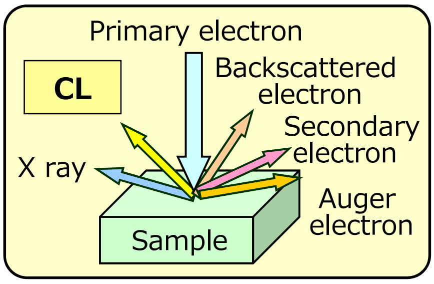
Visualization of damage and stress in GaN HEMT via cross-sectional cathodoluminescence

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)

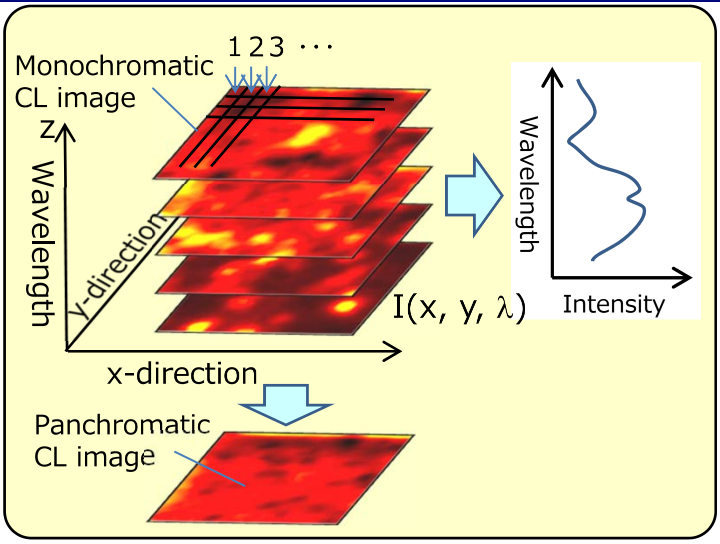


1. Surface analysis at nm level by low-acceleration and large-current e-gun
2. High-speed spectral mapping

Applications

Defects in thin films, process damages (dry etching, ion implantation etc.), stress, failure analysis (LED, LD, HEMT, SiC MOSFET, etc.), nanomaterials, ceramics, oxide semiconductors (Ga_2O_3) etc.

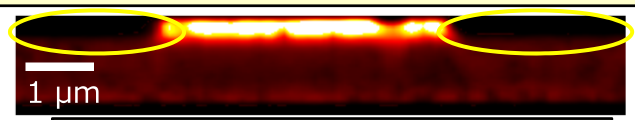
Measurement procedure of high-speed spectral mapping



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.

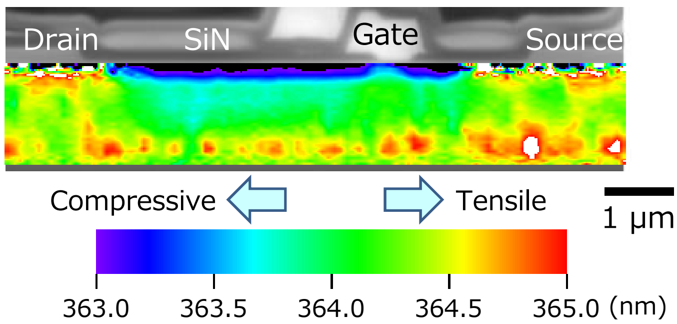
Examples of cross-sectional CL in GaN HEMTs

CL image of **AlGaN (20 nm) layer** at λ=320 nm.



CL image of **GaN layer** at λ=364 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.



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

Peak wavelength image of GaN band edge.

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

P02097構造化学第1研究室20200413-2

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