Supporting Information

For the Manuscript Entitled

Nanoparticles to Nanoholes: Fabrication of Porous GaN with Precisely Controlled Dimension via the Enhanced GaN Decomposition by Au nanoparticles

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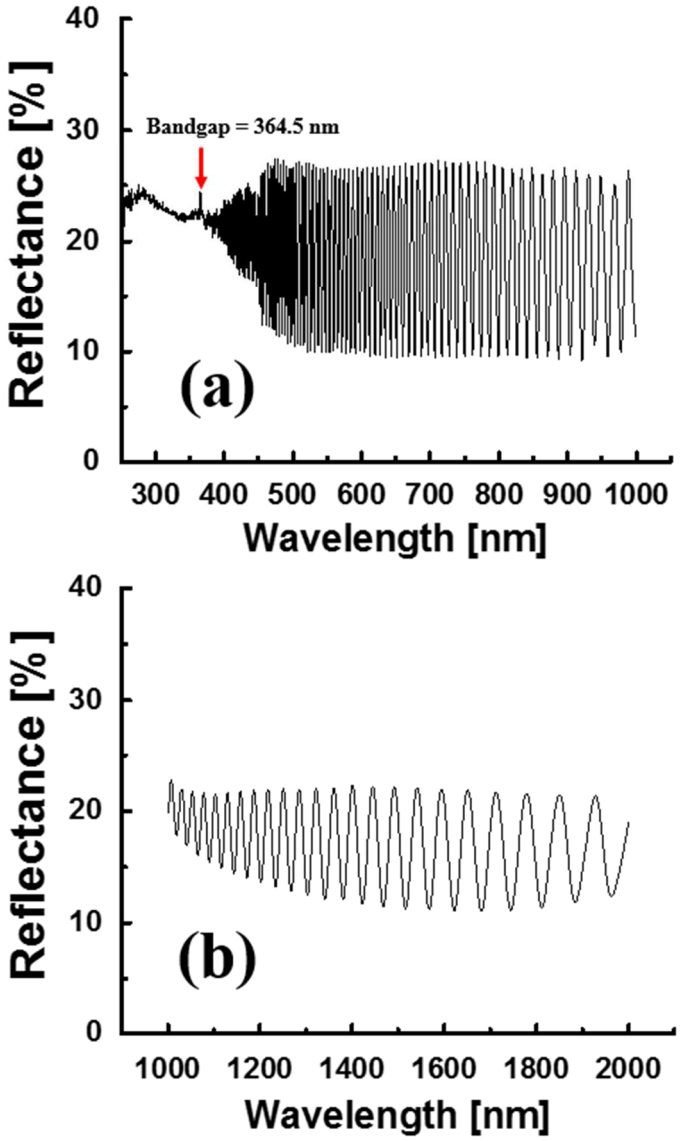

Figure S1. The reflectance spectra of 10 μm-thick GaN (0001) template on sapphire over the wavelength range of (a) UV-Vis-NIR region between 250 and 1000 nm by a CCD and (b) IR between 1000 and 2000 nm by an InGaAs photodetector. The cut-off wavelength of GaN appears at 364.5 nm which is indicated by red arrow. A band gap of ~3.4 eV can be calculated. The spectral oscillations is observed due to the structure GaN template on sapphire.[1]

