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Quantum Dot Display Technology and Comparison with OLED Display Technology

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Abstract: QLED TV is a new television technology that is taking many of its cues from OLED TV technology. It consists of extremely small light-emitting crystals called quantum dots. Most TVs today including all of those made by companies and just about every other TV brand are based on decades-old LCD, or liquid crystal display, technology. In the past few years' Better technology and more advanced manufactured, called OLED or organic light-emitting diode. OLED TVs have the best picture quality we've ever tested, keeping LCD-only companies from achieving the coveted top positions on certain lists. At the moment a new TV display technology on the horizon called QLED, and it might be even better than OLED and LED. Short for "quantum dot light emitting devices," QLED has the potential to match the infinite contrast ratio of OLED, with better power efficiency, better color and more . In this article we will discuss about the QLED and OLED display technology.

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1. Introduction:

Quantum Dot is composed of semiconductor materials which look like a nanocrystal sphere. These nanocrystals emit light with absorbing light due to flow of electric current. The lightning wavelength differs depending on the dot size. LCD alone is not capable of emitting its own light. There should be a light source or backlight. A LED backlight used the three basic colors-blue, green, and red in order to come up with a white color light. Recently, one of the popular LED LCD colors is blue coated with a yellowish phosphor to achieve a white light color and QD LED TV is found as a more advanced version of this. The manufacturer no longer used the blue LED with yellowish phospor, but instead they use QD particles for achieving white color. The QDLED absorbs the emitted blue light then transfer it to red and green to creating the desired white color. This process is also known for achieving an accurate LED colors. OLED is composed of organic molecules made of thin films that create light with the use of electricity. This type of lightning technology is capable of creating crisper and brighter displays on electronic devices than the traditional liquid crystal displays (LCD) and light emitting diodes (LED) .

Meanwhile, the Organic Light-emitting Diode (OLED) display is made of organic compound which releases light with the presence of an electric current. The pixel is capable of emitting light on its own. It only means that this type of LED display have no issues regarding backlight leaking. Thus, Organic Light-emitting Diode is different from Quantum Dot Light-emitting Diode in terms of in expressing colors. QD LED uses LCD-based technology which is slightly difficult to consider as the next generation display. However, OLED is considered as the next generation display which is transparent, flexible and roll-able. It has relatively low processing temperature suited for a plastic substrate when you wish to make a flexible display and because it does not require a backlight as compared to QD, it can be optimized in creating a transparent generation display [1] .

2. OLED Display:

Light-emitting diodes (LEDs) have been encroaching on the long established domain of incandescent and fluorescent lighting due to their long life, intensity, and power efficiency. Certain limitations, however, have restrained LEDs from supplanting conspicuous application, particularly difficulty and cost of production. Organic Light Emitting Diodes (OLEDs) show promise of replacing liquid crystal displays (LCDs) and other lighting appliances, due to their low cost, ease of fabrication, brightness, speed, wide viewing angle, low power consumption, and contrast. The edge gained by OLEDs will facilitate further LED market permeation. An OLED (organic light-emitting diode) is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound which emits light in response to an electric current. This layer of organic semiconductor is situated between two electrodes. Generally, at least one of these electrodes is transparent. OLEDs are used to create digital displays in devices such as television screens, computer monitors, portable systems such as mobile phones, handheld games consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications Bottom or top distinction refers not to orientation of the OLED display, but to the direction that emitted light exits the device. OLED devices are classified as bottom emission devices if light emitted passes through the transparent or semi-transparent bottom electrode and substrate on which the panel was manufactured. Top emission devices are classified based on whether or not the light emitted from the OLED device exits through the lid that is added following fabrication of the device. Top-emitting OLEDs are better suited for active-matrix applications as they can be more easily integrated with a non-transparent transistor backplane. Also Silicones deliver high thermal and photo stability compared to organic materials, such as epoxies or plastics. This stability is an important consideration as LED designers increase the amount of drive current in their devices and decreases the overall size of lighting fixtures. Combined, these trends are pushing LED temperatures to 150°C and higher, which can cause conventional epoxies and plastics to turn yellow and physically degrade over time. In contrast, silicones have demonstrated reliable optical and physical performance at temperatures reaching 200°C and higher. This range helps ensure next-generation LEDs can meet and exceed the lumen maintenance requirements of challenging packaging applications. Traditionally, the view among many veteran LED designers and manufacturers was that phenyl silicones came with certain limitations when it came to thermal stability — but no more. Breakthroughs in phenyl-based silicone chemistry now enable optical silicone encapsulants to perform with exceptional reliability in the latest generation of chip-on-board LED architectures [2].

