

Near Strain-Free GaN/AlGaN Narrow Linewidth UV Light Emission with Very Stable Wavelength on Excitation Power by Using Superlattices

Mo Li^{1,3}, Feiliang Chen¹, Claudius Kocher², Hui Zhang¹, Shuxiao Li¹, Feng Huang¹, Jian Zhang^{*,1,3}, and Robert A. Taylor^{*,2}

¹Microsystem and Terahertz Research Center, CAEP, No. 596, Yinhe Road, Shuangliu, Chengdu, 610200, China;

²Department of Physics, University of Oxford, Parks Road, Oxford, OX1 3PU, United Kingdom;

³School of Electronics Science and Engineering, University of Electronic Science and Technology of China, Chengdu, 610054, China.

Corresponding author*: robert.taylor@physics.ox.ac.uk, jianzhang@uestc.edu.cn

1. Cathodoluminescence measurement of nanopillars

We conducted room temperature cathodoluminescence (CL) measurements of the nanopillars after KOH etching with an electron acceleration voltage of 3 kV to ensure the emission of a single nanopillar. We tested 6 positions, position 1-4 were from different nanopillars, and position 5 and 6 were blank areas without nanopillars. From Fig. S1, we can see there are two peaks at about 330nm and 361nm (with a shoulder of about 368nm) for position 1-4. For position 5 and 6, the peaks around 330nm cannot be observed. Therefore, it proves the emission peak of QW is about 330nm at room temperature. The 361nm peak is a superposition of the Al_{0.1}Ga_{0.9}N layer and the GaN in the SLs. The tested nanopillars have similar sizes and quantum confinement, hence the emission peaks of the QW are almost unchanged.

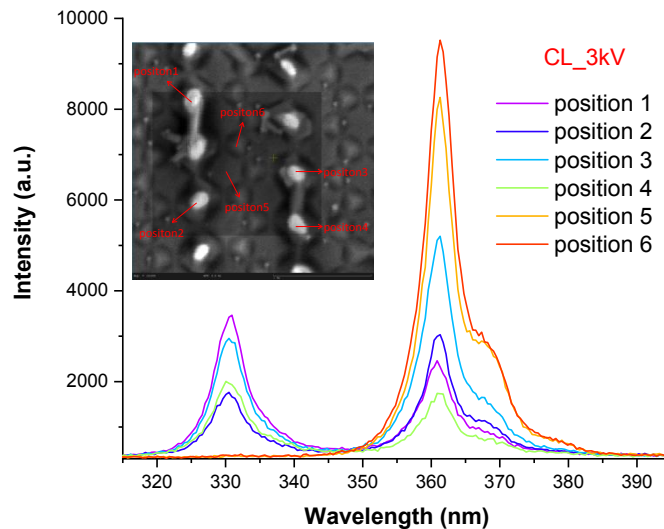


Fig.S1. The CL results of the GaN/Al_{0.3}Ga_{0.7}N SQW nanopillars measured at room temperature.

2. The estimation of the carrier density generated by excitation laser

The average excitation power of the experiment is from 30 μ W to 2mW before the micro-photoluminescence (μ -PL) setup. The total transmission efficiency including the UV mirrors, UV objective and dichroic is about 20%, therefore the average power on the sample is 6 μ W to 0.4mW. The repetition rate of the laser is 80MHz with a 100fs duration, then the laser energy range injected on the sample is about $(6 \times 10^{-6} \text{W} \sim 400 \times 10^{-6} \text{W}) / (80 \times 10^6 \text{Hz}) = 7.5 \times 10^{-14} \text{J} \sim 5 \times 10^{-12} \text{J}$. The spot size of the laser transmitting through the glass window of the cryostat on the sample is about 2 μ m, then the energy density A is:

$(7.5 \times 10^{-14} \text{J} \sim 5 \times 10^{-12} \text{J}) / (\pi \times (2 \times 10^{-4} \text{cm})^2) = 5.97 \times 10^{-7} \sim 3.98 \times 10^{-5} \text{J/cm}^2$. Since $\Delta n = (A \times (1 - R) \times \alpha) / h\nu$, R is the reflectance which is about 0.2, α is the absorption coefficient which is $16 \times 10^4 \text{cm}^{-1}$, then we have
$$\Delta n = \frac{A \times (1 - 0.2) \times 16 \times 10^4}{h \times \frac{3 \times 10^8}{266 \times 10^{-9}}} = 1 \times 10^{17} \text{cm}^{-3} \sim 6.8 \times 10^{18} \text{cm}^{-3}.$$

3. GaussMod fitting of the decay time and the instrument response function (IRF)

Fig.S2 (a) displays a fitting of the time-resolved- μPL of the as-grown sample at 5K with $100 \mu\text{W}$ excitation power. The fitting was performed by using a modified Gaussian function, convolved with an exponential decay, as described in the main text of the paper. The original decay time traces of the two samples with different temperatures with $100 \mu\text{W}$, as well as the IRF are shown in Fig.S2 (b).

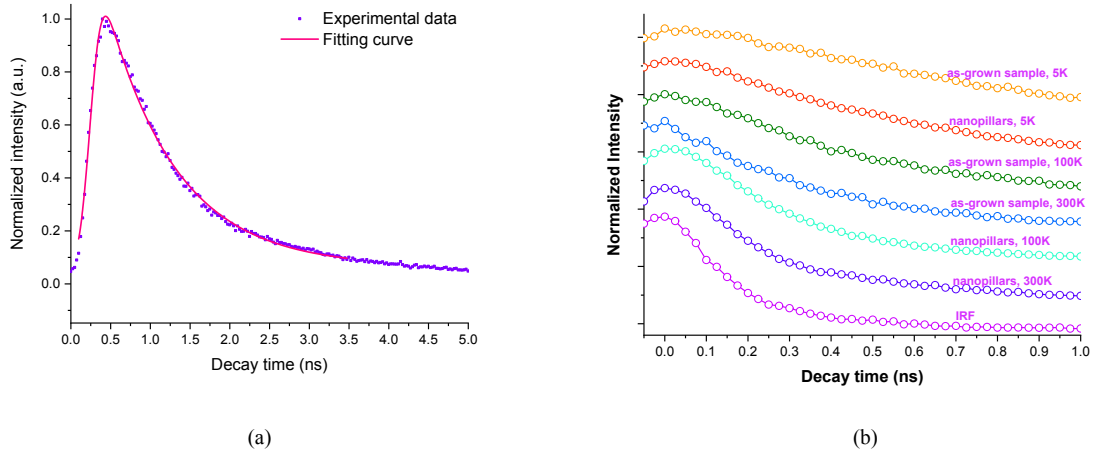


Fig.S2. With $100 \mu\text{W}$ excitation power: (a) The experimental data and the modified Gaussian fitting curve of as-grown sample at 5K; (b) TR- μPL traces of the two samples and the IRF at different temperatures.