Spatio-time-resolved cathodoluminescence studies on wide bandgap wurtzite AlN and GaN

Shigefusa F. Chichibu, Youichi Ishikawa, and Kentaro Furusawa
Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Sendai, Japan
chichibulab@yahoo.co.jp

Wurtzite group-III-nitride semiconductors have intensively been studied for the past few decades, and ultraviolet (UV) to green light emitting diodes (LEDs) as well as near UV to blue laser diodes (LDs) based on InGaN active regions are now in common place. Whilst InGaN LEDs fabricated on defective GaN templates grown on (0001) sapphire substrates, which contain high density threading dislocations (TDs) typically 10^8 to 10^9 cm^{-2}, are commercially available, precise understanding of sub-micrometer scale local carrier (exciton) recombination dynamics in AlN, GaN, and AlGaN quantum nanostructures is necessary not only for achieving ultimate performance and/or excellent reliabilities of deep ultraviolet (DUV) LEDs but also for realizing AlGaN/GaN power-switching transistors.

In order to probe local carrier dynamics in visible-light-emitting semiconductors, scanning near-field optical microscopy with a frequency multiplied short-pulsed laser is widely used. However, the use of a short-pulsed electron-beam (*e*-beam) becomes attractive when characterizing wide bandgap (E_g) materials such as AlN or BN. Spatio-time-resolved cathodoluminescence (STRCL) takes full advantage of such a pulsed *e*-beam, which enables high spatial resolution beyond the diffraction limit of light owing to the focused electronic excitation and thus makes it possible to interrogate local carrier/exciton dynamics. Modifying the STRCL system developed by Merano *et al.* [1,2], we fabricated a STRCL system with the front-excitation scheme photoelectron (PE)-gun with the negatively biased Au photocathode that is excited using a frequency-tripled (3ω) mode-locked Al_2O_3:Ti laser, as shown in Fig. 1 [3,4].

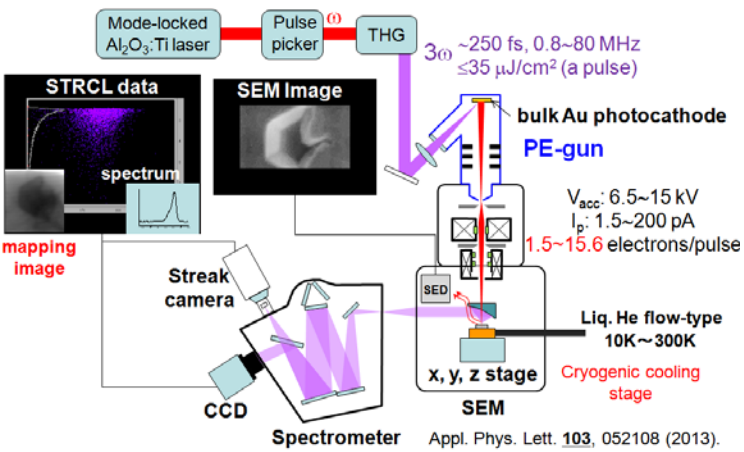

Fig. 1 Schematic diagram of our STRCL measurement system equipped with the front-excitation-scheme PE-gun.

In this presentation, the results of STRCL measurements on dislocated and nearly TD-free AlN epilayers and the area containing basal-plane stacking faults (BSFs) of GaN will be presented to discuss their local luminescence dynamics.

The authors would like to thank M. Tashiro and T. Ohtomo for help in the experiment. This research project was supported in parts by NEDO programs by METI, Grant-in-Aids for Scientific Research # 23656206 from MEXT, The Asahi Glass Foundation, Japan, and AOARD/AFOSR monitored by G. Jessen.

1) Merano *et al.*, Nature **438**, 479 (2005). 2) Corfdir *et al.*, Appl. Phys. Lett. **94**, 201115 (2009). 3) Furusawa *et al.*, Appl. Phys. Lett. **103**, 052108 (2013). 4) Chichibu *et al.*, Appl. Phys. Lett. **103**, 142103 (2013).