Cd-Free ZnCuInS/ZnS Quantum Dot Light Emitting Diodes with Mixed Single Layer

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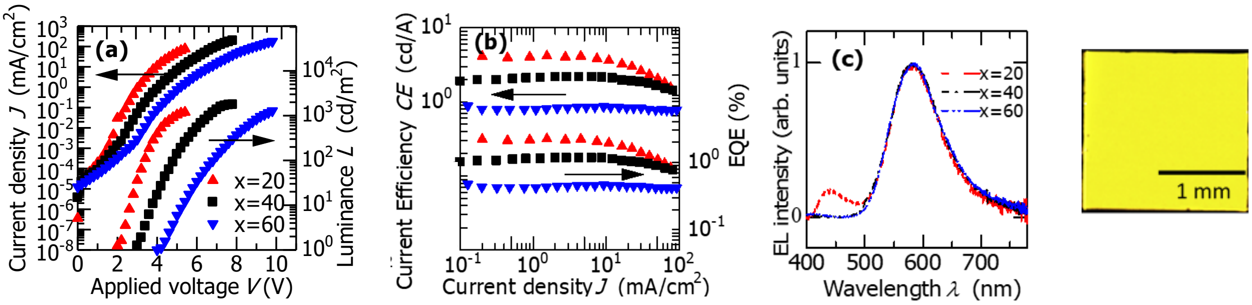
【Introduction】Quantum dot (QD) light-emitting diodes (QLEDs) is one of the emerging research fields due to the highly quantum yield and variation of wavelength by changing a size of QD.[1] Performances of the QLED is dependent not only on the fabrication procedure but also on the device structure, i.e. electron transport material (ETM), and hole transport material (HTM) to balance the carrier mobility.[2] Conventional stacked structured QLEDs is limited to the carrier injection because of a insertion of the QD itself. Considering this problem, we have investigated the mixed single layer (MSL)-QLED by controlling the carrier injection and balance.[3] In addition, in order to prevent an environmental deterioration, we select the cadmium-free QD. Together with Cd-free and MSL-QLED, an inverted device structure were evaluated with metallic ZnO layer as electron injection layer.

【Experiment】Patterned ITO substrate was thoroughly cleaned using the organic cleaning solvents and UV ozone chamber under O_2 ambient. The MSL-QLED device structure is ITO (150 nm)/ ZnO (50 nm)/ polyethylenimine-ethoxylated (PEIE, <1nm)/ MSL (20 nm)/ molybdenum oxide (MoO_3, 10 nm)/ Au (30 nm). The MSL is mixed with 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP, ETM), ZnCuInS/ ZnS-based QD of emission material (EM), and 4,4'-bis(N-carbazolyl)biphenyl (CBP) of bipolar conduction material (BM). To obtain the metallic ZnO layer, ITO substrate was sputtered using the argon gas (100%) without oxygen. Here, the MSL was coated using the solution process in toluene, and the other organic materials were evaporated using the thermal evaporation technique. All the measurements were carried out in air at room temperature, and the device area was 0.04 cm^2.

【Results and Discussion】The mixing ration of the ETM: EM: BM was (100-x)/2: x: (100-x)/2, where x is the mixing ratio in weight. Basically, we have varied the weight ratio of the QD materials (x), which apparently changed the ratio of the other ETM and BM. Considering the stable operation of the device, all the parameters were evaluated at J=50 mA/cm^2. Figure 1 (a) shows, the current density (J)- voltage (V) and luminance (L)-V characteristics of the QLED. A turn-on voltage (V_t, at 1cd/m^2) was gradually increased with increase of the weight ratio of QD materials. In details, the turn-on voltage (V_t) is 2, 3 and 4 V for x value of 20, 40 and 60, respectively. The maximum luminance was observed 1,200, 1,880 and 1,450 cd/m^2 at 5.6, 7.8, and 9.8 V, respectively, for the increment of x. The current efficiency, *CE* was observed 4.2, 2.5, and 1.3 cd/A, and *EQE* 2.3, 1.2, and 0.4%, for x value of 20, 40 and 60, respectively.



(a) (b) (c)

Fig. 1: Characteristics curve of (a) *J*-*V*, *L*-*V* (b) CE-*J*, EQE-*J* (c) EL spectrum of fabricated QLED at different mixing ratios of x.

【Conclusion】 In summary, we have investigated the MSL-QLED. For the weight ratio of x = 20, the maximum luminance with higher CE and EQE was observed.

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