Effect of Hole Transport Materials on Cd-free ZnCuInS/ZnS-based QLED with Mixed-Single Layer

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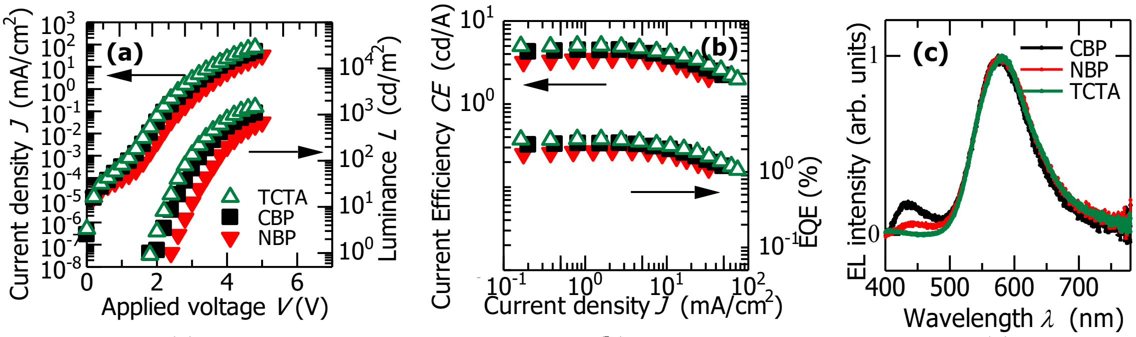
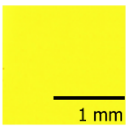
【Introduction】Quantum dot (QD) light-emitting diodes (QLEDs) is one of the eye-catching topics for researchers due to its exponential commercial growth.[1] Recently, the mentionable attributes of Cd-free QDs have created much resonance in the display industries. Considering this, researchers are trying to improve the device's performance. The performances of the QLED depend not only on the fabrication procedures but also on the device structure, particularly the use of electron transport material (ETM), and hole transport material (HTM) to balance the flow of carriers.[2] Normally, the conventional hetero-structured device is familiar for fabrication. Besides, the performance of the mixed-single layer (MSL) device is suitable for its suitable carrier injection balance into QDs, since all the materials are in mixing condition.[3] Another significant feature of MSL-QLED is that the whole QD is covered with the organic layer. This situation is better for the device using common two-mono-layered QD devices.[4] By considering this work, the flow of holes is controlled by changing HTMs in the MSL-QLED to improve the device performance.

【Experiment】First, the ITO substrate was cleaned using the organic solvents and UV ozone chamber under O_2 ambient to remove the carbon-based contamination. The MSL-QLED device structure is ITO (150 nm)/ZnO (60 nm)/ polyethylenimine-ethoxylated (PEIE, 1nm)/ MSL (20 nm)/ molybdenum oxide (MoO_3, 10 nm)/ Al (70 nm). The MSL is spin-coated with ETM, HTM and emission materials (EM), where BCP (bathocuproine) is used as ETM, and ZnCuInS/ZnS is used as EM. In addition, three popular HTMs, NPB (naphthyl-diphenylbenzidine), CBP (carbazolyl-biphenyl), and TCTA (tris-carbazole-triphenylamine) are used as the HTMs. During the sputtering, pure argon (Ar) gas was ensured to obtain the metallic ZnO layer. In addition, the substrate temperature (T_d) of 200°C was applied to increase the carrier concentration of ZnO. All the device characteristics were measured in air at room temperature.

【Results and Discussion】The mixing ratio of the ETM: EM: HTM was 40: 20: 40. Basically, we have changed the HTMs, which apparently changed the flow of holes. Considering the stable operation of the device, all 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. In detail, the turn-on voltage (V_t) is 1.8, 2 and 2.2 V for the HTM of TCTA, CBP, and NBP, respectively. The maximum luminance was observed 680, 1,080 and 1,470 cd/m^2 at 6.8, 5.0, and 4.8 V, for NBP, CBP, and TCTA, respectively. The current efficiency, *CE*, was observed at 3.5, 4.48, and 5.2 cd/A, and EQE at 1.9, 2.4, and 2.8% for the HTMs, respectively.





(a) (b) (c)

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

【Conclusion】 In summary, we have investigated the MSL-QLED with the variation of HTMs. Among them, the TCTA-based device shows the lower V_t, maximum *L* with higher *CE* and *EQE*.

【References】

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