1. Lian, C. X., Li, X. Y. & Liu, J. *Semicond. Sci. Technol.* **2004**, 19, 417-420.

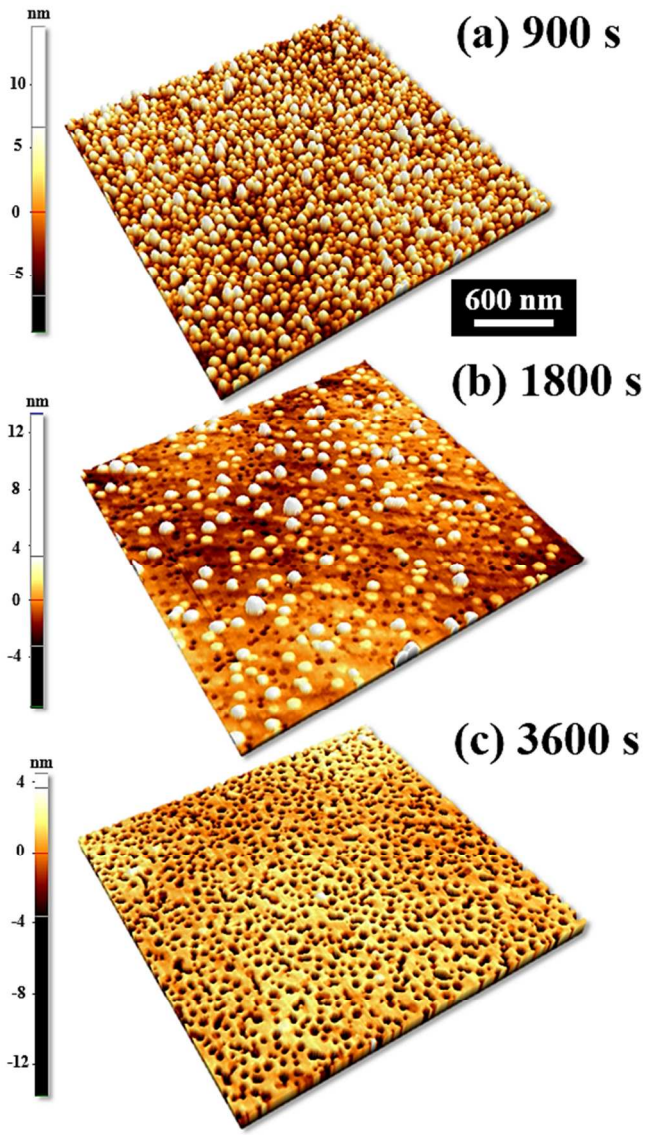

Figure S2. 3-D side-views of annealing duration dependent evolution of Au hexagons into the nanoholes at 800 °C with 3 nm Au deposition on GaN (0001) as labeled. (a – c) AFM 3-D side views of 3 × 3 μm^2. Along with the increased annealing duration, the number of Au hexagons is gradually decreased while the formation of increased number of nanoholes is observed.

