QLED vs. W-OLED: TV Display Technology Shoot-Out

This year's display product introductions—from CES 2017 to the most recent IFA 2017 event—are pointing towards the fact that display technology is poised for evolution. There are two competing technologies that display manufacturers have been using to take the picture quality to the new heights: QLED and OLED.

While the technologies are using similar acronyms, their working principles differ substantially.

With the abundance of marketing materials around both, it could be hard to see the forest for the trees. Samsung Display team set out to take a step back from the advertising jargon and "look under the hood" to help you truly understand what solution best suits your industry and application.

First and foremost, let's get the nomenclature straight.

QLED – Quantum Dot LED

QLED stands for Quantum Dot Light-Emitting Diode, also referred to as quantum dot-enhanced LCD screen. While similar in working principle to conventional LCDs, QLEDs are using the properties of quantum dot particles to advance color purity and improve display efficiency. Quantum dots are integrated with the backlight system of the LCD screen, most commonly with the help of Quantum Dot Enhancement Film (QDEF) that takes place of the diffuser film. Blue LEDs illuminate the film, and quantum dots output the appropriate color, based on their size.

OLED – Organic LED

OLED stands for Organic Light-Emitting Diode, which is self-emitting. Not all OLEDs are using the same tech though. The OLED technology used in phone screens is RGB-OLED, which is completely different from the White OLED (also referred to as W-OLED) used in TVs and large format displays.

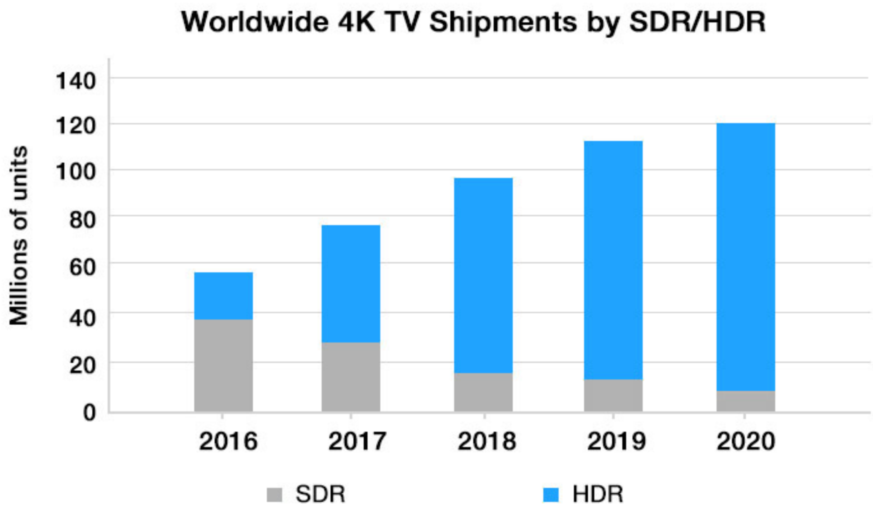
RGB-OLED vs. White OLED

RGB-OLEDs use individual sub-pixels emitting red, green, and blue light. RGB-OLEDs yield excellent color reproduction but are unfit for performance requirements of large format displays. With the evolution of materials and a difference in use cases comparing to TVs, RGB-OLED is a preferred technology for the smartphone use.

White OLEDs, in turn, emit white light, which then is passed through a color filter to generate red, green, and blue—similar to how LCDs function. Modern W-OLED color filters use RGBW (red, green, blue, white) structure, adding an additional white sub-pixel to the standard RGB to improve on the power efficiency, enhance brightness, and to mitigate issues with the OLED burn-in. Although having more complex circuit requirements than LCDs (emission is current-driven rather than voltage-driven), W-OLEDs can be utilized for large-scale displays.

Pros and cons – Q-LED vs. W-OLED shootout

Now as our terminology i's are dotted, let's frame the comparison correctly in the context of large format displays. As the demand for high-end displays featuring both high dynamic range (HDR) and wide color gamut (WCG) continues to grow, let's look at key display characteristics that would most likely affect the purchase decisions to get a comprehensive view on these technologies.



