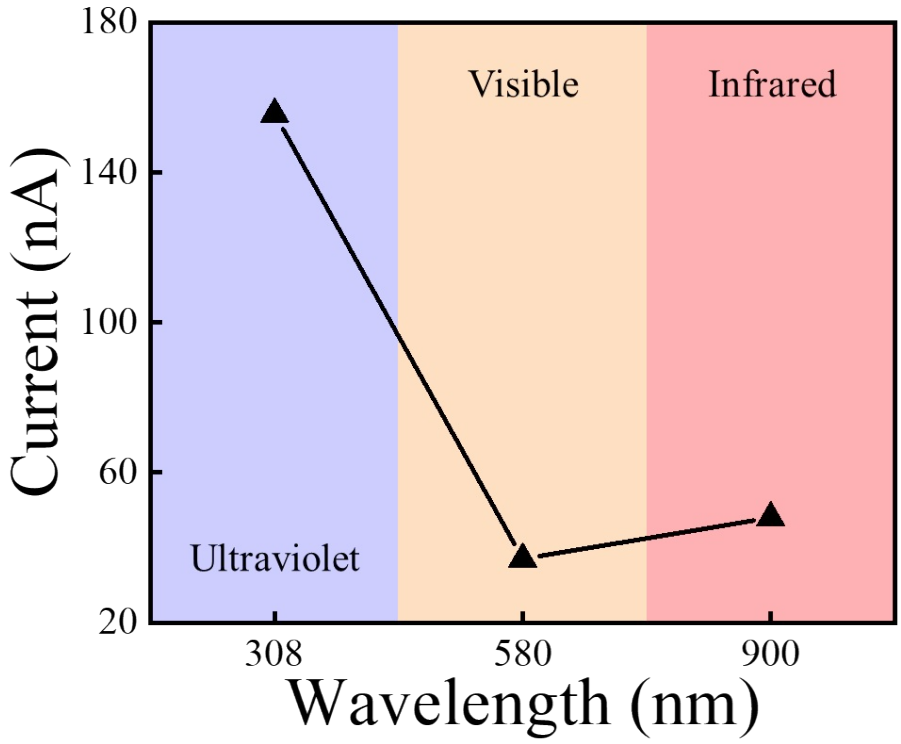

Fig. S10 Photocurrents of 2D GaN/Si PDs for incident light wavelengths of 308, 580 and 900 nm.

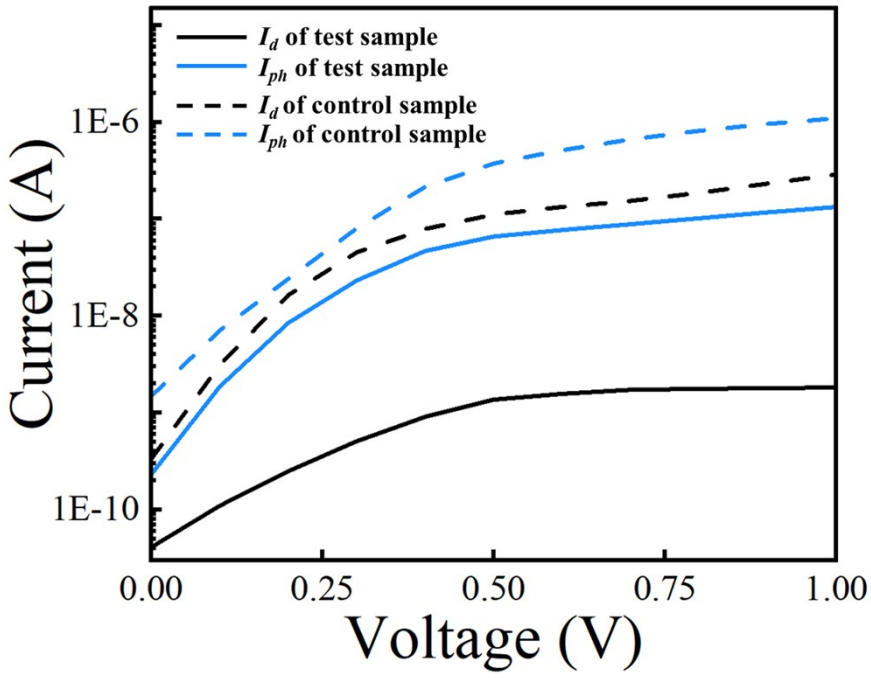

Fig. S11 I-V curves of test and control samples under dark and 308 nm laser illumination with light intensity of 3.667 mW.

