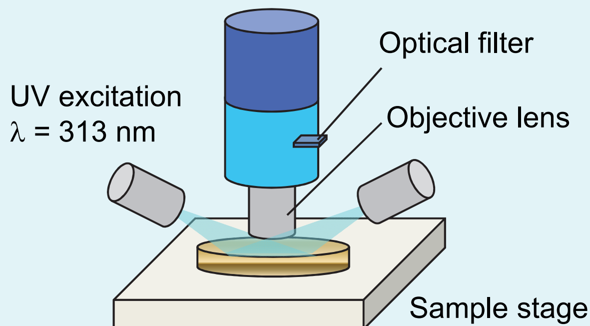
Defect observation by highly-sensitive photoluminescence (PL) imaging

We developed photoluminescence (PL) imaging system mainly for compound semiconductors by introducing highly sensitive CCD camera and optimizing illumination and detection system. Artifacts were drastically decreased and became highly sensitive to defects. It is especially suitable for low luminescent materials.

PL imaging system



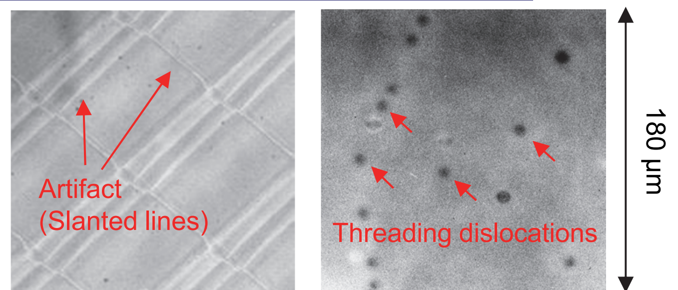
[Measurement procedure]
Illuminate a sample using UV light and detect emissions from the sample. Tilling measurement, which is a successive measurement using moving and detecting, has high spatial resolution image at a whole wafer up to 6 inches.

[Specifications]
Size: 6-inch wafer max.
Wavelength: CCD 300–1100 nm
InGaAs 900–1600 nm
Number of pixels: 1024 x 1024 x number of tiles
Pixel resolution: 0.13 µm / pixel min.
Spatial resolution: approximately 1 µm

Applications

- Defect inspection for compound-semiconductor wafers
- Determination of measurement region for TEM observation (Seamless connection between PL imaging, cathodoluminescence (CL), and TEM)
- Failure analysis for semiconductor devices (PEM: Photoemission microscope)
- Electroluminescence (EL)
- Investigation of film uniformity
- Fluorescent microscope

Defect observation in 4H-SiC wafer

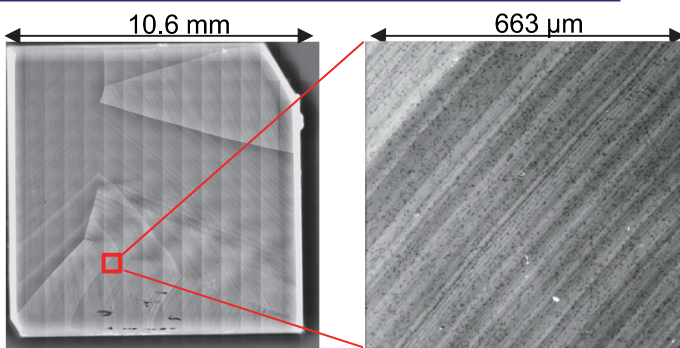


(a) Conventional system (b) Newly developed system

PL images at band-edge emission in the 4H-SiC wafer whose emission is very weak.

Artifacts were drastically decreased. The density of threading dislocation is about 3E4 cm^{-2}.

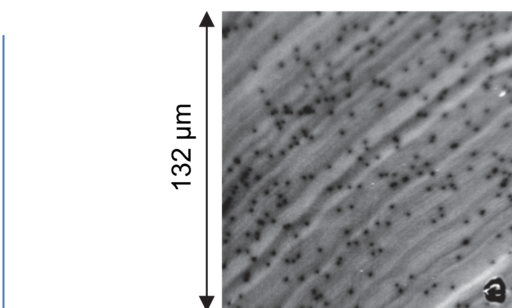
Defect observation in GaN single crystal



PL image of wide area. Total 16 x 16 tiles

Elongated PL image of one tile. Small dark spots correspond to threading dislocations.

PL images at band-edge emission in GaN single crystal.
Objective lens x 20.
Total number of pixels: 1024 x 1024 x 16 x 16 = 2.68E8



PL images at band-edge emission in GaN.
Objective lens x 100

The density of threading dislocation is about 1E6 cm^{-2}. A wide-area image using tilling procedure enables us to investigate wafer uniformity as well as the density of threading dislocation. A combination of PL and CL also effective for the defect characterization.

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