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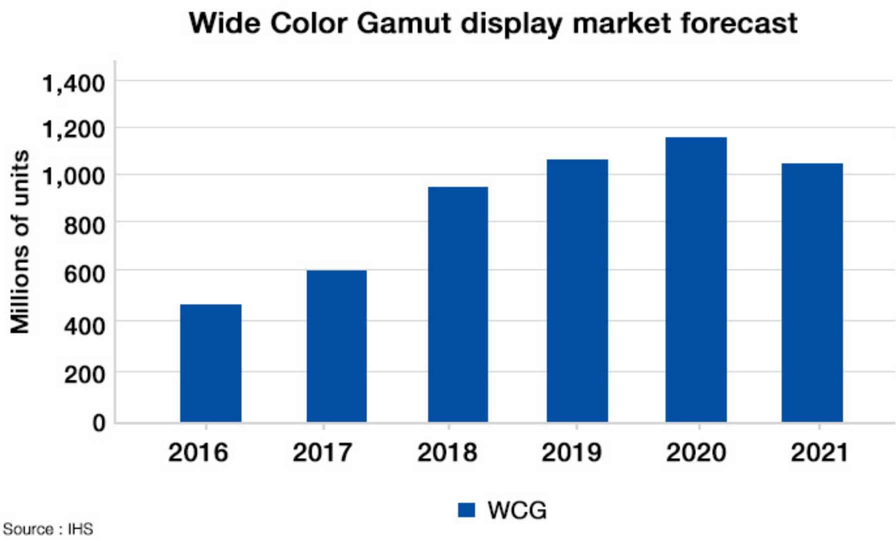

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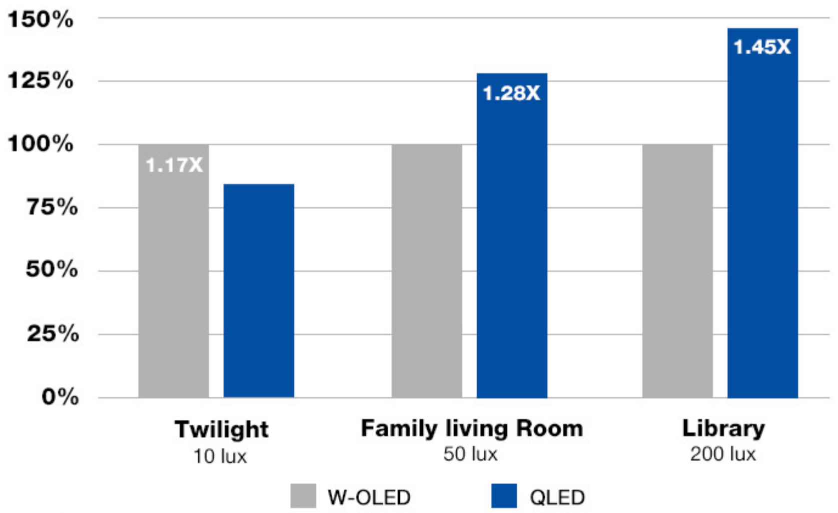
Contrast ratio

Contrast is measured as the ratio between the darkest (black) and the brightest (white) points of the screen. Due to the nature of its technology, W-OLED achieves perfect black levels, as the pixel can be completely turned off rather than blocking the light as in QLED. While local dimming technologies vastly improve the contrast ratio in QLED displays, W-OLED outperforms QLED on the black level scale.

Nevertheless, common viewing environments are never located in complete darkness—reflected ambient light typically affects the contrast ratio. Therefore, display performance is dependent more on peak luminance and reflectivity, rather than black level alone. This is where the concept of the **effective contrast ratio** comes into play. It's calculated as:

Effective Contrast Ratio = Lmax / (Lmin + Lreflected),

where Lmax is peak luminance, Lmin is minimum luminance, and Lreflected is reflectivity.



