Visualization of damage and stress in GaN HEMT via cross-sectional cathodoluminescence

Wide bandgap semiconductors still include many defects. Killer defects are also generated during device fabrication such as ion implantation and dry etching. Cross-sectional cathodoluminescence (CL) is sensitive to the process damages and can be used for process optimization and failure analysis.

### Features and applications of cathodoluminescence (CL)

- **CL**
- **X ray**
- **Sample**

1. **Surface analysis at nm level by low-acceleration and large-current e-gun**
2. **High-speed spectral mapping**

### Measurement procedure of high-speed spectral mapping

- **Monochromatic CL image**
- **Panchromatic CL image**

By measuring all spectral matrix data (for example 400 x 400), spectra at any region of interest, and intensity, wavelength, and width images can be obtained afterward.

### Examples of cross-sectional CL in GaN HEMTs

- **CL image of AlGaN (20 nm) layer at \( \lambda = 320 \text{ nm} \).**
- **CL image of GaN layer at \( \lambda = 364 \text{ nm} \).**

The thin AlGaN layer is clearly observed in the CL image. The intensity decay near the source and drain regions shows that the ion-implantation damage is not fully recovered by the annealing after the ion implantation.

- **Compressive**
- **Tensile**

One nanometer (nm) at 364 nm equals about 500 MPa of stress.

The peak wavelength of the band-edge emission mainly related to the stress. The blue shift near the channel layer is clearly observed.

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**P02097構造化学第1研究室20200413-1**