Supporting Information

A Direct Photolithography Strategy for Full-Color QLEDs via a Bisazide Crosslinker

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Chemicals and reagents

4-azido-2,3,5,6-tetrafluorobenzaldehyde was purchased from Extension Technology. Methanol (99.9%, water≤30 ppm, J&KSeal), potassium hydroxide (AR≥85%, flakes, General-Reagent), acetone (A.R., Shanghai Lingfeng Chemical Reagent CO., LTD), THF (99.5%, extra dry, Energy Chemical), acetonitrile (HPLC, J&KSeal), toluene (A.R.), and PEDOT:PSS (Heraeus, Clevios™ P VP.AI 4083.) were employed. All QDs were purchased from Suzhou Xingshuo Nanotech Co., Ltd. All chemicals were used as received.

Synthesize details of the crosslinker

In a 4 mL dry brown sample vial, 1.315 mL of methanol was added, and 219 mg of 4-azido-2,3,5,6-tetrafluorobenzaldehyde was dissolved therein. Subsequently, 87.5 μL of 20 wt% aqueous potassium hydroxide solution was added, and finally, 36.25 mg of acetone was added dropwise. The reaction system was stirred at room temperature, with the reaction process monitored by Thin-Layer Chromatography (TLC). After a certain period of reaction, an orange-yellow solid precipitate appeared. The reaction was terminated after 1 hour, and the reaction system was diluted by adding 0.87 mL of methanol and 1.32 mL of deionized water. Thereafter, the mixture was filtered to separate the filter residue, yielding a yellow solid.

The obtained product was redissolved in 4.39 mL of acetone and 0.22 mL of tetrahydrofuran (THF). Then, 43.86 mL of water was slowly added dropwise using a constant-pressure dropping funnel while stirring. After 2 hours, filtration was performed again. The resulting solid was washed with water and subjected to vacuum drying, finally obtaining the yellow target product (the crosslinker). The yield of this reaction was 52%.

^{1}H-NMR (400 MHz, $CDCl_3$): δ=7.69 (d, 2H), 7.30 (s, 2H); ^{19}F-NMR (377 MHz, $CDCl_3$): δ= −151.77 (m, 4F), −139.25 (m, 4F) .

Device fabrication details

The architecture of the patterned quantum dot light-emitting diode (QLED) device is as follows: Glass/Indium Tin Oxide (ITO)/Poly(3,4-ethylenedioxythiophene):Polystyrenesulfonate (PEDOT:PSS)/Quantum Dots (QDs) with or without Crosslinker/Zinc Magnesium Oxide (ZnMgO)/Aluminum (Al).

Initially, the glass substrate coated with ITO undergoes a sequential ultrasonic cleaning protocol, with each step lasting 30 minutes, utilizing ITO cleaning solution, deionized water, and isopropyl alcohol (employed twice in succession). This cleaning process is followed by ultraviolet (UV) ozone treatment to ensure surface activation prior to device fabrication.

Subsequently, a solution of PEDOT:PSS is spin-deposited onto the ITO layer at a rotational speed of 3000 rpm for 30 seconds, after which thermal annealing is performed at 150 °C for 30 minutes to induce film consolidation. Thereafter, the substrate is transferred into the glovebox, and a composite solution containing QDs dissolved in n-octane and crosslinker dissolved in toluene is spin-cast at 3000 rpm for 45 seconds. The QD film is annealed at 100 °C for 5 minutes. For QD mixed with the crosslinker, the QDPR layer is subsequently exposed to UV radiation to induce crosslinking. The unreacted QDs are removed via spin-rinsing with n-octane. Subsequent to this, a ZnMgO solution is spin-coated at 2000 rpm for 30 seconds, with annealing at 100 °C for 10 minutes to densify the film. Ultimately, an aluminum cathode (100 nm in thickness) is deposited using a custom high-vacuum evaporation system.

Direct lithography procedure

Substrate Pretreatment: Substrates targeted for patterning undergo a sequential ultrasonic cleaning protocol, with each step lasting 30 minutes, utilizing a cleaning solution, deionized water, and isopropyl alcohol. Post-cleaning, the substrates are preserved in isopropyl alcohol for storage purposes. Prior to utilization, they undergo a secondary ultrasonic cleaning and are subsequently dried via nitrogen purging.

Deposition of the Quantum Dot Layer: Quantum dots dispersed within n-octane are mixed with the crosslinker dissolved in toluene, where the weight ratio of the crosslinker ranges from 3% to 5%, according to the different colors. Ultrasonic agitation is employed to achieve complete dispersion of the quantum dots. Before application, the solution is subjected to filtration, and the quantum dot suspension is then spin-cast onto the substrate using a spin coater under yellow-light environment.