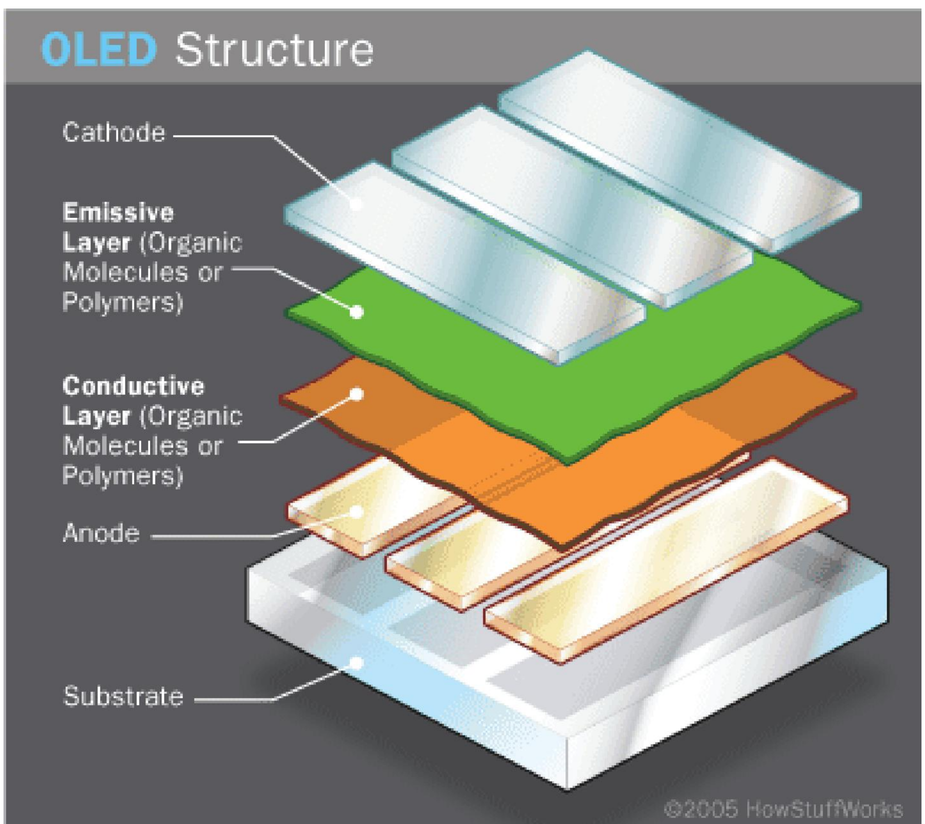

Figure 1: Oled structure: OLED components include organic layers that are made of organic molecules or polymers.(Electronics - How Stuff Works)

3. OLED Advantages: [3]
(1) The plastic, organic layers of an OLED are thinner, lighter and more flexible than the crystalline layers in an LED.
(2) Because the light-emitting layers of an OLED are lighter, the substrate of an OLED can be flexible instead of rigid. OLED substrates can be plastic rather than the glass used for LEDs.
(3) OLEDs are brighter than LEDs. Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layers of an LED, the conductive and emissive layers of an OLED can be multi-layered. Also, LEDs and LCDs require glass for support, and glass absorbs some light. OLEDs do not require glass.
(4) OLEDs do not require backlighting like LCDs. LCDs work by selectively blocking areas of the backlight to make the images that you sees, while OLEDs generate light themselves. Because OLEDs do not require backlighting, they consume much less power than LCDs. This is especially important for battery-operated devices such as cell phones.
(5) OLEDs are easier to produce and can be made to larger sizes. Because OLEDs are essentially plastics, they can be made into large, thin sheets. It is much more difficult to grow and lay down so many liquid crystals.
(6) OLEDs have large fields of view, about 170 degrees. Because LCDs work by blocking light, they have an inherent viewing obstacle from certain angles. OLEDs produce their own light, so they have a much wider viewing range.

4. OLED Disadvantages:
(1) Usually only with a lifespan of 5,000 hours; 10,000 hours lower than LCD at least.
(2) Large quantity production of large-size screens is not available. It is therefore, only applied to those portable digital products.
(3) Problems of color purity still remains: it is difficult to display fresh and rich colors.
(4) Water can easily damage OLED.
(5) Sunlight Effect: Another disadvantage of OLED display is that they are hard to see in direct sunlight. So if you have open lobbies where sunlight reaches directly, you will not get benefit of viewing these screens.
(6) Manufacturing - Manufacturing processes are expensive right now.