Source : Nanosys

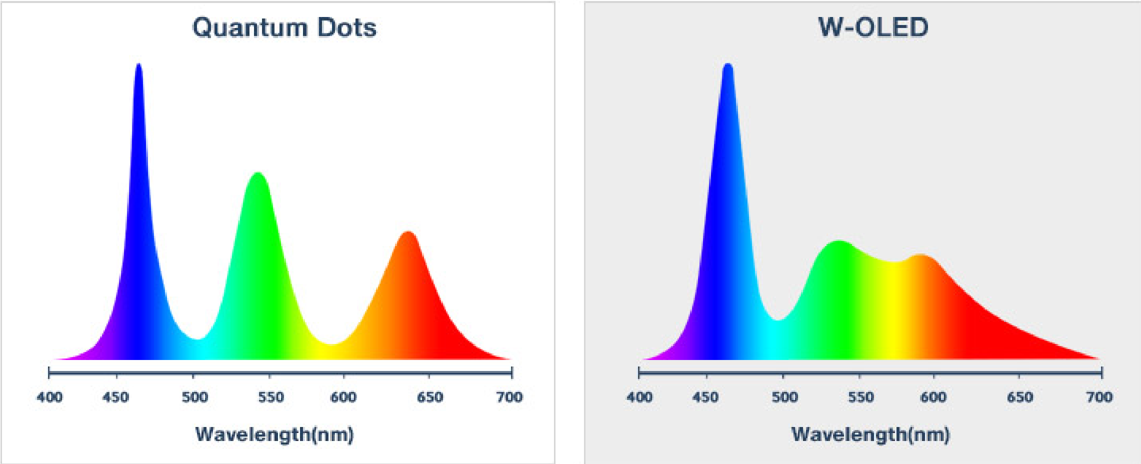
When comparing QLED and W-OLED effective contrast ratios, you can see that W-OLED performs 17% better in complete darkness. QLED screens, however, outperform W-OLED under normal (by 28%) and high brightness (by 45%) conditions.

Color volume

Color volume is the measure of the color precision describing the color capacity of a display at all luminance levels, aggregating color gamut and luminance scales.

We have previously discussed the importance of the broad spectral output (wide color gamut) and balance between chrominance and luminance components. If a display is measured on the color gamut or peak luminance specifications alone, it will only tell a part of the story as varying luminance levels have a big effect on how colors are displayed. Accurate reproduction of HDR content requires highly saturated and very bright color.

Here is how the spectral outputs of QLEDs compare to W-OLED:

