Quantum Dots: Enabling the Full UHD Experience

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The Ultra High Definition (UHD) video format, as defined by the Blu-ray Disc Association, includes a number of significant visual experience improvements over Full High Definition (FHD) video. These include not only higher resolution, but also Wide Color Gamut (WCG) with support for BT 2020 and High Dynamic Range (HDR) with support for minimum 750 nit peak luminance.[1] The combination of WCG and HDR is key to reproducing a life-like visual experience as bright, highly saturated colors, such as flames, are often found in the natural world. Due to technology challenges, until recently, WCG and HDR features were only found on expensive, premium-class devices. Quantum Dot technology offers consumer electronics manufacturers a cost-effective path to enable all three of UHD's next generation video features across a wide range of devices today.[2]

To demonstrate the performance of LCDs using Quantum Dots, we retrofitted a 65 inch full-array direct-lit 4K LED TV which is capable of local dimming. The original panel was a standard BT 709 display with white LEDs. We made only two changes to this display: replacing the white LEDs with blue LEDs and replacing the bottom diffuser with a sheet of Quantum Dot Enhancement Film (QDEF). With only these changes the device was able to support both WCG and HDR requirements for the UHD video experience.

UHD requires BT 2020 color gamut, the ultra-high color gamut standard BT 2020, in which the color primaries are on the color locus of the CIE (Commission Internationale de l'Eclairage) 1931 diagram, was originally defined for laser-based projectors.[3] Because of its deeply saturated color coordinates, Rec. 2020 is beyond the capabilities of today's cutting-edge organic LEDs. We achieved a color gamut covering 90% of BT 2020: see Figure 1. In particular, the red and green primaries are very close to those of the BT. 2020 color standards, both lying within 0.02 in the u' and v' coordinates of an x-y grid in which the visible spectrum is mapped. The blue primary, off by less than 0.03, lies furthest from the color standard.

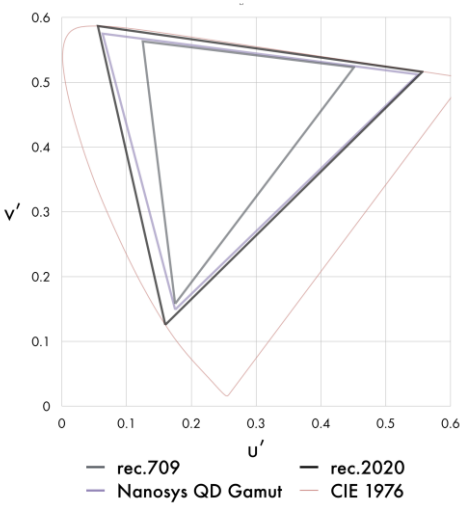

Figure 1: Color Gamut

HDR requires significantly higher peak luminance than today's Standard Dynamic Range (SDR) devices are able to reproduce. A good rule of thumb is a minimum of 750 nits is required or approximately 350 nits greater than a typical LCD TV on the market today. In our demo set, QDEF combined with full-array LED backlight, was able to achieve peak luminance of 800 nits with significantly brighter primaries as shown in Table 1 below, while still able to display a perfect black (0.01 nit) in a normal lit indoor viewing environment.

Table 1: Luminance (nits) of Nanosys QD display by color

White	Red	Green	Blue
806	86	552	168

References (to be updated)

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2. J. Van Derlofske, J. Hillis, A. Lathrop, J. Wheatley, J. Thielen, G. Benoit 2014. "Illuminating the Value of Larger Color Gamuts for Quantum Dot Displays." SID Symposium Digest of Technical Papers. Volume 45, Issue 1. Pp. 237-240
3. Kenichiro Masaoka, Yukihiro Nishida, and Masayuki Sugawara Designing display primaries with currently available light sources for UHDTV wide-gamut system colorimetry http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-22-16-19069