5. Quantum dot display: QLED means Quantum dot light emitting diodes and are a form of light emitting technology and consist of nano-scale crystals that can provide an alternative for applications such as display technology [4] . The structure of a QLED is very similar to the OLED technology. But the difference is that the light emitting centers are cadmium selenide (CdSe) nanocrystals, or quantum dots . A layer of cadmium-selenium quantum dots is sandwiched between layers of electron-transporting and hole-transporting organic materials. An applied electric field causes electrons and holes to move into the quantum dot layer, where they are captured in the quantum dot and recombine, and emitting photons. The spectrum of photon emission is narrow, characterized by its full width at half the maximum value. There are two major fabrication techniques for QD-LED, called phase separation and contact-printing. QLEDs are a reliable, energy efficient, tunable color solution for display and lighting applications that reduce manufacturing costs, while employing ultra-thin, transparent or flexible materials [5].

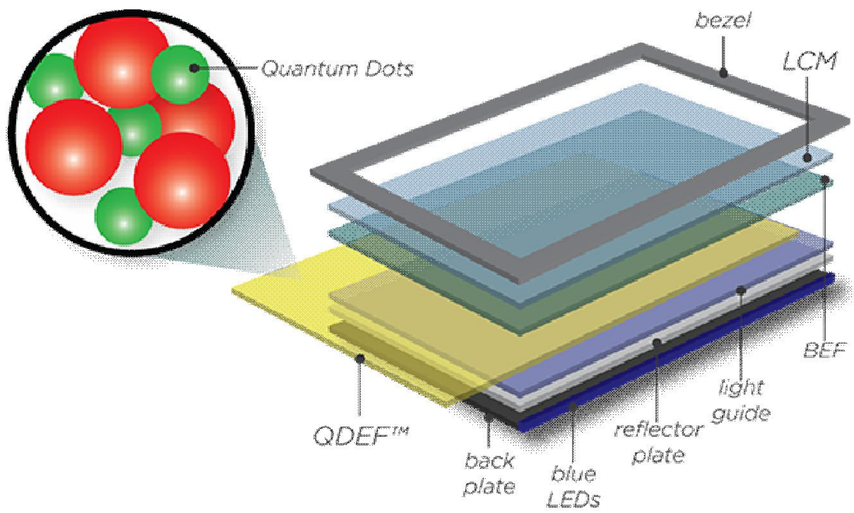

Figure 2: Quantum dot display structure (OLED-TV Displays Infos - OLED-Display.net)

Quantum Dot (QD) displays are quite different as the technology is based on small conducting nanocrystals, usually in the range of 2 to 10 nanometers in diameter. The color of light produced or filtered by a dot is based on its diameter and using a few of these could produce all your necessary colors. Like OLED, light and colors could be supplied on demand and QD-LEDs can be very bright. However, current QD displays are based on a blue LED backlight which is then filtered to a white light before passing through the familiar LCD color producing layer.

Color gamut is seen as one of OLED's big advantages over LCD, allowing for more vivid viewing experiences and accurate color reproduction, so long as the media also supports it. LCDs often fall short on color accuracy and gamut because of their reliance on a pseudo-white backlight (this is made from blue LEDs with a yellow phosphor coating). However, the highly accurate nature of Quantum Dots means that developers can use a pure blue back light and accurate red and green filters produce a true white light, which can then be filtered into better looking colors[6].

As Quantum Dot displays don't have to worry about inaccuracies in the white light, there is less compensation required in the LCD filtering layer, so manufacturers can drive up the color brightness and gamut of the display. As a result, QD LED TVs are able to match and sometimes even exceed the color accuracy of OLED panels [7] .

However, as QDs are currently reliant on a backlight, the deep black accuracy and contrast ratio will still suffer from similar drawbacks as existing LCD displays. Therefore, OLED should still win out when it comes to contrast and high dynamic range imagery, as it can switch off pixels for a pure black dot, but QD displays will still see a boost in brightness over traditional LCD [8] .

This leads us onto viewing angles, an area that OLED again boasts superiority over LCD displays and this is unlikely to change much with the introduction of Quantum Dot displays. Because backlight based displays require a filter layer rather than producing light directly on the surface, some light is blocked when you don't look at the display from head on. While perhaps not likely to be a major problem on your small mobile phone, Quantum Dot displays won't match OLED's viewing angles until designs come along that eliminate the need for a backlight [9] .