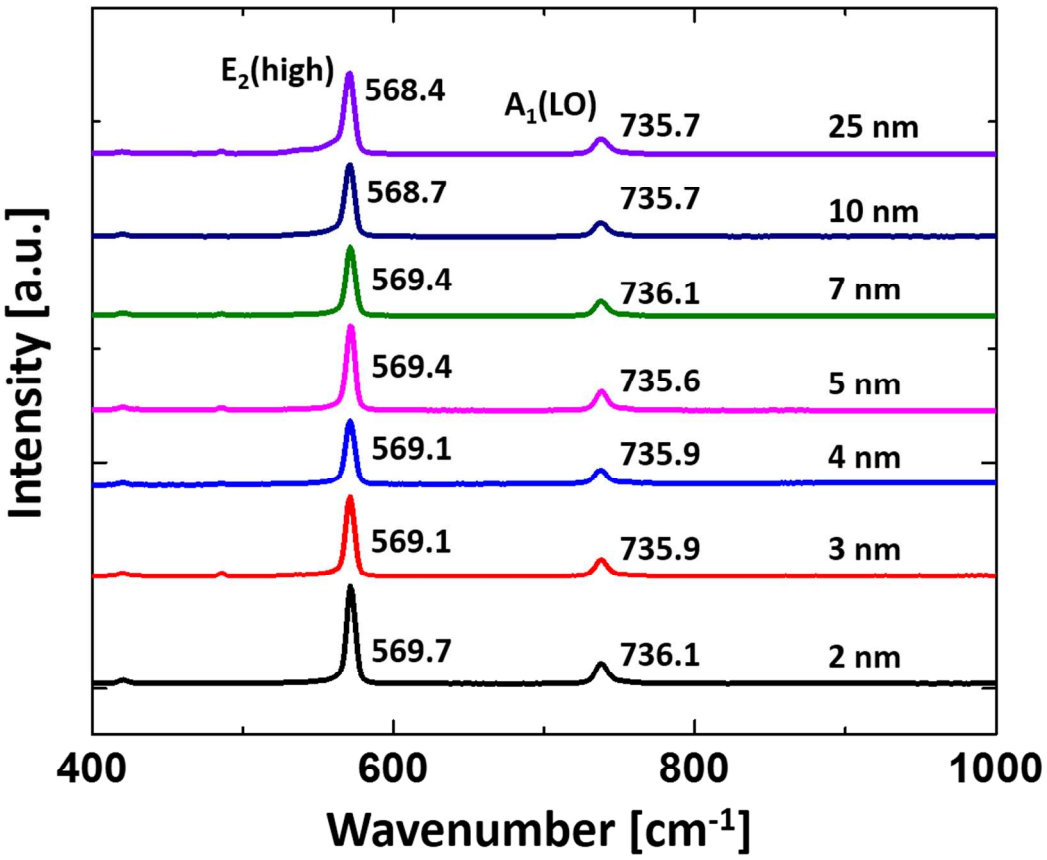

Figure S3. Raman spectra of nano-hole samples with the variation of Au deposition amount as labeled on GaN (0001) in the range from 400 to 1000 cm^{-1} with a laser power of 120 mW. The measurement was performed with a laser excitation of 532 nm at room temperature. The Porous GaN E_2 peak is observed at the range from 568.4 to 569.7 cm^{-1}, while GaN LO (longitudinal optical) phonon was observed at the range from 735.6 to 736.1 cm^{-1}.[2]

2. Harima, H. *J. Phys.: Condens. Matter* **2002**, 14, R967-R993.

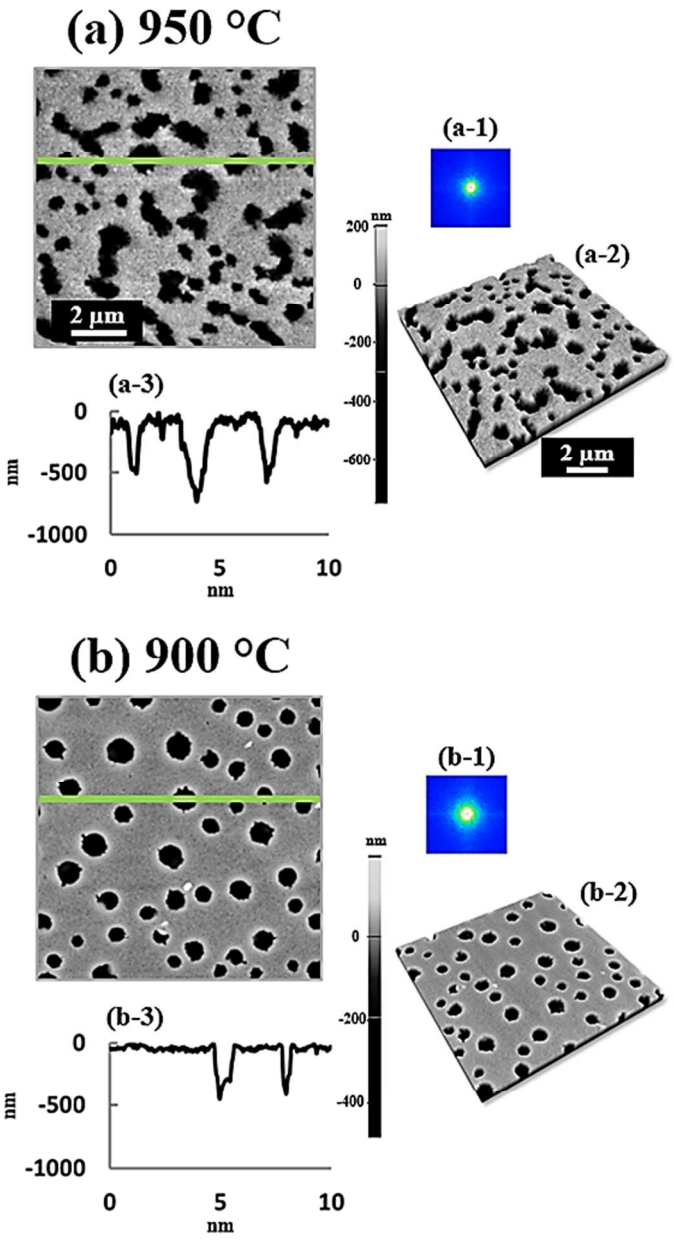

Figure S4. Nanoholes fabricated with 10 nm Au deposition at (a) 950 °C and (b) 900 °C for 3600 s. Panels a – b AFM top-views of 10 × 10 μm^2. Panels a-1 – b-1 FFT power spectra. Panels a-2 – b-2 Corresponding AFM side-views. Panels a-3 – b-3 Line-profiles. Along with the increased annealing duration, significant increase of the depth of holes were observed between 3600 and 7200 s.