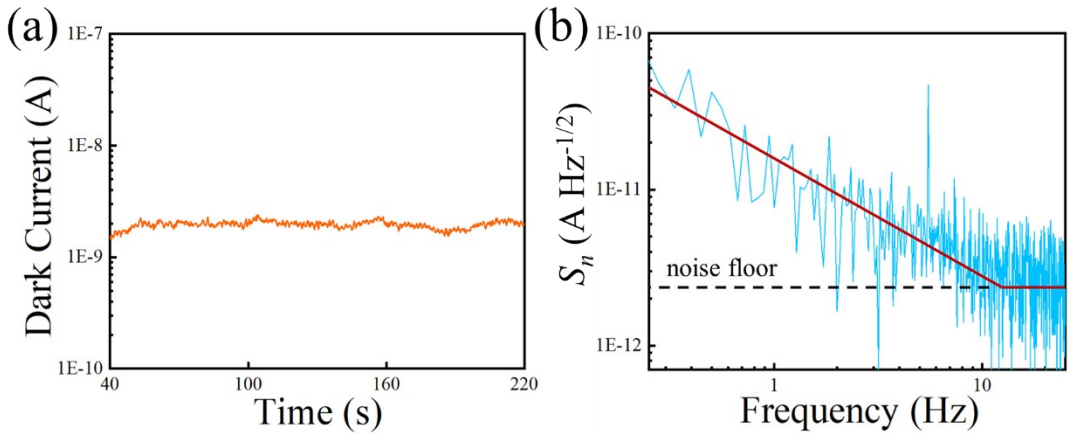

Fig. S12 a) Drak Current traces as a function of time at V = 1 V, b) Noise spectral density as a function of frequency

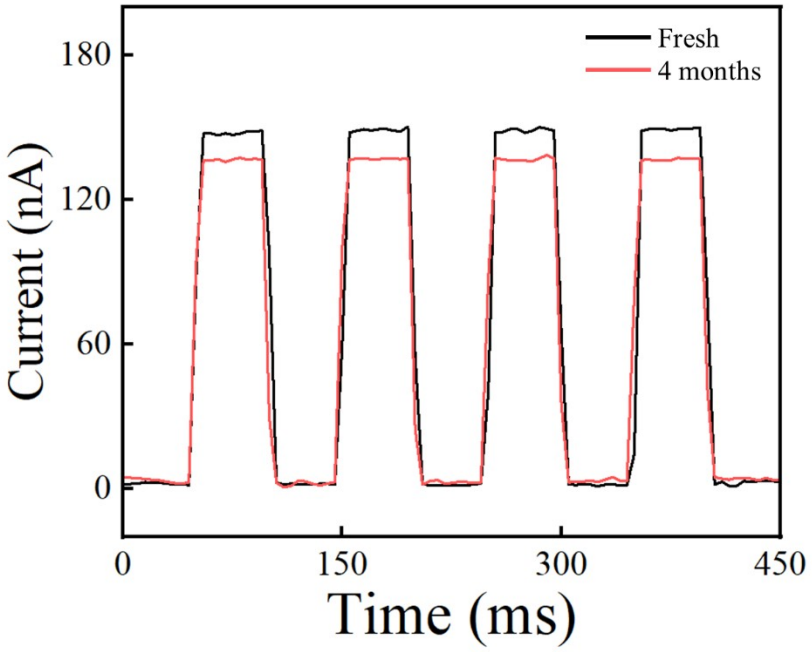

Fig. S13 Long-term stabilty test of 2D GaN/Si PDs