Nonpolar light-emitting diodes using hydrothermally grown a-plane ZnO

Hyonwoong Kim[1], Kwang Hyeon Baik[2], Soohwan Jang[1]

1. Department of Chemical Engineering, Dankook University, Yongin, 448-701, Korea
2. Department of Materials Science and Engineering, Hongik University, Jochiwon 339-701, Korea

Light-emitting diodes (LEDs) are increasingly employed as general lighting sources in many applications. LED has great advantages over traditional lighting sources such as incandescent bulb and fluorescent lamp in their low power consumption, fast response and long lifetime. Presently, commercially fabricated LEDs consist of GaN related material system, which is grown along the polar c-axis ([0001]) of wurtzite crystal structure. In this crystal orientation, there exists spontaneous and piezoelectric polarization inducing electric fields which results in spatial separation of electron and hole wave functions. This quantum confined stark effect (QCSE) causes reduction in radiative recombination efficiency under high current injection. To overcome this efficiency droop, there have been many efforts to reduce both spontaneous and piezoelectric polarization. One of solution is using nonpolar GaN substrates including a-plane (11-20), and m-plane (1-100), or semi-polar substrate of (11-22) and (1-101) plane.

ZnO is promising alternative light emitting material which has many advantageous properties in that it has both a direct wide band gap of 3.37 eV and large exciton binding energy of 60 meV. Also, it has same crystal structure as GaN with only 1.9% lattice mismatch. A variety of method have been reported for ZnO growth such as laser-assisted plasma enhanced chemical vapor deposition (PECVD), metal organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), and hydrothermal synthesis. While laser-assisted PECVD, MOCVD, and MBE require high temperature and vacuum conditions in complicate and expensive equipments, low-cost facile hydrothermal epitaxial growth can be achieved under low temperature and atmospheric pressure.

We have successfully grown high quality nonpolar a-plane ZnO on (11-20) plane GaN by hydrothermal method. Furthermore, Non-polar n-type ZnO/p-type GaN LED with strong band edge electroluminescent emission and low turn-on voltage was demonstrated. In this presentation, a-plane ZnO film growth and characterization, device fabrication and performance of LED will be presented.

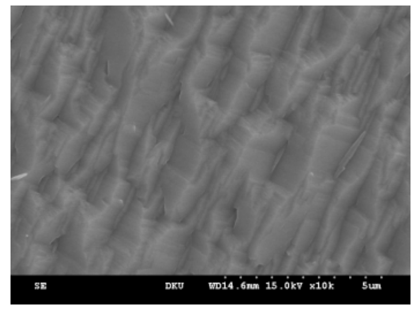

Figure 1. SEM image of hydrothermally grown ZnO film

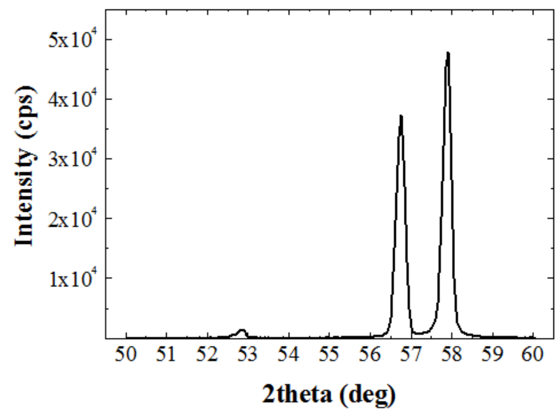

Figure 2. XRD patterns of a-planer ZnO grown on p-GaN

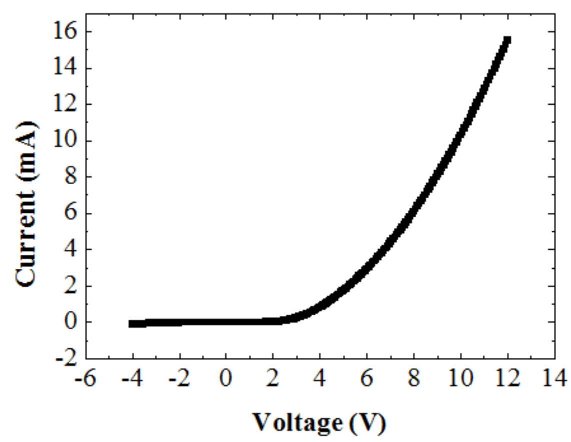

Figure 3. Current-voltage characteristics of nonpolar n-ZnO/p-GaN heterojunction LED

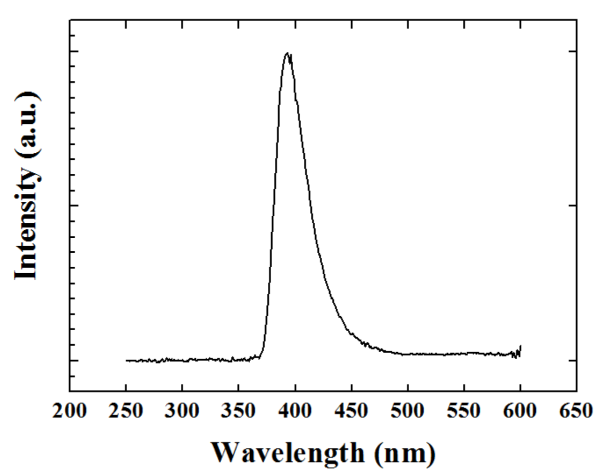

Figure 4. EL spectra of nonpolar n-ZnO/p-GaN heterojunction LED.