Ink-jet Printing Perovskite Emissive Color Filter for Liquid Crystal Display

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Advanced color converting materials such as quantum dots (QD), quantum rods (QR) and perovskite nanoparticles (PNP) are predicted to lead the next generation of display with the concept of photoluminescence color filters (PLCF). PLCF is functional in various displays, including LCD, OLED, mini-LED and μLED. By replacing conventional broadband color filter, problem of spectrum crosstalk is eliminated. So for LCD, it further improves color performance in comparison to LCD with PNP or QD composite color enehancement film at the bottom with passive color filter on top. In regard of efficiency, PLCF could remove the absorption loss of traditional CF for LCD. And color down-conversion could solve efficiency problems for full color μLED display, where "green-gap" and turn-on voltage discrepency exsits which makes integrating individual RGB μLED on one chip quite complicated and inefficient.

However, it's not easy task to truelly fullfill this conception. Several obstacles are on the way concerning about pixel patterning techniques and optics design. Micro-contact printing, nanoimprint, IJP, and photolithography are three of the most popular fabrication methods of patterned arrays. They are generally speaking prospective techniques for mass production beacause of the scalability and low cost. But none of them is proved to be good enough to complete this task. IJP allows more material flexibility for ink to solve material stability and poor PL property issues. But it is hard to insure a jettable ink, uniform pattern without coffee-ring problems and stable film all together. Besides, the minimal printed PNP pattern size are above 90μm, limiting the display resolution. And what's more, bank structures are always deployed to confine the ink spreading on the substrate to make fine patterns. But bank means additional processing and it will increase the cost. Up to now, a multi-color ink jet printing using perovskite with good pattern uniformitiy, good stability and acceptable resolution has not been reported yet.

In this article, we use green $CsPbBr_3$ nanoparticles and red CdSe quantum rod (QR) to make full color emissive color filter. The patterned PNP and QR matrix was fabricated by ink-jet printing to a porous polyethylene terephthalate (PET) film. Due to the strong capilary force of the sub-micron pores in the template, the printing pattern was free of coffee-ring effect. And the minimal printing dot size is as small as 40μm (printing nozzle diameter ~ 21.5μm) without using any bank structure.

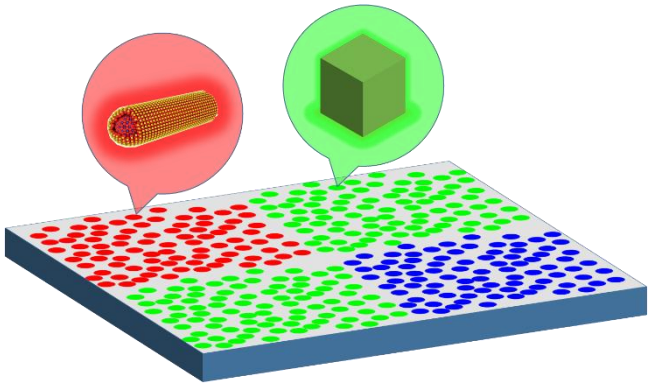

Figure 1. Illustration of ink-jet printing perovskite/quantum rod color filter in porous film

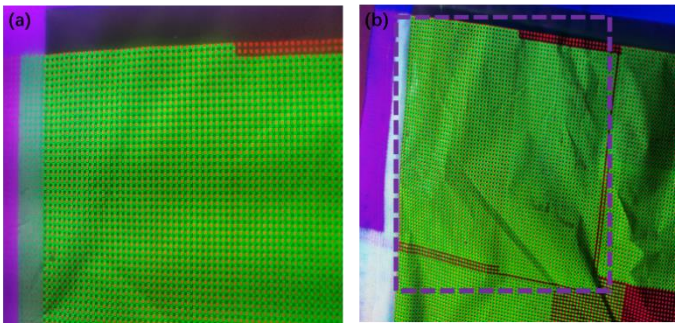

Figure 2. Photos of a full color printed film under UV excitation at different time (a) freshly printed. (b) after stored in ambient environment for 4 months.

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