Display Application Technology Development Trend of Quantum Dot

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2-2 Application to LCD backlight

2-2-3 Color conversion material for Mini LED backlight

- The emission spectral width and conversion efficiency of phosphors (e.g. KSF) and QDs (CdSe, InP, Perovskite) as green and red color conversion materials are plotted in Figure 1. The spectral width corresponds to color purity and the conversion efficiency to luminance (or power consumption if luminance is constant). The figure shows that phosphors are superior to QDs such as InP and CdSe in terms of power consumption, but in Green, Perovskite has almost the same power consumption as phosphors and much better color purity. On the other hand, for Red, KSF is superior in both color purity and power consumption. *
- Figure 2 shows which combination of Green and Red is superior in terms of Rec2020 coverage and luminance, with Perovskite for Green and KSF for Red being the best combination.

Fig. 1 *

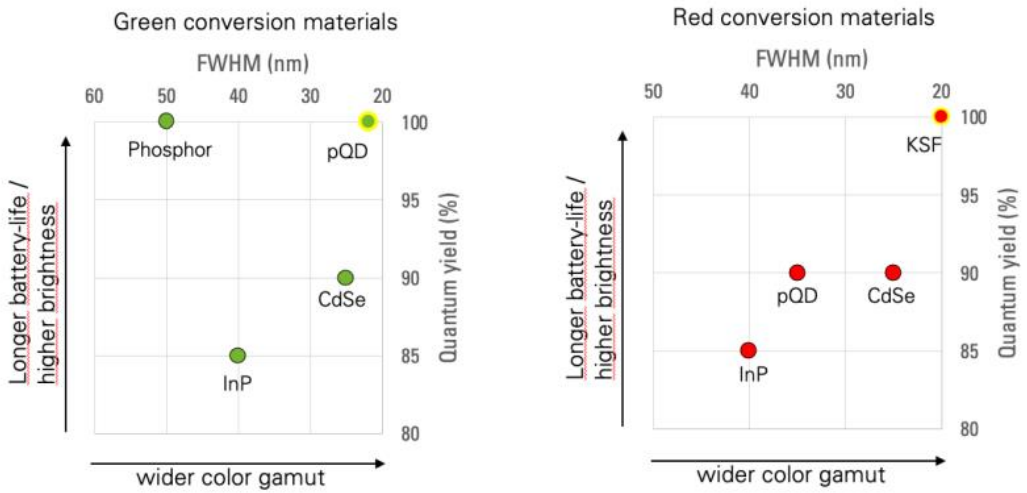
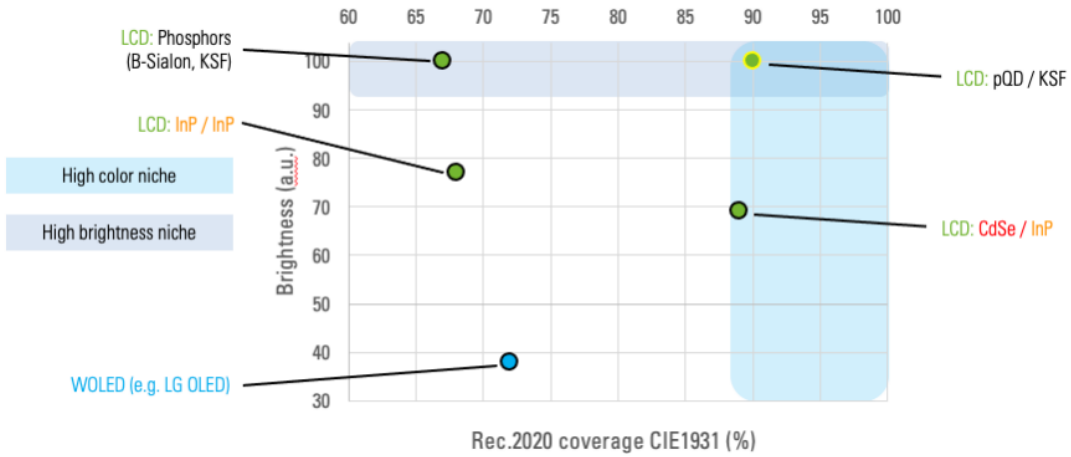