Quantum Dot LCD displays retains many of the benefits of LCD's lower production costs. The QD filter layer does not add a huge cost or complexity to the production of a display, as it is simply a mixed assortment of red and green dots rather than an intricately laid out matrix. Typically this adds no more than $100 to the cost of a large-size TV, so we are likely looking at less than $10 for a 5-inch smartphone. However these small costs aren't always accurately reflected in consumer prices and the falling cost of OLED might make QD technology a tough sell in lower cost products, where LCD is currently commonplace. Quantum Dot is certainly a viable rival to OLED, but it is more of an evolution of LCD than a likely successor to OLED panels. Both have their pros and cons, much like display types found on the market today, but Quantum Dot panels close some of the most notable gaps between the two. We are likely to see a number of high-quality Quantum Dot and OLED based devices hit the market in the coming years [6][10 -11].

6. QLEDs advantages:

(1) Pure color will deliver 30-40% luminance efficiency advantage over organic light emitting diodes (OLEDs) at the same color point.
(2) Low power consumption QLEDs have the potential to be more than twice as power efficient as OLEDs at the same color purity.
(3) Low-cost manufacture the ability to print large-area QLEDs on ultra-thin flexible substrates will reduce luminaire manufacturing cost.
(4) Ultrathin, transparent, flexible form factors QLEDs will enable designers to develop new display and lighting forms not possible with existing technologies [5].

7. Similarities with QLED and OLED technology

Quantum Dot TVThat's a good question. When we read the specifications and technological reports on QD technology they look suspiciously similar to OLED technology. For example, OLED cells do not need a backlight, are extremely thin and are based on liquid crystal cells – all traits that QD technology claims. OK maybe they are not claiming the compounds used are organic, but they must be for all these compounds and phosphors are really natural or organic substances. If we wanted to, we could call plasma TVs, organic plasma TVs due to the organic or natural phosphors used. Another similarity between the two is the claim of a flexible screen in the future. That is a claim that we heard from OLED manufacturers at the beginning as well. We've already seen .25 inch OLED TVs displayed and Sony even produced one for sale the Sony XEL-1. QD will likely be the same and no better in terms of screen or panel or layer depth capability. Energy usage on both is low due to the high efficiency of the crystals, so large displays are a good possibility for both technologies [5] [12-13].

Both OLEDs and quantum dots can also be printed onto substrate, or plastic or other materials or developed into a super thin multi-layer nanofilm. Another similarity is that the cells from both are excited (OLED) or activated (QD) by a very slight electric current. Both are extremely energy efficient in this regard. In the case of OLED TVs – they are charged by the thin film transistor backplane. For QD we don't know what the charge source will be yet but probably the same or similar for televisions. Or it could be from small LED lighting.

8. Differences with QLED and OLED

It looks like whether the color producing crystals are organic or inorganic is the primary difference. As we know, many of the first OLED had blue phosphors that only lasted about 7000 hours and we suspect the red and green phosphors were not much better. Now, those numbers have increased considerably. But OLEDs are made from rare earth materials and thus are expensive to produce as those materials become harder to get. Qds are made from inorganic semiconductor crystal substance which is one of the reason manufacturers are probably excited about the technology. It will likely be much less expensive to produce. Another difference is that OLEDs directly emit light whereas Qds conduct pass through light, thus OLEDs would theoretically have slightly better viewing characteristics in this regard from the off angle viewing perspective. Supposedly, many of the same companies that develop OLED technology are supporting QD. Sony, Samsung, LG and Sharp are rumored to be the main TV manufacturers assisting with the development of the technology [5] [14].

Result:

Though the structure of QLED is quite similar to OLED, you can easily tell the difference between the two by checking its light emitting centers which is made of cadmium selenide nanocrystals or simply called quantum dots. QLEDS are known for having less manufacturing costs and lower power consumption. QLED's manufacturers claim that QLED TVs are more power efficient than OLEDS with same color purity. When OLED hit the market, it was the absolute, most perfect TV technology ever. The type of picture quality that it produced was simply not seen with any previous technology. It can produce a wide range of colors, deep blacks, and superb contrasts that render brilliant pictures. QLED, as an improvement over OLED, significantly improves the picture quality. QLED can produce an even wider range of colors than OLED, which says something about this new tech. QLED is also known to produce up to 40% higher luminance efficiency than OLED technology. Further, many tests conclude that QLED is far more efficient in terms of power consumption than its predecessor, OLED [15].

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