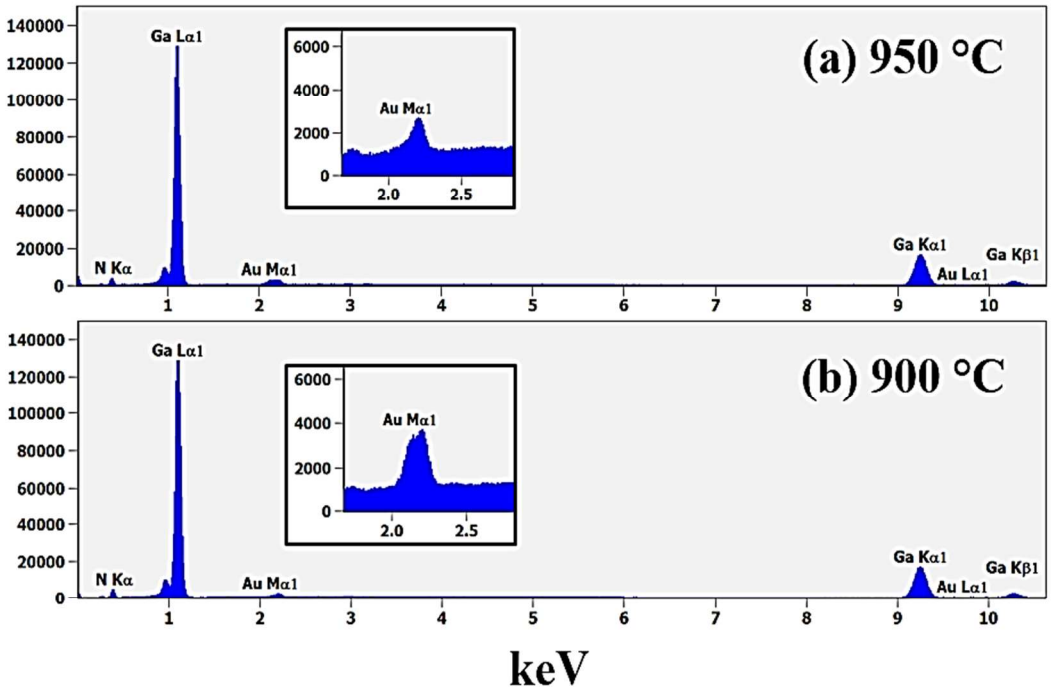

Figure S5. EDS spectra of nanoholes fabricated with the 10 nm Au deposition on GaN (0001), annealed at (a) 950 and (b) 900 °C for 3600 s. The samples show similar magnitude of the Ga Lα1, Kα1, Kβ1 and N Kα peaks while the intensity of Au Mα1 shows a big difference; i.e. ~ 2800 counts with the 950 °C annealing and ~ 4000 with the 900 °C.