Fig. 2 *



* Norman A Luechinger SID2022 Digest 26-2 p299

2-3 In-Pixel Color Conversion

2-3-5 Micro LED microdisplay In-Pixel color conversion

❖ Patterning by photolithography

- In the photolithography of QDs, where photoresist is applied and developed on the QD film, there is a risk of damage to the QD film during the process. A solution-based process using dibenzophenone (DiBP) was developed by Sungkyunkwan Univ. as a method to prevent this and reported in IDW2023. *
- When InP and DiBP in chloroform are applied by spin-coating as shown in Fig. 1 and exposed to UV light, DiBP generates ketyl radicals, which interact with InP to form cross-links. This is illustrated in Fig. 2, where the ketyl radicals generated form new C-C bonds by C-H insertion reactions in the presence of a neighboring QD ligand to form a cross-link.
- The Green InP pattern produced by this process is shown in Fig. 3. The size of the pattern is 50 μm.

Fig. 1

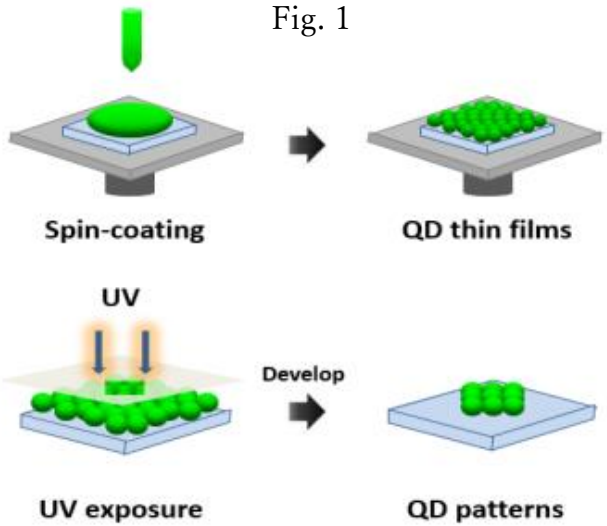


Fig. 2

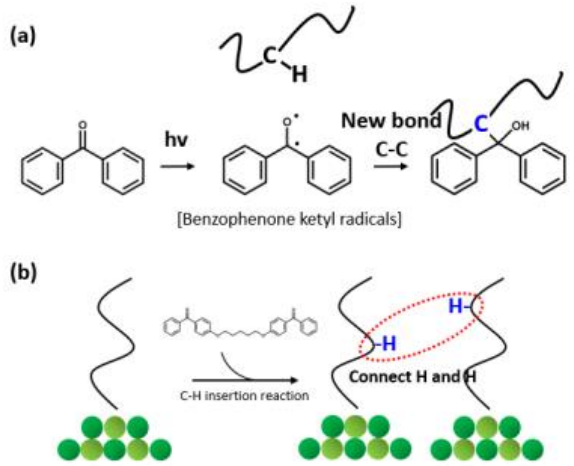
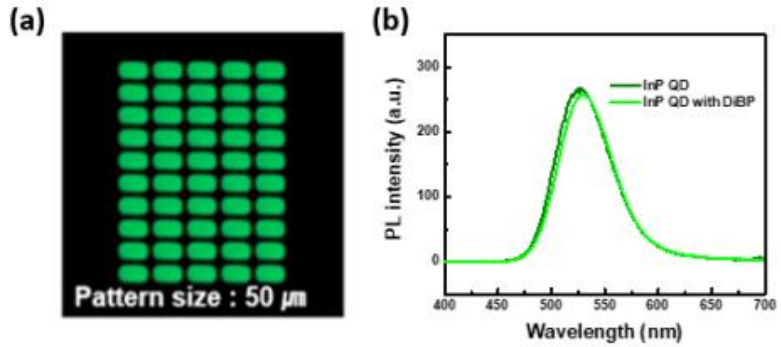


