Improvement of Surface Shell of QD-LED Device

Zhexu Xi, Hao Li

[1]College of Chemistry and Chemical Engineering, Xiamen University, Xiamen 361005, Fujian Province

[2] College of Civil Engineering, Jilin Architectural University 130000, Changchun City, Jilin Province

Abstract

This paper introduces the concept and basic characteristics of colloidal quantum dot light-emitting diodes from the operation principle of colloidal quantum dot LED light-emitting devices and the micro-chemical principles of device structure and performance. It discusses and analyzes its processing and architecture in devices. The technology and its principle in the process of improvement, and the improvement of the microscopic importance and surface shell engineering of the surface shell of QD-LED devices.

Keywords

Colloidal quantum dot led light-emitting device; OLED; Luminescence principle; Surface shell.

1. Introduction

In recent years, the number of colloidal quantum dot light-emitting devices has increased year by year, and its external quantum efficiency has been increased from less than 0.01% to 20.5%, which has been the efficiency of organic semiconductor light-emitting diodes (OLEDs).Colloidal quantum dots as a novel nanoparticle synthesis method, with its unique advantages, such as high fluorescence quantum yield, high color purity and easy adjustment, high solution process ability, narrow and finely adjustable excitation spectrum, etc. The field of display and illumination with luminescent properties is becoming more and more widely used.With the synthesis of new quantum dots and the research on quantum dot electrolumine scence mechanism, exciton attenuation mechanism, electron transfer efficiency and device processing engineering, quantum dot-based LED performance is gradually optimized, especially surface engineering improvement process. aspect.

1 QD-LED principle of illumination

The figure below shows the structure of a classical quantum electroluminescent diode, which consists of three parts: active light-emitting layer, electron transport layer and hole transport layer.

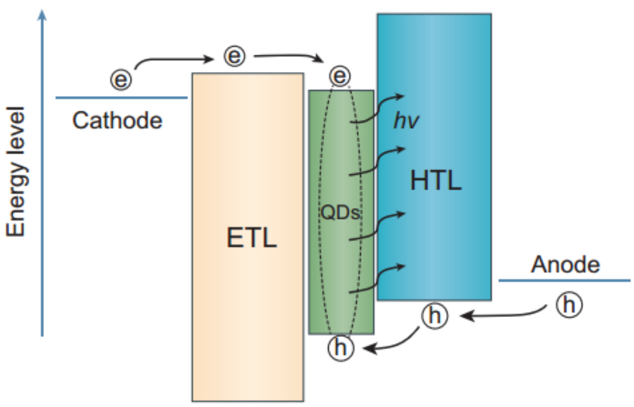

Fig.1 Schematic diagram of the structure of the classic QD-LED and a simple model diagram of the principle of illumination

Driven by the electric field, electrons and holes enter the electron transport layer and the hole transport layer, respectively, and migrate toward the intermediate active light-emitting layer.After entering the active luminescent layer, electrons enter the conduction band, holes enter the valence band, and then become excitons through interaction.After exciton recombination, energy is released by photon radiation, and radiation can be released by phonon and Auger-composited carriers.The released photons will apparently form a phenomenon in which the device emits light.

2. Surface shell improvement engineering of QD-LED devices

2.1 Microscopic importance of the surface shell

As a protective layer of the bare core structure protecting the quantum dots, the wide band gap layer acts as a protective layer covering the surface, which can enhance the electron mobility restriction and coherence, and at the same time passivate the non-radiation existing on the surface of the large specific surface area. The binding site allows the excitons to release energy in the form of photon radiation as much as possible, which is beneficial to the improvement of luminous intensity and luminous stability.

2.2 Surface shell engineering

Most of the atoms are exposed on the surface shell of the quasi-nanocrystalline structure, many of which are incompletely coordinated to free the ligand in solution, and the loss of the ligand easily causes the surface to form lattice defects and surface dangling bonds, making The probability of distribution of the radiation binding site increases, making it easy for excitons to release energy in the form of non-photons such as phonons and Auger electrons, reducing quantum efficiency.As shown in the figure below, the quantum dots can be covered with a higher band gap inorganic shell material, resulting in a core-shell structure, which can successfully confine the carriers inside the quantum dots, which can reduce the surface and O_2 and H_2. The potential reactivity of O and the probability of forming dangling bonds.

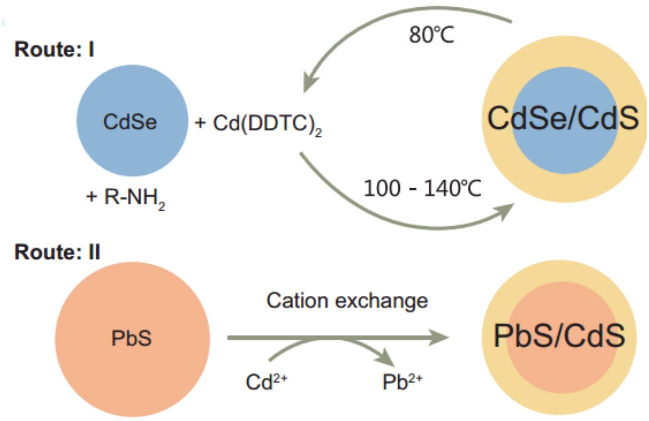

Fig. 2 Effect of CdSe and PbS core-shell model on luminescence performance in QD-LED

In order to effectively avoid the surface lattice strain and improve the carrier mobility, the shell layer and the quantum dot core should be matched as much as possible and the lattice constants should be matched.Although the well-structured core/shell structure greatly improves the stability of optical properties and reduces the crystal strain, the luminous efficiency and the thickness of the shell are not simply a simple function relationship. The excessive thickness and too thin of the shell are not conducive to luminous efficiency. Improvement.It has been found that the structure of quantum dots leads to the imbalance of electron transport and hole transport over the energy barrier. Generally, the hole injection has a higher energy level, so the hole energy barrier can be lowered to accelerate its movement or not affect the current density. Under the premise, the electron blocking layer of appropriate thickness is selected to reduce the migration speed of electrons to regain the balance of electron and hole injection.

On the other hand, it is worth noting that although a typical inorganic material such as a metal oxide is used as the hole transport layer, the luminous efficiency can be stabilized and the internal quantum efficiency can be improved, but the excessive carrier density itself tends to cause excitons to be

Excitation of non-radiative binding sites, or trapped by lattice defects on the surface of the shell layer, easily causes fluorescence quenching of quantum dots, reducing luminous efficiency and stability.

3. Conclusion

In summary, adopting the core/shell structure and appropriately adjusting the shell layer to a suitable thickness, and properly controlling the band gap width and the number of layers and the lattice matching, can effectively improve the dielectric confinement effect, and the structure of the shell surface. Optimization plays an important role.

References

[1]Lim J, Bae WK, et al. Perspective on synthesis, device structures, and printing processes for quantum dot displays [J]. Optical Materials Express, 2012, 2(5):594-628.
[2]Klar TA, Franzi T, et al. Super-efficient exciton funneling in layer-by-layer semiconductor nanocrystal structures [J]. Advanced Materials, 2005, 17(6):769-773.
[3]Hollingsworth JA, Klimov VI. Nanocrystal quantum dots 2nd edition [J]. 2010.