Ultraviolet Exposure: The substrate coated with the quantum dot layer is positioned beneath a pre-fabricated photomask with desired pattern and exposed to ultraviolet radiation (operating at a wavelength of 365 nm) with a cumulative dosage of 50 mJ cm^{-2}.

Development Process: Toluene functions as the developing agent. The quantum dot-coated substrate is submerged in this solvent for a duration of 30 seconds,

facilitating the dissolution of the quantum dot film in regions not subjected to ultraviolet exposure.

Multicolor overlay: Repeat the procedures mentioned above on the top of the obtained substrate; the green and blue QD can be deposited and patterned as defined by the mask. The overlay precision is guaranteed by the alignment marks, which can be found under the microscope.

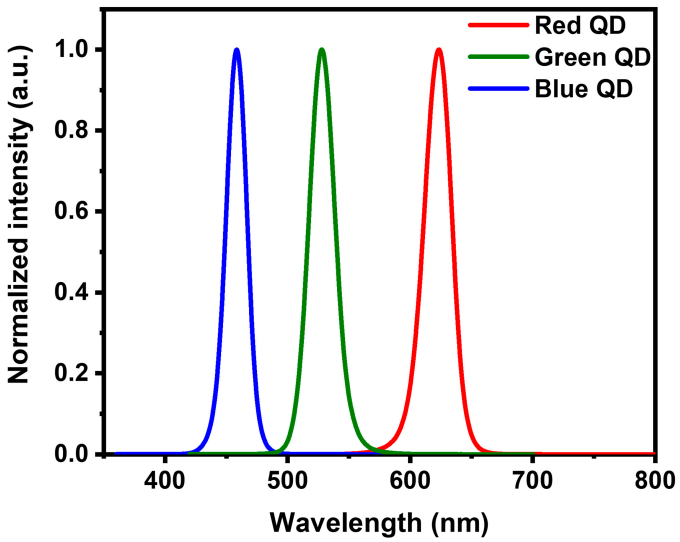


Figure S1. The PL spectra of pristine R, G and B QDs.

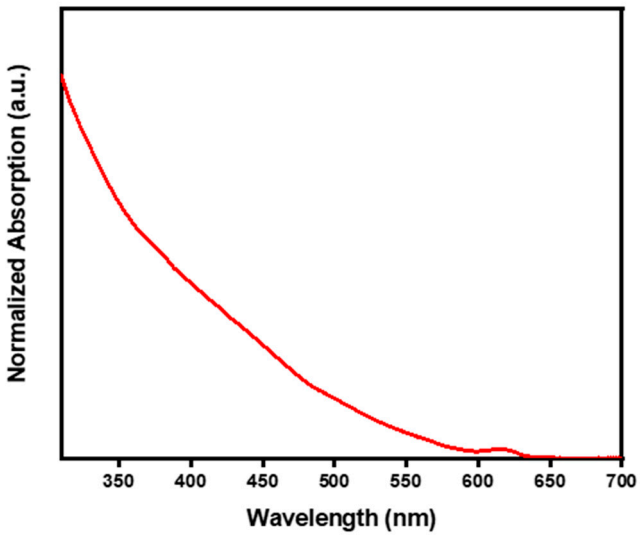


Figure S2. The UV–Vis absorption of red QD.