Fig. 3

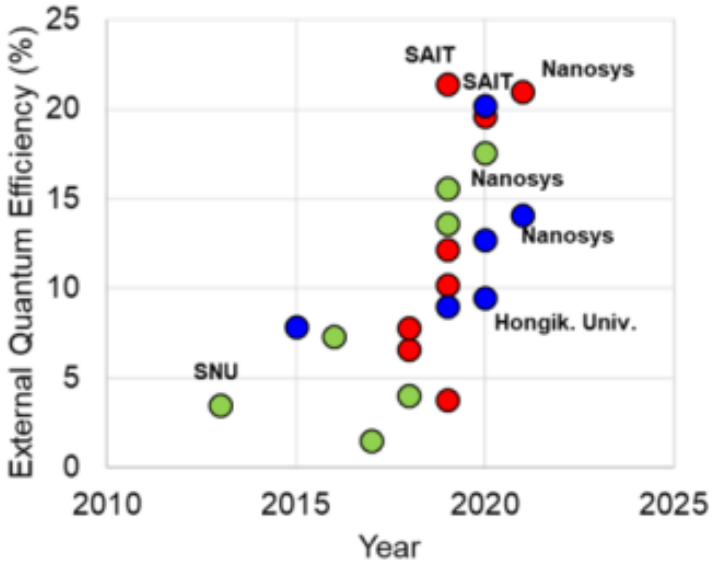


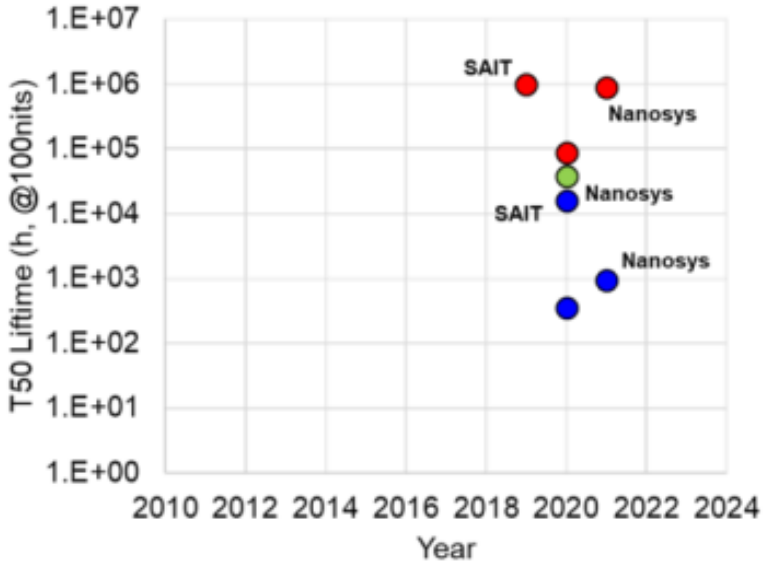
* Boram Kim et. al. IDW2023 Digest FMC11-2L p404

3-2 Evolution and Current Status of QD-LED Characteristics

3-2-3 Evolution of non-Cd QD-LED characteristics

- Samsung Display presented All Inkjet QD-LEDs using InP QDs at SID2022, in which the evolution of EQE and lifetime of non-Cd QD-LEDs is summarized in the diagram below. *
- Nanosys has produced good properties, but SAIT (Samsung Advanced Institute of Technology) has also reported comparable properties.





