p-ZnO/n-ZnO Nanoparticles based UV Light Emitting Diodes

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Currently, GaN-based LEDs attract attention for various applications such as lighting and display. However, they have a cost issue because all of the commercial LEDs are fabricated by an expensive single crystal-based semiconductor process. Our group had demonstrated nitrogen-doped ZnO nanoparticles (NPs) based near UV LEDs by coating p-ZnO NPs on GZO film [1]. This NP based process needs no single-crystal substrate that has the potential to realize ultra-low-cost semiconductor devices. We had also reported the enhancement of emission intensity by inserting n-ZnO thin film as an active layer [2, 3]. However, n-ZnO layers were still single-crystal films growth by MOCVD. In this work, we successfully made LEDs using both p-type ZnO and n-type ZnO NPs. This is the world first demonstration of all nanoparticles based pn junction LEDs that will be one of the technological innovation of semiconductor devices and fabrication process.

In our research, nitrogen-doped ZnO NPs for p-ZnO layer was synthesized by dc arc plasma gas evaporation method [4]. N-type ZnO NPs were prepared by Ga doping into ZnO NPs by thermal diffusion using Ga_2O_3 as a Ga source. The n-ZnO NPs deposited on a GZO transparent electrode by simple spin coating or spray method. P-type ZnO NPs were mixed with a binder (Silsesquioxane) and coated on the n-ZnO NPs layer by spin coating. These layers were sintered by the hot plate at~ 300°C. Gold electrodes with 30 nm thickness were evaporated on both p-ZnO NPs layer and GZO layer as shown in Figure 1. We evaluated the properties of LEDs with and without inserting ZnO: Ga NPs active layer. Figure 2 shows the comparison of electroluminescence. We will present the detailed of the results.

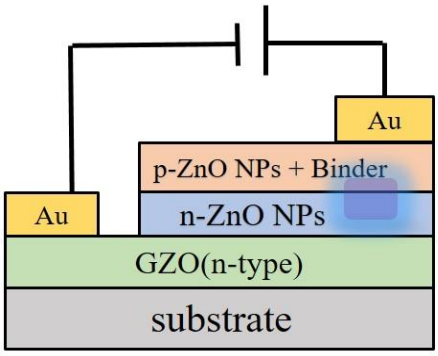

Figure 1 Cross sectional view of device structure.

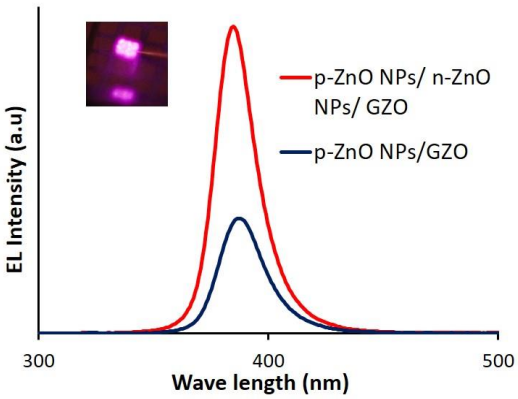

Figure 2 Electroluminescence spectra.

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Reference

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