

Red Emission of InGaN/GaN Double

Heterostructures on GaN Nanopyramid Structures

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1. Electron trajectory simulation for depth-resolved CL experiment.

We simulated the electron trajectory in the material depending on the acceleration voltages. Monte Carlo simulation program (Casino V2.4) was used for simulation.

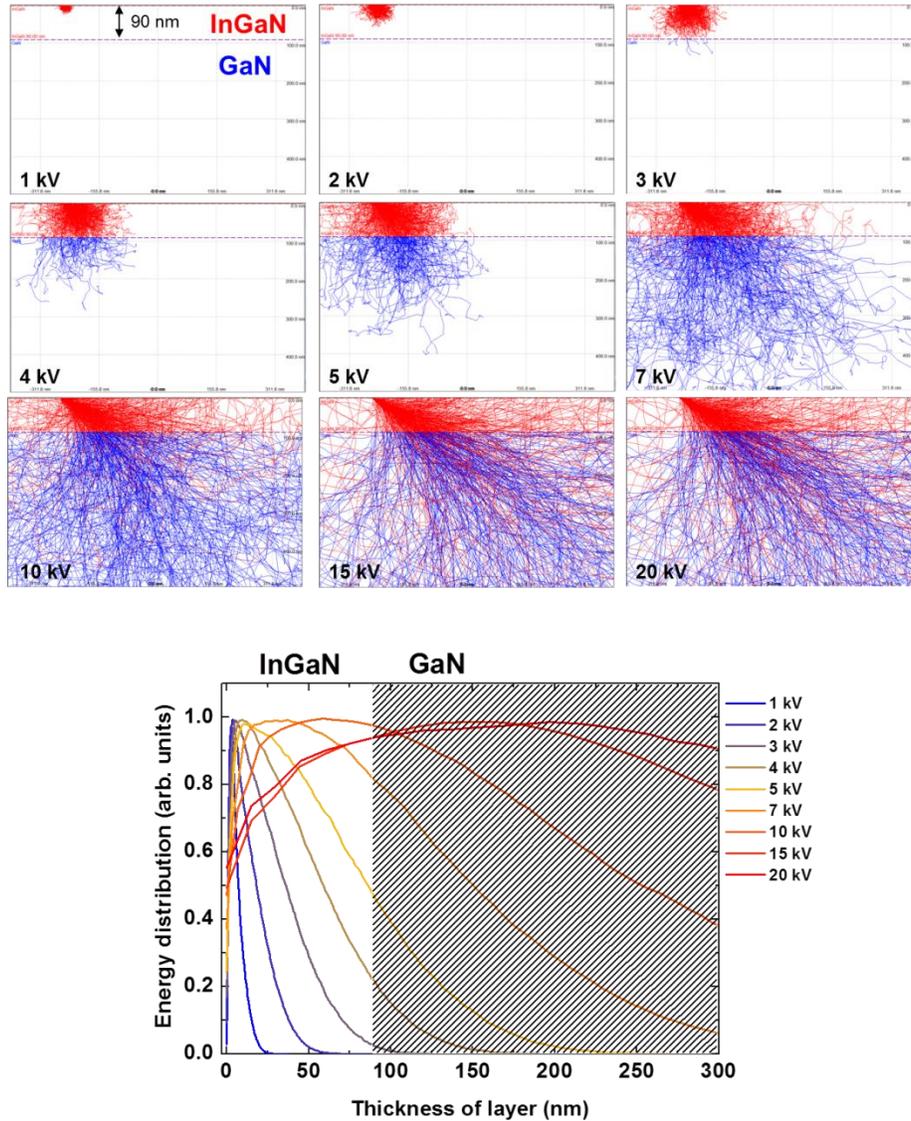


Figure. S1. (a) Electron trajectory simulation of penetration depth in the InGaN (90 nm) and GaN (2000 nm) heterostructures at various acceleration voltages from 1 kV to 20 kV. The electron beam has an incident angle of 60 degree to describe the semipolar facets in our structure. Red and blue colored regions represent the InGaN and GaN materials, respectively. (b) Depth profile of the energy distribution depending on acceleration voltages.

2. Carrier density dependent CL spectrum analysis.

To investigate the influence of carrier density in the CL experiment, we measured CL spectrum by changing the spot size of the electron beam, which changes the current density. At each step, the beam current increases about three to four times. Therefore, the current varies from a few pA to few tens of nA. The results show negligible peak shift or slight red shift with increasing current density. This is opposite to the results of Figure 2h in the manuscript, and thus, the blue shift behavior with increasing acceleration voltages (Figure 2h) does not originate from the increased carrier density.

