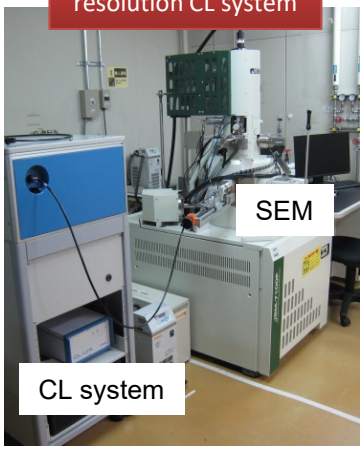
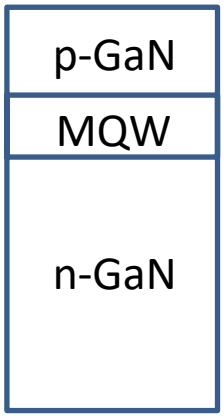
Process optimization and failure analysis of Micro-LEDs and Mini-LEDs

Analysis technologies such as cathodoluminescence (CL) and Raman spectroscopy are useful for Micro-LEDs and Mini-LEDs, which will be adopted in the next generation displays. Especially, our technologies are effective for process optimization and failure analysis.

Overview of high-resolution CL system

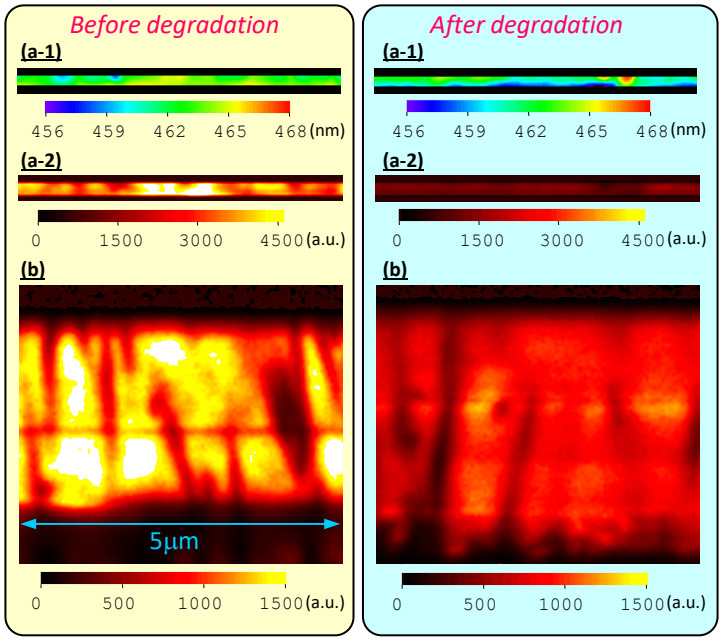


Micro-LED structure



Cross-sectional CL analysis of MQW and GaN layers

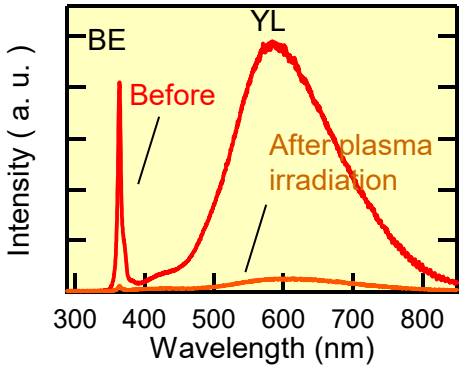
Cross-sectional samples were prepared before and after degradation.



CL spectral mapping
InGaN MQW : (a-1) Wavelength, (a-2) Intensity GaN : (b) Intensity

Evaluation of plasma damage (GaN on sapphire)

After plasma treatment of GaN film, damage at the extreme surface (acceleration voltage: 0.5 kV, penetration length: 4.3 nm) was evaluated by CL.



CL spectra (surface measurement)

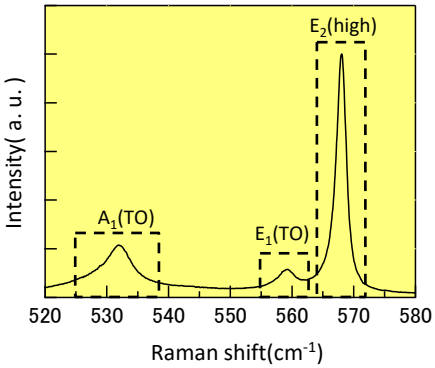
Consideration of Cross-sectional CL analysis

Decreased luminescence intensity of GaN and InGaN → Decreased crystallinity, resulting in an increase in non-luminescent centers. Wavelength shifts caused by composition, stress, and other factors are also observed with high precision (the average emission wavelength shift for InGaN layers is about 2 nm).

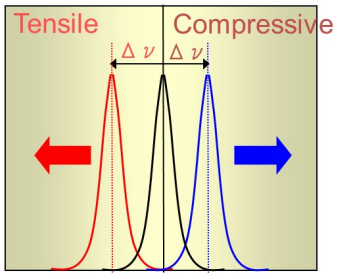
Consideration of surface CL analysis

The band edge emission (BE) intensity of the GaN layer is greatly reduced due to plasma damage. It is possible to evaluate the process damage at the extreme surface layer with high sensitivity.

Stress evaluation of GaN by Raman Spectroscopy



An example of Raman spectrum of GaN (a-plane)



$\Delta\nu\ (cm^{-1}) = C \cdot \sigma\ (MPa)$

$\Delta\nu$ is proportionate to stress σ

Raman scattering in GaN

GaN has anisotropy because of its hexagonal crystal structure.
⇒Multiple Raman line can be observed. Understanding the nature of vibration modes is important.

Temperature-dependent stress in GaN

Raman can be used for the optimization of packaging

Our features

- High precision measurement
  Stress can be determined within ± several MPa.
  (Wavenumber precision : ± 0.02cm^{-1})
- Temperature-dependent stress measurement
  A temperature of the sample can be changed from -150 to 300°C.
  Stress analysis can be performed at any temperatures.

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