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Performance enhancement of optoelectronic devices using transparent conductive electrodes

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The novel ZnO transparent conductive layers with different dopant sources were used as the transparent conductive electrodes and enhanced the performance of the optoelectronic devices. Here, we will also introduce that the ZnO layers were prepared by different methods dependent on the applications. One was grown by metalorganic chemical vapor deposition (MOCVD) and the other was grown by atomic layer deposition (ALD).

As applied the ZnO TCL to GaN blue light-emitting diodes (LEDs) , it was found that high performance of Ga-doped ZnO (GZO) prepared using MOCVD can be obtained. There was a high light extraction efficiency of 77% achieved in the GZO-LED as compared with that in the ITO-LED at injection current of 20 mA. At 350 mA injection current, the output power of 256.51 mW of GZO-LEDs, corresponding to a 21.5% enhancement as compared to ITO-LEDs was obtained. The results are promising for the development of GZO using the MOCVD technique for GaN LED applications.

On the other hand, aluminum doped zinc oxide (AZO) thin films used as transparent conductive layer were deposited on GaP window layer of high-brightness p-side-up thin-film AlGaInP-based light-emitting diodes (LEDs) to enhance the performance of LED device. The p-side-up thin-film AlGaInP-based LEDs was fabricated by twice wafer-transfer technique. Because the p-side-up thin-film AlGaInP-based LEDs can not stand for the high growth temperature, the ZnO was grown by ALD. In order to Ohmic with the AZO , p+-GaP:C ohmic-contact layer is used to form the ohmic contact with AZO thin film. The AZO thin film with different Zn:Al cycle ratio of 15:1, 20:1 and 25:1 were deposited onto p+-GaP:C window layer as current spreading layer byALD. The output power of p-side-up thin-film AlGaInP LED with an AZO layer (Zn:Al=20:1) exhibited the largest improved up to 27.5% at injection current of 350 mA, as compared with that of LED with ITO electrode. The p-side-up thin-film AlGaInP LED with different cycle ratio of Zn:Al AZO current spreading layer exhibited excellent performance stability, the emission wavelength shift of p-side-up thin-film AlGaInP LED with ITO and AZO thin film(Zn:Al cycle ratio of 15:1, 20:1 and 25:1) are 8 nm, 2 nm, 3 nm and 5nm under the injection current increased from 20 mA to 1000 mA, respectively. This performance improvement of LED device can be attributed to the following factors: (1) refractive index matching performed by introducing AZO thin film between the epoxy and the GaP window layer enhances light extraction; (2) the most of photon are extracted from the LED surface and further reduce the accumulation of Joule heat.

Details on the growth mechanisms and application considerations will be discussed in the presentation of the conference.