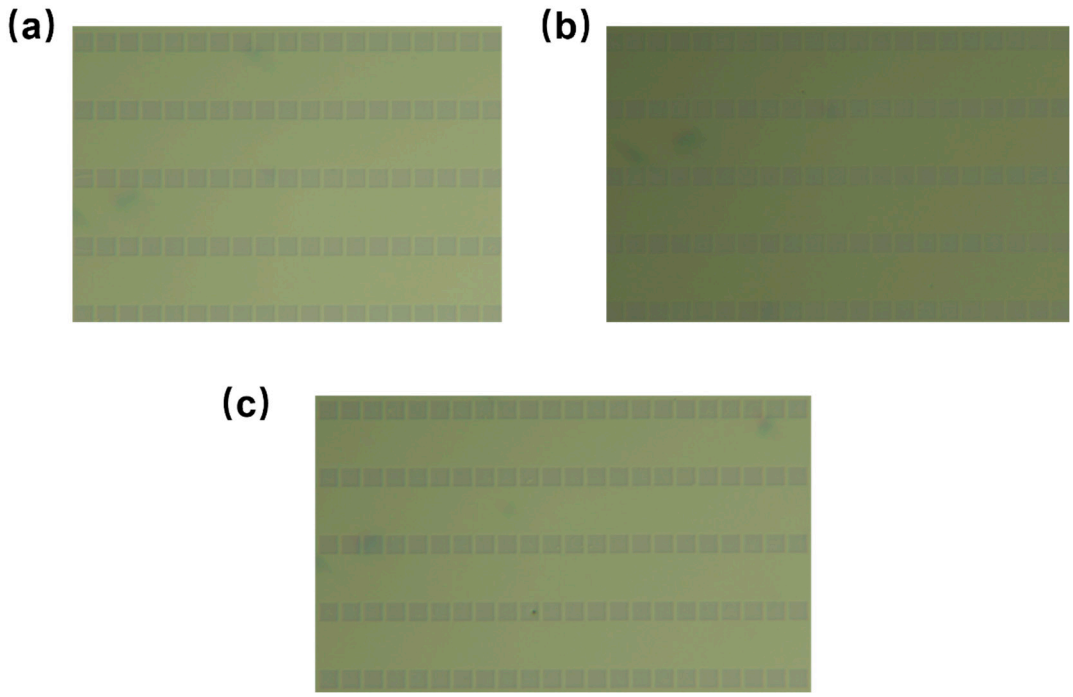


Figure S3. The optical photos of red **(a)**, green **(b)** and blue **(c)** QDs under microscope.

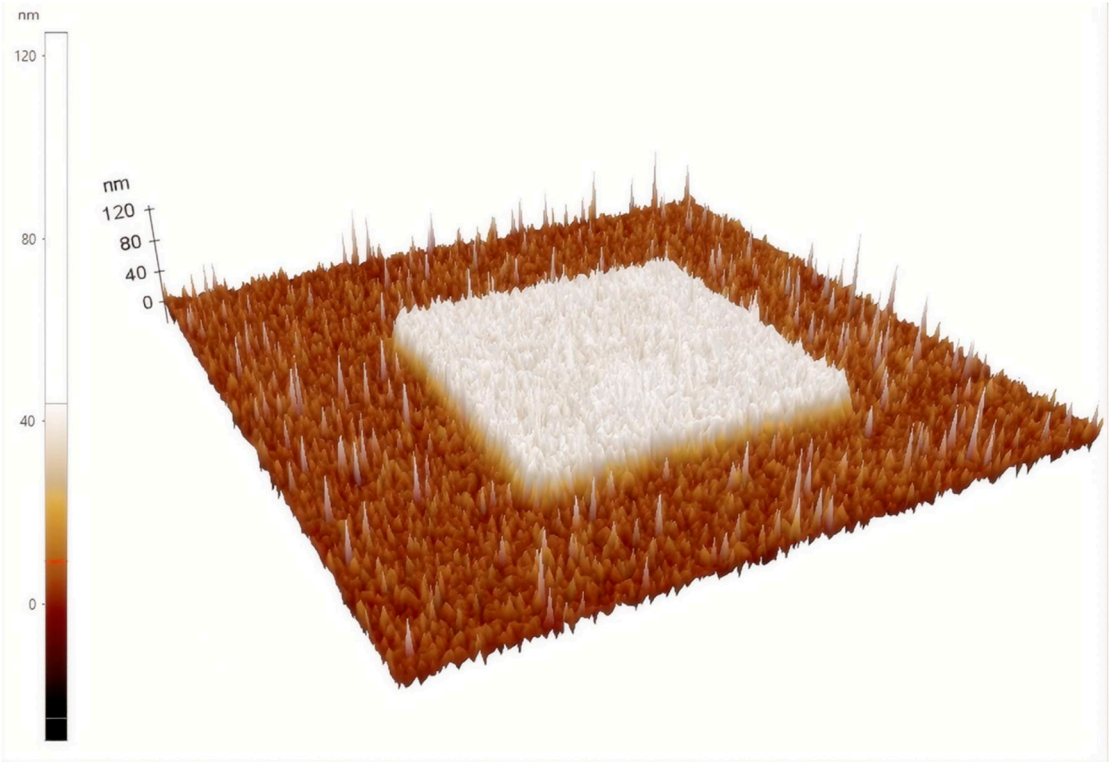


Figure S4. The 3D rendering AFM picture of the pixel after the lithography patterning.