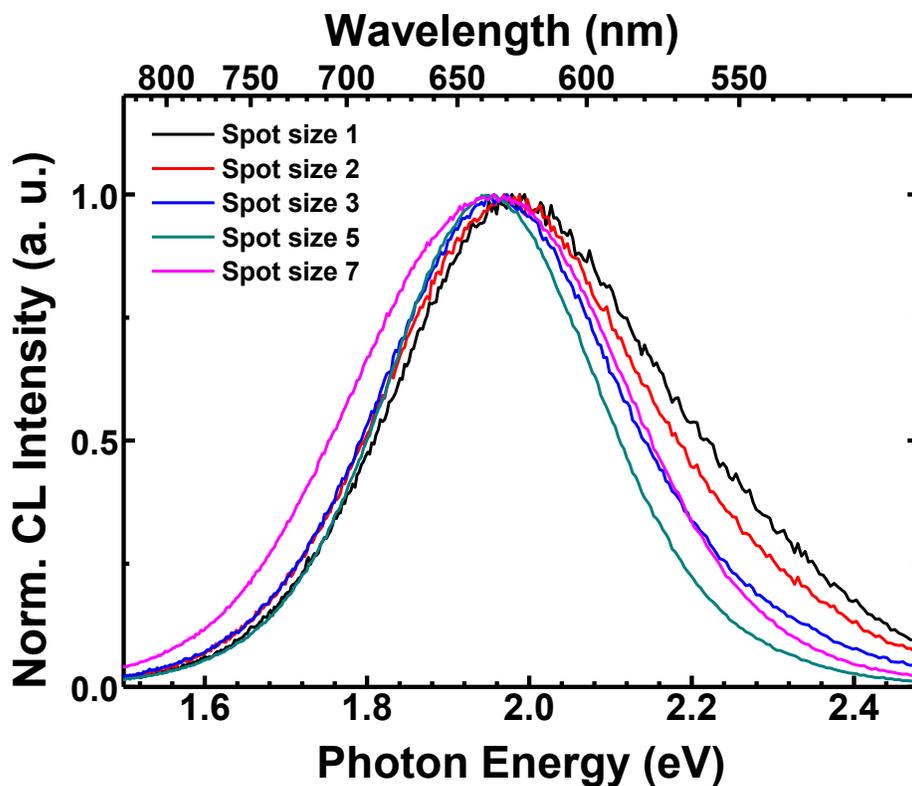


Figure. S2. Normalized CL spectrum of the DHS on nano-pyramids. We fixed the acceleration voltage at 5 kV and changed the spot size of electron beam.

3. Carrier density dependent PL experiment

The influence of carrier density is also analyzed by the PL experiment at 10 K. The results show the increase of PL intensity, but negligible peak shift with excitation power. Conventional InGaN QWs show blue shift behavior with increasing carrier density due to the field screen effect and band filling effect.^[1,2] The results represent that the DHS on nano-pyramid has a negligible internal field and reduced carrier density by the use of semipolar facets and enlarged active volume.

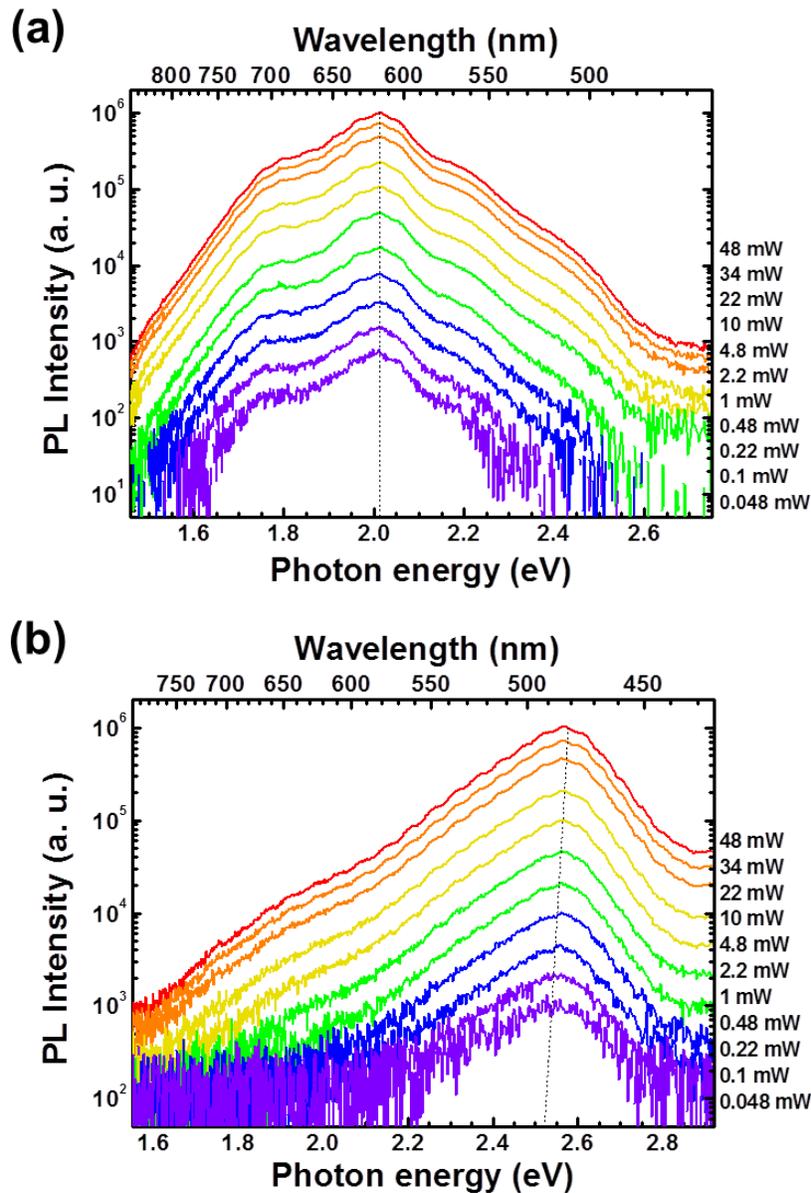


Figure. S3. Excitation power dependent PL spectra of the (a) DHS on nano-pyramids and (b) single QW on nano-pyramids measured at 10 K.