Optimization of organic-inorganic hybrid quantum dot light emitting diode based on ZnO NPs as ETL

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In the past decade, the research on colloidal quantum dots (QDs) has been actively conducted by a number of researchers. Light emitting diode (LED) using colloidal quantum dot emitters shows the advantage of wide absorption and narrow emission spectral bandwidth. In addition, emission wavelength can be easily controlled by changing the size of the QDs during the synthesis and the solution process is available. Despite in these advantages, QD-LEDs have some issues to solve such as high turn on voltage, lifetime, low device efficiency in practicable brightness region. As an solution to this issue, metal oxide materials such as ZnO, TiO_2, MoO_x and SnO_2 as an electron transfer layer (ETL) are in the limelight. Among them, ZnO NPs have a low energy barrier with Al of cathode. It can facilitate electron injection in a LED device, an exciton can be formed by a recombination with a hole and electron in QD emitters. And the metal oxide layer can effectively prevent the injection of oxygen and moisture from the QD emitters than organics layer. Also, the ZnO NPs can reduce a turn-on voltage and improve the luminance power efficiency by Auger-assisted energy upconversion at interface between ZnO NPs and QD emitters. A number of approaches for generating electroluminescence from films of CdSe/CdS/ZnS core/shell/shell QDs have been reported, including device structures including organic, inorganic and hybrid approaches to the formation of charge transport and injection layers.

In this study, we used an organic-inorganic hybrid structure of QD-LED and compared the performance of device based on ZnO NPs and TiO_2 as commonly used metal oxide for ETL. The QDs and ZnO NPs applied to EML and ETL were synthesized using solution syntheses. A device structure is composed with ITO / PEDOT:PSS / CdSe/CdS/ZnS QDs / ZnO NPs / Al as anode / HIL / EML / ETL / cathode, respectively. As a result, we demonstrated that the device applying the ZnO NPs as ETL shows lower turn-on voltage and higher luminance than TiO_2 based device. Further, in order to improve the luminance and luminance efficiency, we insert a PVK as HTL. As a result, luminance is enhanced three times because the PVK as HTL is complements the large energy barrier between the PEDOT:PSS and QDs as HIL and EML. By using this structure, we optimized the thickness and density of ZnO NPs and obtained better performance of hybrid QD-LEDs.

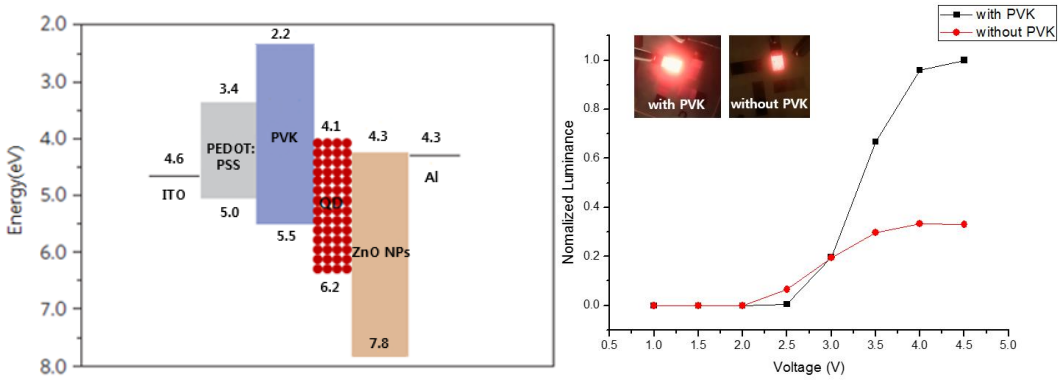

Fig. 1 Energy diagram of organic-inorganic hybrid structure and I-V-L curve

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