Redesign of commercial color filters for color enriched LCD displays

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Having as much as different colors on displays is the main aim for a high color gamut LCD. Using conventional backlight systems, a blue LED with a YAG phosphor layer implemented onto it, a high portion of CIE 1931 color space is missed [1,2]. Not only broad emission spectrum of Yttrium Aluminum Garnet (YAG) for yellow light, but also crosstalk of commercial RGB color filters have huge impact of that result. Using quantum dots (QDs) which are promising backlight agents in terms of color quality can increase the number of different colors on displays thanks to their narrow emission spectra, ease in controllability of optical properties and high photoluminescence efficiency [3:5]. However, when it comes to the color filters, broad transmission spectra and crosstalk between those spectra reduces the quality [6]. In this study, we design, simulate, analyze a QD based backlighting system and compare it with conventional phosphor based white light. Simulating both yellow phosphor based LED and QD based LED in software, we engineer spectral parameters i.e. full width at half maximum, peak emission wavelength and intensities of emitters. Furthermore, we investigate the effect of commercial color filters on those two systems and propose a new, industrially appropriate color filter spectra. Using QD based backlight increases the NTSC color gamut area from 65-70% to 127% with more than 99.8% coverage and the negative effect of commercial color filters, around 15% that reduced the gamut ratio to 109%, is balanced with suggested spectral transmission parameters of RGB color filters for QD based backlighting systems.

References:

[1] Ozdemir M., Genc S., Ozdemir R., Altintas Y., Citir M., Sen U., Mutlugun E., and Usta H., “Trans–cis isomerization assisted synthesis of solution-processable yellow fluorescent maleic anhydrides for white-light generation,” Synthetic Metals, 210, 192-200 (2015).
[2] Jang H.S., Hang J.H., Won Y.H., Lee S., and Jeon D.Y., “Mechanism for strong yellow emission of $Y_3Al_5O_{12}:Ce^{3+}$ phosphor under electron irradiation for the application to field emission backlight units,” Appl. Phys. Lett. 90, 071908 (2007).
[3] Erdem T., and Demir H.V. “Color science of nanocrystal quantum dots for lighting and displays,” Nanophotonics 2(1), 57–81 (2012).
[4] Luo Z., Chen Y., and Wu S.T., “Wide color gamut LCD with a quantum dot backlight,” Opt. Express 21(22), 26269–26284 (2013).
[5] Altintas Y., Genc S., Talpur M.Y. and Mutlugun E., “CdSe/ ZnS quantum dot films for high performance flexible lighting and display applications,” Nanotechnology, 27, 295604 (2016).
[6] Genc S., Uguz M, Yilmaz O., and Mutlugun E., “Rec.2100 color gamut revelation using spectrally ultranarrow emitters,” Opt. Eng., 56(11), 115106, (2017).