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RESEARCH HIGHLIGHT

A low-cost route toward a vivid display with striking colors and high efficiency

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If you have ever compared the image quality of a laser display and a liquid-crystal display side by side, you might never forget the striking color images from the laser display, which has a color gamut >140% of the standard of the National Television Standards Committee of USA (NTSC). However, the laser display is expensive and bulky in size. Can we expect a vivid display product that is inexpensive, lightweight, flexible, portable, self-emitting, highly stable and highly efficient? Quantum dot light-emitting diodes (QLEDs) would be the best answer. In *Nature*, Jin and colleagues[1] described how a high-performance QLED can be produced through a solution process. The team has fabricated a high-performance, solution-processed red LED that is superior or comparable to state-of-the-art vacuum-deposited organic red LEDs in terms of color purity, quantum efficiency and operational lifetime.

Solution-processed QLEDs have been investigated owing to the advantages of low-cost fabrication and their compatibility with flexible substrates.[2] However, the overall performance of the QLEDs was inferior to that of the organic LEDs. Jin and Peng's team[1] made great progress in device fabrication. Their deep-red QLEDs exhibit not only a saturated color peak at 640 nm with a full-width at half-maximum (FWHM) of 28 nm corresponding to Commission Internationale de l'Eclairage (CIE) color coordinates of (0.71, 0.29) but also high external quantum efficiencies of up to 20.5% and a long operational lifetime of >100 000 h at 100 cd m^{-2}. There are two important 'tricks' for their success. One trick is the synthesis of phase-pure zinc blend CdSe–CdS core shell quantum dots with 10 monolayers for the CdS shell, which possesses a photoluminescence quantum yield of >90%. The other is the insertion of an insulating layer polymethylmethacrylate between the quantum dot layer and an oxide electron-transporting layer that can balance charge recombination in the device and preserve the outstanding properties of the quantum dots.

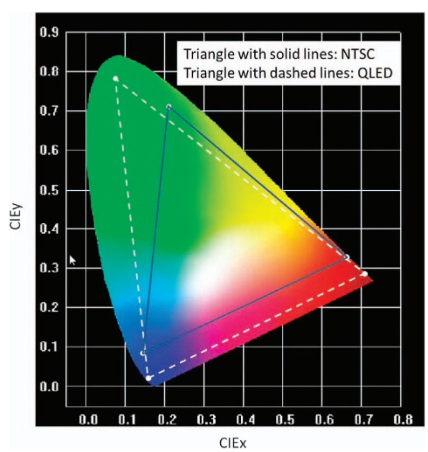

Figure 1 Color gamut formed with the red[1], green[3] and blue[4] QLEDs.

These fabrication techniques present no fundamental obstacles to the improvement of green or blue QLEDs. Recently, both high-efficiency green QLEDs (at 516 nm, FWHM of 21 nm and CIE ~(0.08, 0.78))[3] and deep-blue QLEDs (at 452 nm, FWHM of 31 nm and CIE ~(0.153, 0.027))[4] have been reported. If we draw the CIE coordinates according to the above-specified red, green and blue colors, we can see the color gamut shown in Figure 1. Once the overall performance of the green and the blue QLEDs can be further improved similar to that of the red QLEDs, a high-efficiency and vivid display with a striking color gamut of >140% of NTSC can certainly be obtained. This extremely high-performance QLED could also be potentially useful as high-efficiency solid-state lighting.

1 Dai, X., Zhang, Z., Jin, Y., Niu, Y., Cao, H., Liang, X., Chen, L., Wang, J. & Peng, X. Solution-processed, high-performance light-emitting diodes based on quantum dots. *Nature* **515**, 96–99 (2014).
2 Choudhury, K. R., Song, D. W. & So, F. Efficient solution-processed hybrid polymer-nanocrystal near infrared light-emitting devices. *Org. Electron.* **11**, 23–28 (2010).
3 Lee, K.-H., Lee, J.-H., Kang, H.-D., Park, B., Kwon, Y., Ko, H., Lee, C., Lee, J. & Yang, H. Over 40 cd/A efficient green quantum dot electroluminescent device comprising uniquely large-sized quantum dots. *ACS Nano* **8**, 4893–4901 (2014).
4 Lee, K.-H., Lee, J.-H., Song, W.-S., Ko, H., Lee, C., Lee, J.-H. & Yang, H. Highly efficient, color-pure, color-stable blue quantum dot light-emitting devices. *ACS Nano* **7**, 7295–7302 (2013).

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