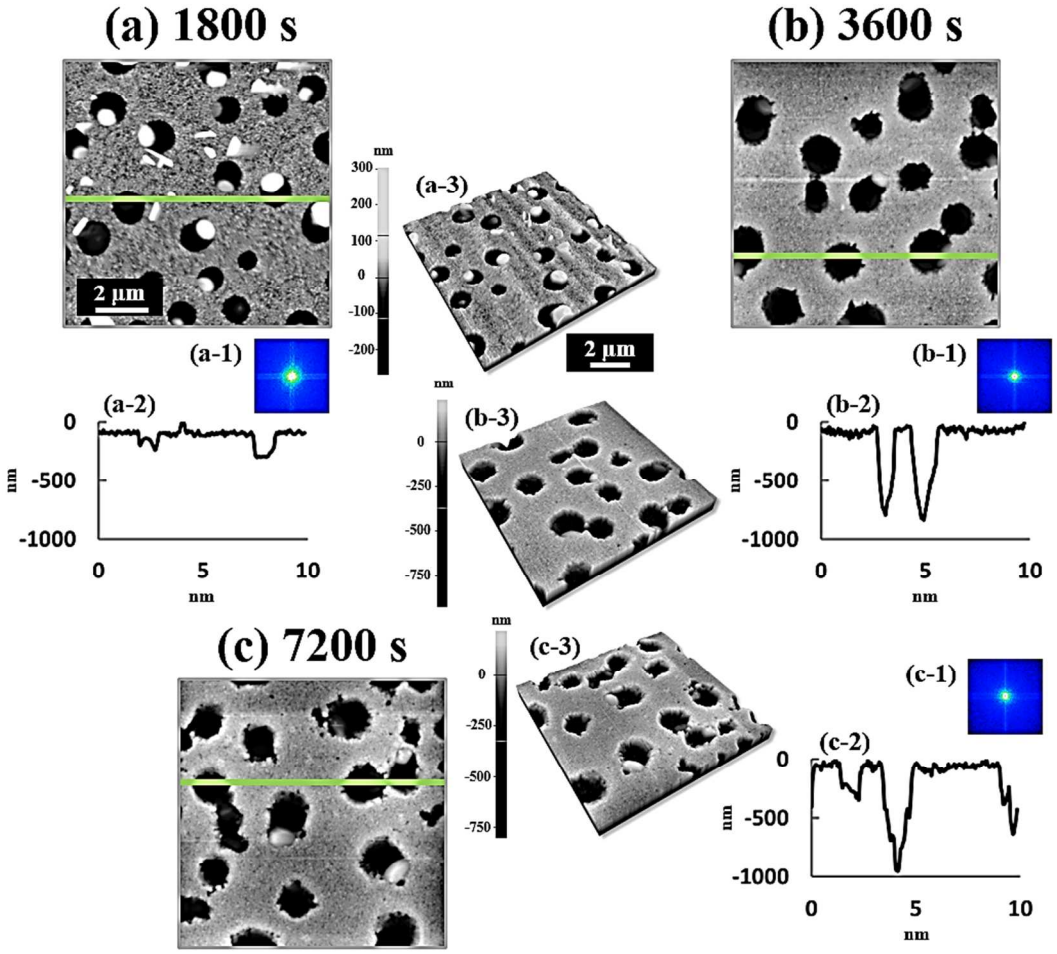

Figure S6. Nanoholes fabricated with 25 nm Au deposition at 900 °C for (a) 1800, (b) 3600 and (c) 7200 s. Panels a – c AFM top-views of 10 × 10 μm^2. Panels a-1 – c-1 FFT power spectra. Panels a-2 – c-2 Corresponding line-profiles. Along with the increased duration of annealing, significant increase of the depth of holes were observed between 3600 and 7200 s.

