Crystalline characterization of ZnO nanowire, and GaN flake using STEM-CL

STEM-CL is an analytical tool which is similar to well-known techniques: SEM-CL, PL, and EELS. We developed new STEM-CL apparatus. In this work, we introduce crystalline quality of GaN flake, and ZnO nanowire by STEM-CL.

1. Crystalline characterisation of ZnO nanowire (NW) by STEM-CL

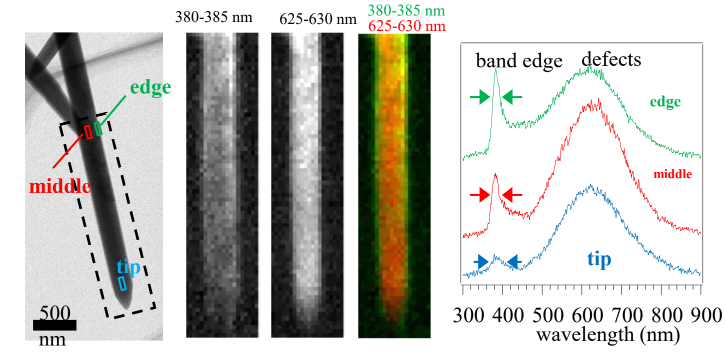
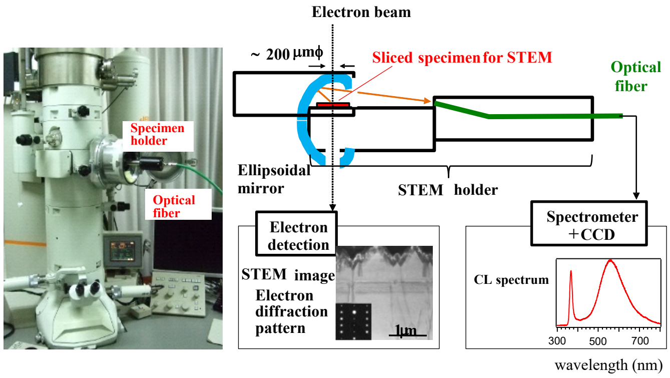


Figure 1-1. (a) BF-STEM, (b) CL images at various wavelengths, and (c) CL spectra of ZnO NW



Set up of STEM-CL

The CL intensity image at 380-385 nm, which is assigned to band-edge emission (BEE), tends to become weak, approaching to the tip of NW. In general, the CL intensity attributable to BEE decreases near dislocations or defects, because the dislocations and defects in ZnO act as non-radiative recombination centres (NRRCs) like as GaN. Decrease in the CL intensities at tip of NW implies that the crystalline quality of NM decreases near the tip. In Fig. 1-1(c), the intensity ratio of the band-edge CL peak at approximately 380-385 nm normalized by the CL peak at 620 nm decreases as the measured position approached from the edge to the tip. This implies that the crystalline quality decreased, approaching from the edge to the tip.

2. Crystalline characterisation of GaN flake by STEM-CL

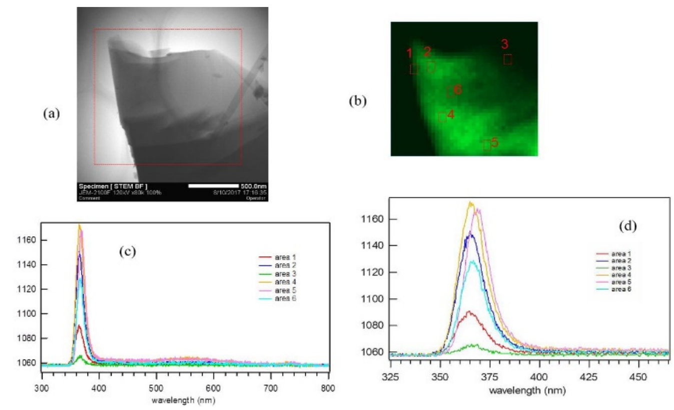


Fig.2-1. (a) STEM and (b) CL intensity image (365-nm peak) in a scanning area of 1 μm × 2 μm, and CL spectra at points 1–6 (c) from 300 to 800 nm and (d) from 325 to 465 nm of a piece of GaN crystal flake with a thickness of less than 100 nm, measured by an acceleration voltage of 120 keV.

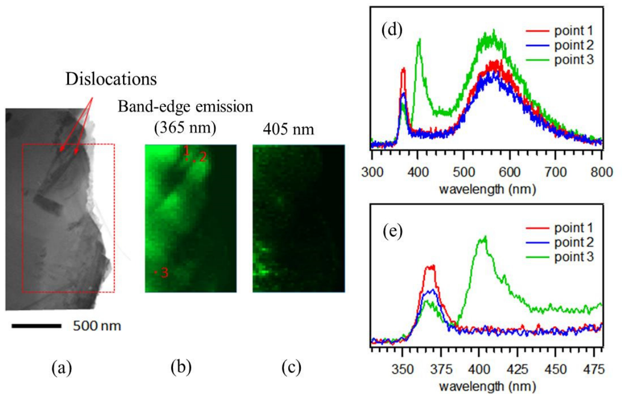


Fig. 2-2. (a) STEM, (b) CL image at 365 nm, and (c) CL image at 405 nm in the scanning area of 1 μm × 2 μm, and the CL spectra at points 1–3 from (d) 300 nm to 800 nm, and (e) from 325 nm to 476 nm of a GaN crystal.

The CL peaks at approximately 365 and 580 nm are assigned to BEE and defect-related broad luminescence (YL), respectively. In Fig. 2-1(d), the CL peak is due to BEE shifts by 5 nm (−46 meV) from 365 nm (3.397 eV) to 370 nm (3.351 eV), depending on each position. This red-shift of 46 meV means that the crystal flake is under tensile or compressive stress by approximately 21.7 MPa. As seen in Figs. 2-2(a) and (b), the STEM image in the vicinity of dislocations of the GaN crystal flake in Fig.2-2(a), coincides well with the CL intensity image at 365 nm in Fig.2-2(b). Generally, the CL intensity attributable to BEE decreases in the vicinity of dislocations, because the dislocations in GaN act as NRRCs. Decrease in the CL intensities at points 1, 2, and 3 near the dislocations implies that the crystalline quality of GaN decreases in the area near the dislocations.

P02325海外営業部(滋賀)20210914

Toray Research Center, Inc.