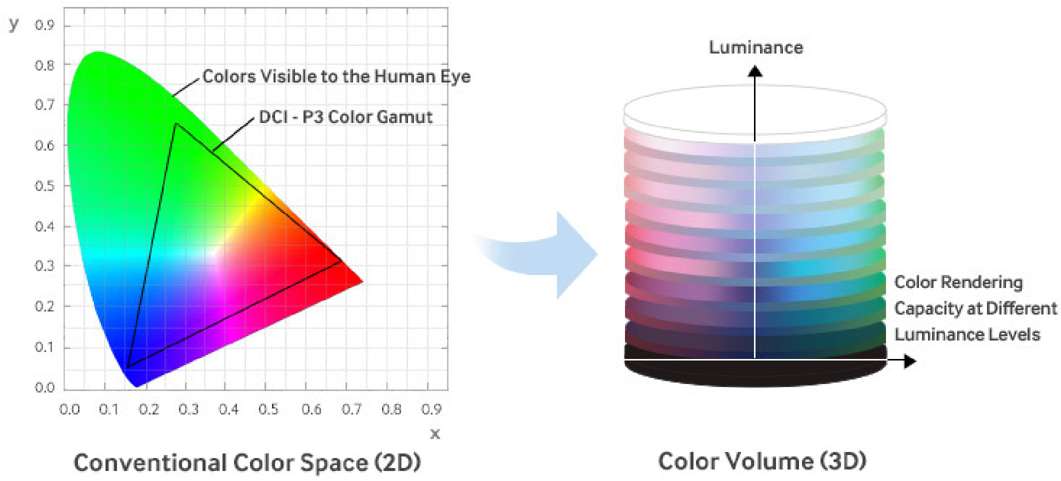


Source : Nanosys

W-OLEDs can deliver HDR, but only on a lower brightness scale. [Peak OLED brightness of OLED displays is about 700 nit], while LCD HDR screens can exceed 2,000 nit. The RGBW pixel structure is precisely what constraints the OLED displays' ability to reproduce color volume at high brightness levels.

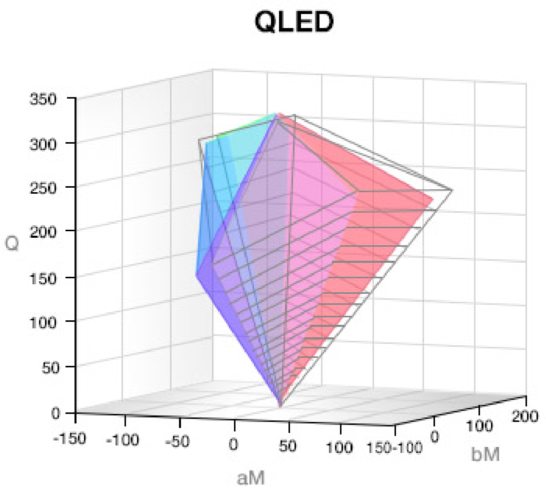
Only quantum dot enabled devices deliver both high color saturation and high brightness (simultaneously).

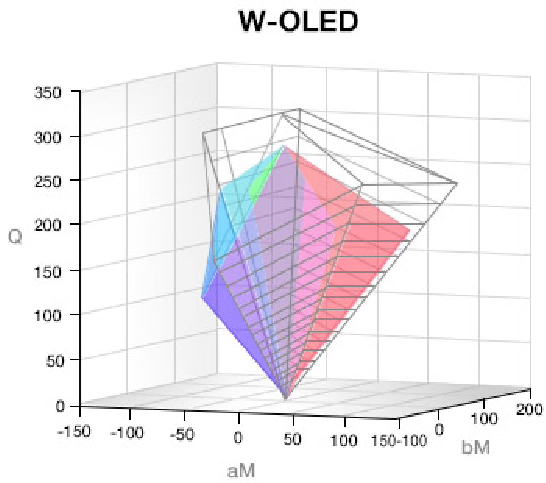
Today [QLED TVs deliver higher percentage of color volume], which means that these screens can display [nearly all colors of DCI-P3 color space] regardless of the level of brightness. This guarantees the HDR content can be displayed as intended.



Source : Samsung Newsroom

Let's see how specific models from each technology perform in terms of key specifications.





Source : Nanosys

Technology	QLED	W-OLED
Model	Samsung KS9800	LG B6
DCI-P3 coverage	96%	97%
Peak luminance	1,468 nit	700 nit
Volume color reproduction capability (VCRC)	2,843,268	1,985,651
Color volume: % of DCI-P3 at 1,000 nits	84%	58%
Average full-screen luminance	573 nit	131 nit
Power	299 W	243 W
Efficiency	2.2 nit/W	0.6 nit/W

Durability

Reliability and longevity are of a concern to customers, especially when the devices are used in commercial settings. As large format displays are usually employed in professional environments and need to be on for extended periods of time, the question of durability is certainly among the primary considerations when looking into the choice of the display technology.

One of the major concerns about OLED display performance is the burn-in issue, which has been debated within professional AV communities since the launch of the technology. Burn-in is the term for a permanent image retention (or sticking), occurring when a static image is left on the screen for extended periods of time, particularly at peak brightness.

