Fabrication of Cd-free Quantum Dot Light Emitting Diodes by varying the thickness of sputtered Zinc Oxide layer

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【Introduction】Quantum dot (QD) light emitting diode (QLED) is one of the emerging research fields due to rapid growth of display industries [1]. Consequently, many researchers are trying to improve the different sections of the QLEDs, considering the luminance and efficient electron and hole-transport. From the early age of the QLED system, most of the efficient QLEDs are dependent on the Cd-based QDs. However, the Cd substances will cause serious environment and human health issues [2]. Therefore, at present, most of the researchers are trying to improve the use of Cd free QDs. Up to now, researchers are struggling with quantum dot light emitting devices, related to yellow/orange emission [3]. Besides, the lucrative luminance and efficiency of QD device is obtained using the inverted structure [4]. Additionally, the inverted structure is mainly focused on the oxide layer, generally, used as electron transport layer (ETL). The most attractive oxide base semiconductor materials are ZnO [4] and TiO_2. In this research work, we have preliminary fabricated QLED, where, the sputtered ZnO film was used as electron transport material, where the ZnO thickness was considered with the luminance (*L*) and current density (*J*) using ZnCuInS QDs.

【Experiment】Patterned ITO substrate was thoroughly cleaned using organic cleaning solvent and UV ozone chamber under O_2 ambient. The device structure is ITO (100nm)/ZnO (05, 20, 50, 80, and 110 nm)/QD (ZnCuInS)/ N,N′-Di(1-naphthyl)-N,N′-diphenyl-(1,1′-biphenyl)-4,4′-diamine (α-NPD, 60nm)/ Molybdenum oxide (MoO_3, 10nm)/ Al (70nm). The device performance was analyzed in the *J-V* (voltage), and *L-J* characteristics. During sputtering of ZnO, the Ar and O_2 mixing ratio was 70:30. The evaporation rate for the organic materials was maintained below 2Å/s. All the measurements were carried out in air at room temperature, and the device area was 0.04cm^2.

【Results and Discussions】 Figure 1(a) shows photographs of emission area varied with different thickness of zinc oxide (ZnO) layer. By increasing the ZnO thickness, emission pattern will be changed uniformly, because of the coverage of ZnO layer on ITO substrate. Figure 1(b) shows the *J-V* and *L-J* characteristics. Lower voltage operation and higher luminous efficiency were obtained at ZnO thickness of 80 nm. This optimum condition is related with the series resistance of ZnO and surface coverage of the ZnO, i.e., enhancement of the electron injection. The QLED with 80 nm ZnO layer shows luminance of 5,520 cd/m^2 (J = 230 mA/cm^2), power efficiency of 12.5 lm/W at 100mA/cm^2.

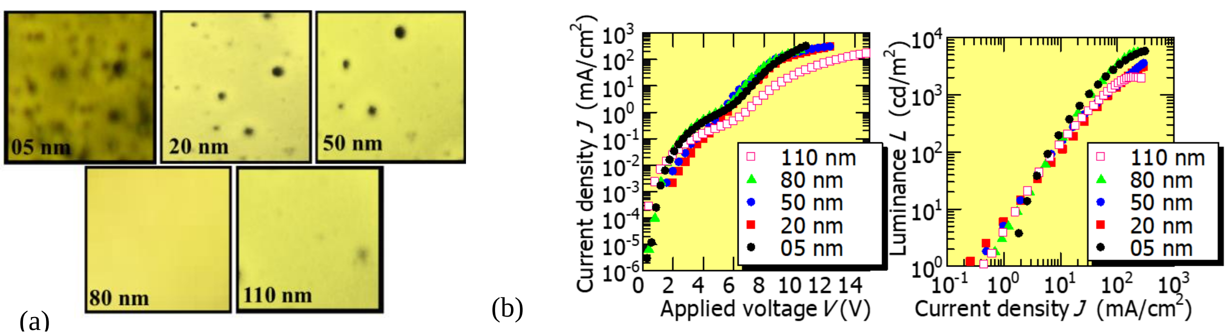

Fig. 1 (a) Photographs of emission area in devices, characteristics of (b) *J-V* and *L-J* characteristics of devices with different thickness of ZnO layer.

【Conclusions】 The characteristics of QLEDs with the different ZnO layer thickness were investigated. The optimum condition of the ZnO thickness of 80 nm was obtained for coverage of electron injection layer and series resistance. By changing the organic/inorganic materials and thickness, better device performance will be realized.

【References】
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