Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Micropore Filling Fabrication of high resolution patterned PQDs with a pixel size less than 5 μm

Wenchao Sun,[a,b] Fei Li,[c] Jin Tao,*[a] Panyuan Li,[a,b] Licai Zhu,[a,b] Jiwei Li,[a,b] Jinguang Lv,[a] Weibiao Wang,[a] Jingqiu Liang,[a] and Haizheng Zhong*[c,d]

a. *State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun, Jilin 130033, China. E-mail: taojin@ciomp.ac.cn*

b. *University of Chinese Academy of Sciences, Beijing 100049, China.*

c. *QD LAB, Beihang University National Science Park, Hefei, 230001, Anhui.*

d. *School of Materials Science & Engineering, Beijing Institute of Technology, Beijing, 100081, China. E-mail: hzzhong@bit.edu.cn*

Preparation of Perovskite Quantum Dots/Polymer Gel: The preparation of red emissive perovskite quantum dots/polymer composite material includes two stages. Stage I: a precursor solution included 2 mmol RbI, 2 mmol CsI, 3 mmol PbI_2, 2.5 mmol OAI and 100 g PMMA powder in 1000 mL of DMF. Then the precursor solution is coated onto PET substrate with 50 cm width and 60 cm length to obtain a uniform precursor coating layer by doctor blade method. Stage II: the PET substrate with precursor coating layer put on a drying chamber at 130 °C to boost the evaporation of solvent and facilitate the crystallization of γ-$Rb_{0.5}Cs_{0.5}PbI_3$ gradient-alloyed QDs. After 3 min heating, the red emissive PQDs film formed. The green emissive perovskite quantum dots/polymer composite material was fabricated by varying the precursor RbI, CsI and PbI_2 by MABr and $PbBr_2$ following a similar strategy. Then the prepared composite material was shatter by cryogenic crushing to obtain the perovskite quantum dots/polymer particle. Finally, the particle mixed with Poly(dimethylsiloxane) with mass ratio of 1:2 to prepare the gel.

Preparation of the SU8 micropore mold: Patterned SU8 molds were fabricated on glass substrate by standard photolithography processes, First, put the glass in the absolute ethanol for ultrasonic cleaning, and then rinse with plenty of water after cleaning. Use a nitrogen gun to blow off the residual moisture on the surface and then put it on a hot plate at 200 °C for 6 minutes. After cooling for 5 minutes, oxygen plasma treatment was performed, the RF power was 120W, and the treatment time was 60s. After the treatment, the SU8-2015 photoresist was spin-coated on the treated glass sheet in two steps (500rpm for 10s, 1000rpm for 30s). After spin coating, pre-bake at 95°C for 4min52s, after cooling for 5 minutes, expose the sample to 365nm UV light (8.9mw/cm2) for 20.3s, then bake at 95°C for 5min52s, and then the sample was put into PGMEA developer solution for 2min44s, and washed with IPA solution. Finally, the sample was baked at 160 °C for 6 min to harden the mold. In this way, the SU8 gravure mold is made.

Fluorescence uniformity analysis method: A CCD was used to acquire the image of the prepared QDCC under 365nm ultraviolet light excitation. After dividing the three-channel image into 8-bit single-channel images, use Image J to analyze and process the images under the green channel, The average fluorescence intensity data of 3136 pixels of a single 5mm*5mm color conversion layer were obtained, Refer to the "Measure methods of light emitting diode (LED) displays" in the National Standard of the People's Republic of China, Randomly select 30 pixels from all pixel points, and calculate the arithmetic mean of the fluorescence intensities of these 30 pixels to obtain $\overline{I}$. Calculate the pixel intensity uniformity with the following formula:

$$I_G = \frac{\left|I_i - \overline{I}\right|}{\overline{I}} \times 100\%$$

Where, $i = 1{\sim}30$; $\overline{I} = \sum_{i=1}^{30} I_i / 30$; The largest of these is its fluorescence uniformity. We randomly selected 5 sets of data, each containing the fluorescence intensity of 30 pixels, calculated the uniformity of each set of the data using the above method, and then arithmetically averaged the calculated 5 uniformities. then calculated the standard deviation of the five sets of the results. the uniformity I and the standard deviation σ are obtained, the final fluorescence uniformity is $I \pm \sigma$.

Process of making dual-color QDCC by overlay method: Using the prepared monochrome quantum dot color conversion layer as the substrate, repeat the above photolithography process (setting the hard bake temperature to 110 °C for 5 min) to make a layer of SU8 micropore mold on the single-color quantum dot color conversion layer, Then, another color of perovskite quantum dot solution was coated on the SU8 micropore mold, and then the perovskite quantum dots on the surface of the mold were repeatedly scraped with a scraper. After the perovskite quantum dot solution was solidified (70°C, 20min), the residual perovskite quantum dots on the surface of SU8 micropore mold were removed with polishing equipment, that is, a dual-color quantum dot color conversion layer is obtained.