* Myoungjin Park et. al. SID2022 Digest 3-3 p5

3-5 QD-LED Device Structure

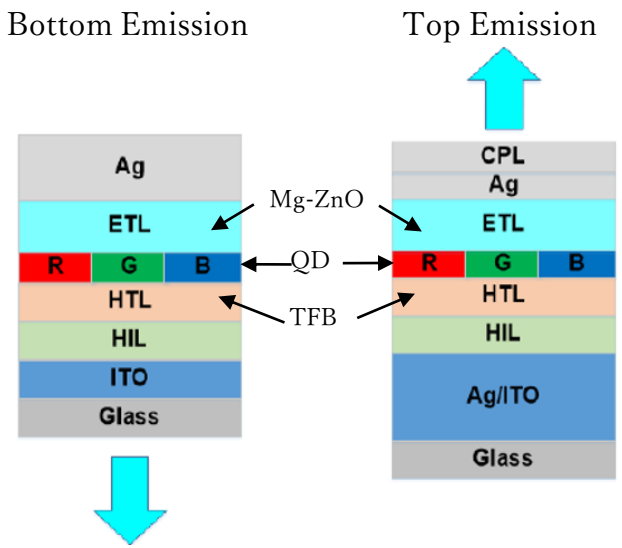
3-5-4 Top Emission

❖ Strong cavity & RGB

- TCL used CdZnSe/ZnS-based Core/Shell type QDs for all RGB colous, which were reported at SID2021 as Top Emission devices in comparison with the characteristics of Bottom Emission devices. *
- The characteristics of the normal stack Bottom Emission QLED made with the configuration shown in Fig. 1 are summarized below. This characteristic can be said to be almost equivalent to that of solution process OLEDs.
- The current efficiency of the Top Emission QLEDs is compared in Fig. 2. The current efficiency of Green and Blue TE-QLEDs improved by 1.8 and 1.5 times respectively. The practical lifetime of the Red and Green Top Emission QLEDs was comparable to that of the Bottom Emission QLEDs.

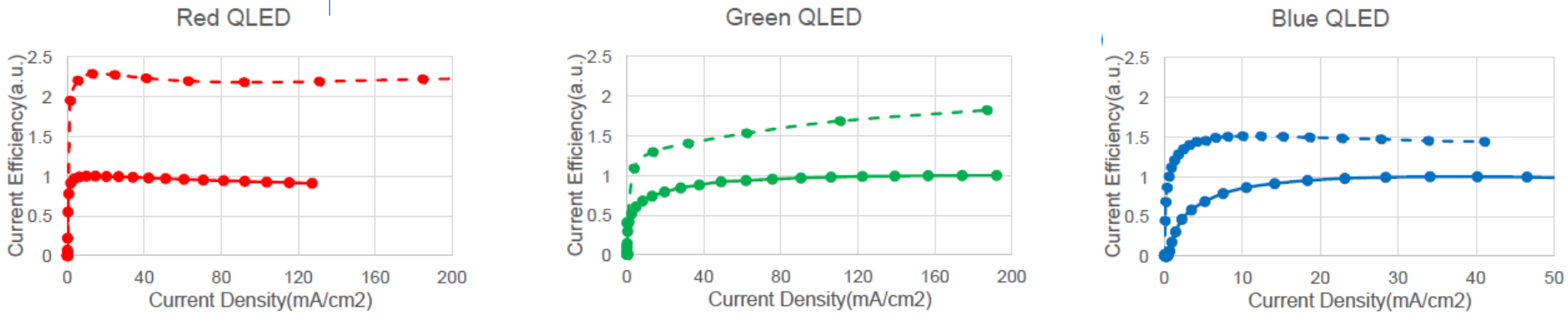
* Wenjin How et. al. SID2021 Digest 63-1 p.920

Fig. 1



	R	G	B
Current Efficiency (max)	20 Cd/A	80 Cd/A	8 Cd/A
LT95@1,000Cd/m	4,000 h	7,000 h	200 h
FWHM	22 nm	23nm	22nm