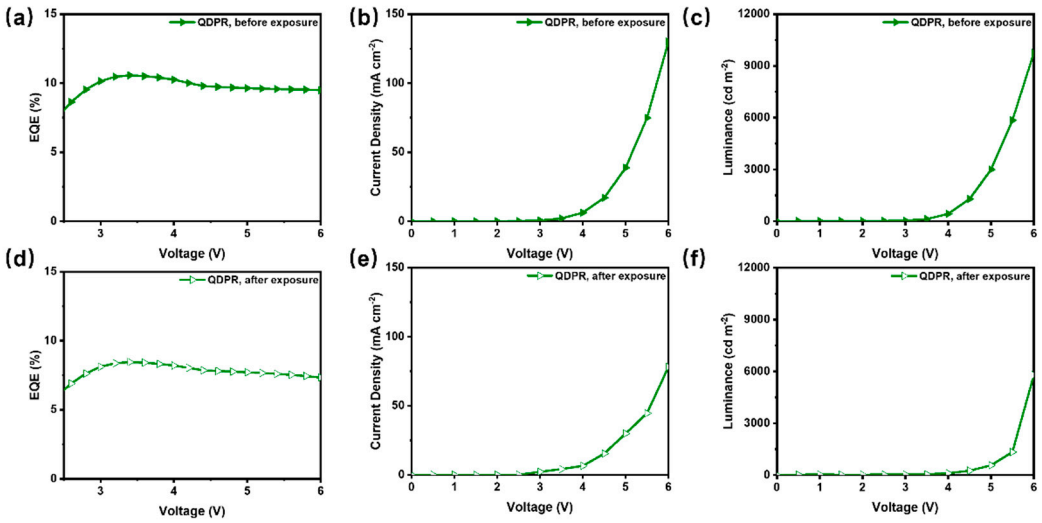


Figure S5. The performance of green QD devices before and after UV exposure.

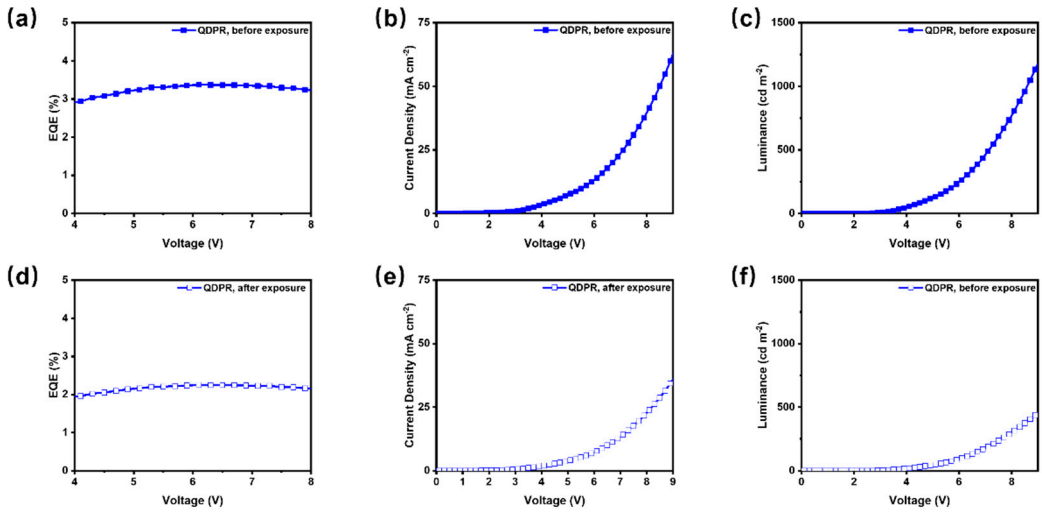


Figure S6. The performance of blue QD devices before and after UV exposure.

Table S1. The PLQY and PLQY retention for different formulation ratios, as well as before and after UV exposure.

Type of Film	pristine QD film	1% QDPR	2% QDPR	3.5% QDPR	2% QDPR after UV
PLQY (%)	91.1	76.8	88.0	62.1	79.8
Retention (%)	100	84.3	96.6	68	87.6

Table S2. The PLQY and PLQY retention for R, G and B QDPR film before and after

UV exposure.

Type of Film	Red QDPR film before exposure	Red QDPR film after exposure	Green QDPR film before exposure	Green QDPR film after exposure	Blue QDPR film before exposure	Blue QDPR film after exposure
PLQY (%)	88.0	79.8	73.2	59.1	44.3	33.8
Retention (%)	100	90.7	100	80.8	100	76.3