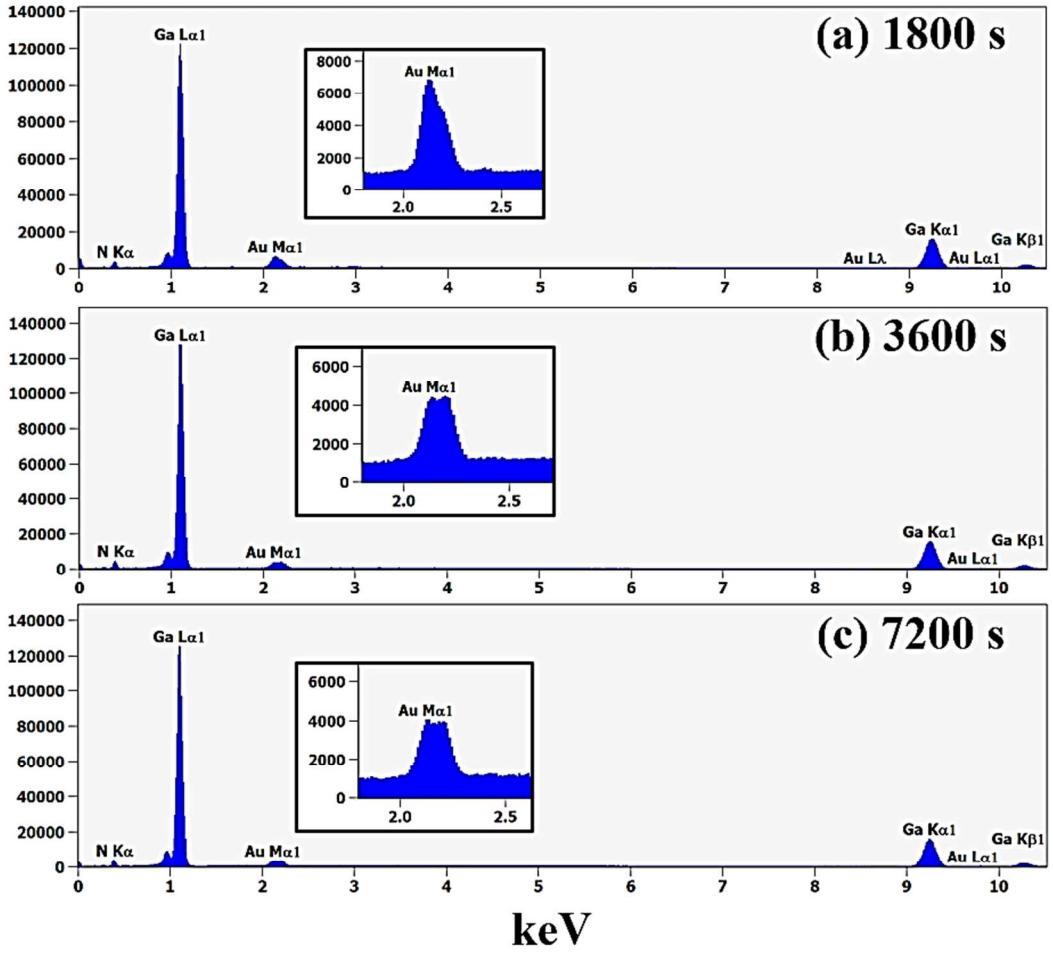

Figure S7. EDS spectra of nanoholes fabricated with the 25 nm Au deposition at 900 °C on GaN (0001), annealed for (a) 1800, (b) 3600 and (c) 7200 s. Three samples show similar magnitude of the N Kα, Ga Lα1, Kα1 and Kβ1 peaks and while the counts of Au Mα1 show a big difference; i.e. ~ 6800 counts with the 1800 s annealing and ~ 4200 counts with the 3600 s annealing and ~ 3900 with the 7200 s.

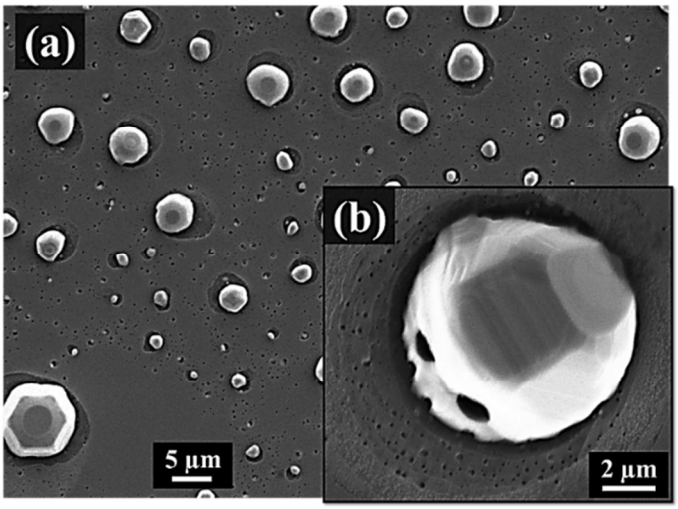

Figure S8. SEM images of Au nanoparticles with 100 nm deposition amount after annealing at 950 °C for 3600 s on GaN (0001). Even after 1 hr annealing, due to very large size, a lot of Au particles were still remained on the surface while they were slightly drilling into the surface. Around the Au particles multiple steps were observed with the formation of small holes in (b).

Table S1. Summary of the nanoholes: average depth, lateral diameter, and average density along with the variation of Au deposition amount.

Amount [nm]	Depth [nm]	Diameter [nm]	Density [cm^{-2}]
2	35.5	58.5	8.4×10^9
3	42.3	69.1	6.0×10^9
4	40.6	97.0	3.5×10^9
5	52.3	159.75	7.0×10^8
7	121.7	499.17	5.5×10^7
10	361.0	660.3	4.8×10^7
25	835.1	1336.3	1.6×10^7