Fig. 2



3-6 QD-LED Process

3-6-3 EHD (Electro Hydro Dynamic) Printing

- Unlike piezo inkjet printing (IJP), EHD Printing can dispense droplets 2 to 5 orders of magnitude smaller than the nozzle diameter (i.e. in the range 0.001 to 10 pL) due to the high electrostatic force between the nozzle and the substrate as shown in Figure 1. Furthermore, whereas piezoelectric inkjets can dispense ink viscosities in the range of 1-30 mPa.s, EHD Printing can dispense a wide range of ink viscosities from 1-10,000 mPa.s, which significantly reduces the restriction on the concentration of QDs in the ink.
- Fraunhofer reported at SID 2023 the results of EHD Printing using QD/organic nanohybrids in which InP/ZnSe/ZnS QDs are integrated with semiconductor polymers with thiol functionality. *
- As shown in Figure 2, EHD Printing resulted in 5 μm pitch printing. (a) Fluorescence micrographs of a QD/organic nanohybrid and (b) a TFB used as HIL printed at 5 μm pitch.

Fig. 1

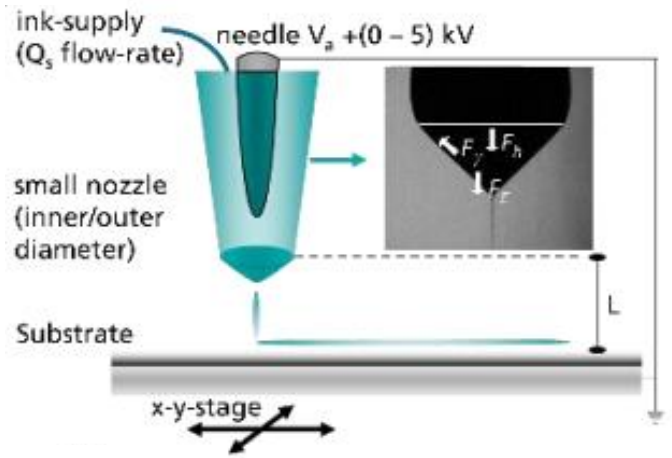
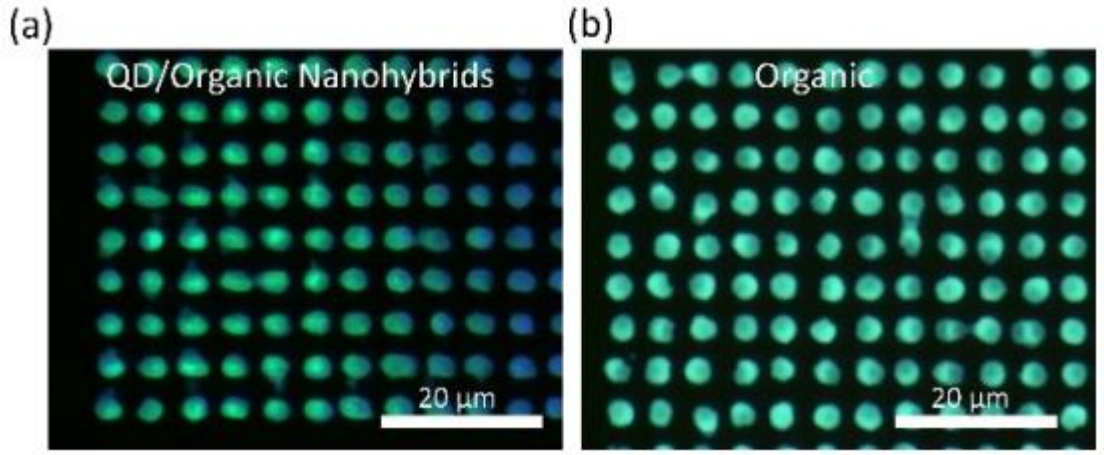


Fig. 2



* Yohan Kim et. al. SID2023 Digest 69-4 p.982