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Introductory Chapter: Quantum-Dots Based Organic Light-Emitting Diodes - The State-of-the-Art

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1. Promising QD-OLED technology

Organic light-emitting diode (OLED) is a light source in which a thin layer of organic material placed between two conductors that can emit light of specific color by applying electrical current. To accelerate the commercialization of organic light-emitting diodes (OLEDs) have enhanced due to their capabilities as new generation displays and lighting sources. In comparison with other display technology, OLED displays are thin, efficient, flexible and transparent. In addition, they have better contrast, higher brightness, fuller viewing angle, a wider color range, much faster refresh rates and consuming lower power, thinner, very durable and also they can operate in a broader temperature range. But they have some disadvantages too. The cost of OLED displays is still too high. They have limited lifespan and suffer from permanent image retention. If these limitations can be overcome, OLED displays can find faster growth **opportunities** in specific **display technologies**.

In recent years, the display industry is rapidly interested in the world to combine semiconductor nanocrystals or quantum dots (QDs) with organic light-emitting diode. Semiconductor nanocrystals or quantum dots (QDs) have considerable potential in assisting OLED displays and lighting to overcome their technological barriers. They are a type of nanomaterials which exhibit good optical characteristic. One of the important properties of QDs is that the absorption and photoluminescence (PL) spectra can be adjusted by their size. Consequently, the pure and tunable spectra of QDs can be conventionally obtained. Therefore, QDs can be used in photovoltaic devices, sensors and light-emitting diodes (LEDs). The smaller dimension of the QD results in shorter wavelength light emission and longer wavelength of light emitted will cause by bigger QDs. Therefore, it was believed that the next generation of OLED can be introduced by employment of this type of photonics material in manufacturing process of OLED.

Researchers all around the world try to improve this field and they found that quantum dots (QDs) can be helpful. Excellent color-rendering properties and high luminous efficiency (LE) of OLED are obtained when the combination of colloidal QDs with light-emitting diodes (LEDs) was done. QD-LEDs are the important part of the next generation of solid-state lighting and display technologies due to their great color saturation features, tunable wavelength and narrow full-width at half-maximum (FWHM). Nevertheless many developments have recently been made in display and lighting board technology and this ability was specially developed to build a very thin flexible and transparent displays; scientists have found that using some extra thin layers between two conductors and choosing appropriate materials can be helpful for better performance of QD-LEDs [1, 2]. High brightness, flexibility, efficiency with long lifetime and low processing cost of QD-LEDs makes them different from LCDs, OLEDs and plasma displays.

QD-LEDs can produce dark blacks and whiter whites and create higher brightness than OLEDs. In addition, a wider and more true-to-life color palette will be possible in QD-LEDs than in OLEDs. Because, an improvement in operation lifetime of OLED devices can be achieved by using quantum dots. Finally yet importantly, QD-LEDs are cheaper than OLEDs. Nowadays, researches try to improve efficiency of passing light through the quantum dot crystals, which can help the QD-LEDs performance [3]. QD-LEDs have some unique features such as better color accuracy, higher brightness, more stable performance and lower cost. Also, they are solution processable and suitable for wet processing techniques.

Colloidal nanocrystal-based LEDs can be classified into two main categories. In the first type of configuration, QD-doped material applied over the emitter chip and optically excited by a conventional epitaxial blue or UV LED. In the second category, the QDs themselves are directly excited by the passing of current through a QD-containing film. In QD-OLEDs, a layer of quantum dots is placed between layers of electron-transporting and hole-transporting organic materials. By applying the electric field, electrons and holes move into the quantum dot layer, recombine in QDs and emitting photons. The full width at half the maximum value of the QDs shows the width of the spectrum of emitted photons. In that case, a thin emissive layer is sandwiched between a hole-transport layer (HTL) and an electron-transport layer (ETL) to capture electrons and holes in the small region. Organic materials are used as the ETLs and HTLs, until now. The electron-hole recombination generally occurs near the cathode because organic electroluminescent material transport holes faster than electrons. Therefore, the exciton produced will be quenched. In order to prevent this event, a hole-blocking layer will be used.

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