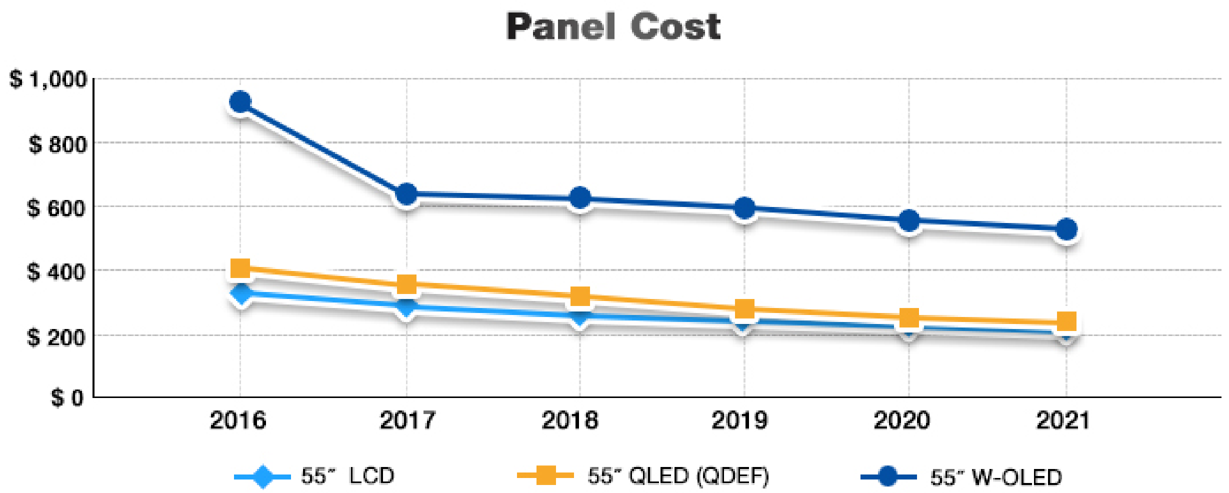
Burn-in is characterized by permanent discoloration of the panel, "ghosting" images, or fading colors.

When OLED screen is displaying a static image for a while, particularly in high brightness, the pixels in these parts of the display will degrade faster, often causing image retention and sometimes permanent damage.

Costs

Both QLED and W-OLED are quite expensive to enter the mass market just yet. Depending on the model, prices range from $2,500 to $6,000 for QLED TVs (max size 110") and $2,300 to $8,000 for W-OLED (max size 77") models. How soon will these prices come down in order for these TVs to make it in an average household? This will be determined by the manufacturing capacity and cost efficiencies that panel makers are able to achieve in the near future in order to make the mass production profitable.

Let's take a look at the research conducted by Display Supply Chain Consultants (DSCC). We'll examine the panel costs for the most popular size screens: 55".



Source : DSCC

As the data demonstrates, significant manufacturing cost gap will continue to exist between W-OLEDs and QD-LCDs through 2021. This is largely due to W-OLED's inability to achieve economies of scale. Currently, there is only one panel maker who is producing large format W-OLEDs on scale. DSCC projects that a W-OLED vs. QLED manufacturing cost (about $600 today) will be sustained all the way into 2021 (at least will remain $323 more).

DSCC also reports that the cost premium currently observed between conventional LCDs and QLEDs will narrow from today's 25% to only 4% by 2021. Higher manufacturing capacity and higher production volumes of LCDs will facilitate the sustained cost advantage.

Conclusion

Whether QLED or W-OLED technology will prevail in the high-end display market will be determined over the next few years based on the performance and cost. Although a few manufacturers are betting on OLED, Samsung and many other prominent brands, such as Vizio, Hisense, and TCL are investing in quantum dot-enabled LCDs to deliver on HDR requirements.

Specific viewing environments and user preferences will determine what type of display is best suited for each particular situation. When it comes to the mass adoption, the prognosis for QLED is much brighter—both because of the outstanding visual performance and due to the economies of scale that LCD market already enjoys.