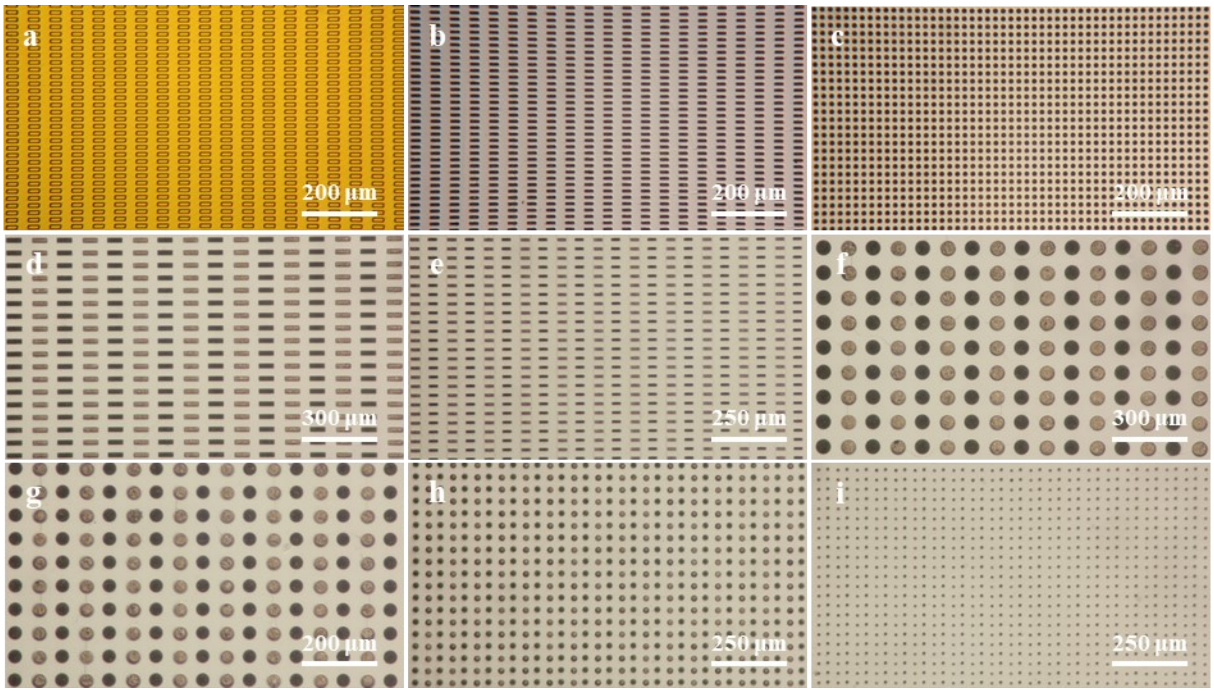

Fig.S1 (a) Optical microscope image of SU8 micropore mold. (b)(c) Optical microscope images of monochromatic patterned perovskite quantum dots as rectangles with dimensions of 30 × 10μm and circles with diameters of 10μm, respectively. (d)-(i) Optical microscope images of dual-color patterned perovskite quantum dots, which are rectangles with dimensions of 60 × 20μm and 30 × 10μm and circles with diameters of 60μm, 40μm, 20μm and 10μm, respectively.

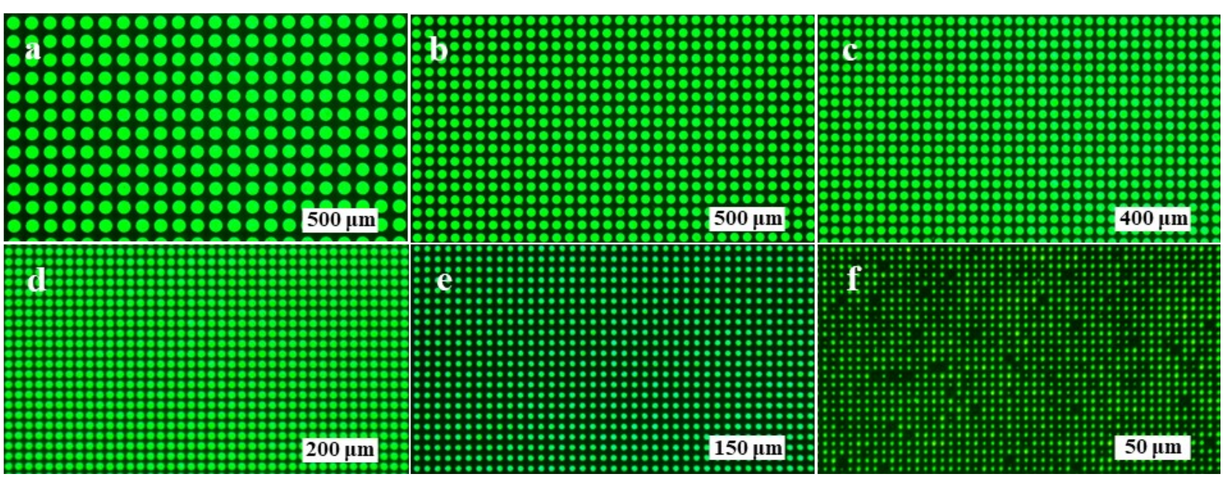

Fig.S2 (a)-(f) arrays with pixel sizes of 90μm, 60μm, 40μm, 20μm, 10μm and 2μm, respectively.

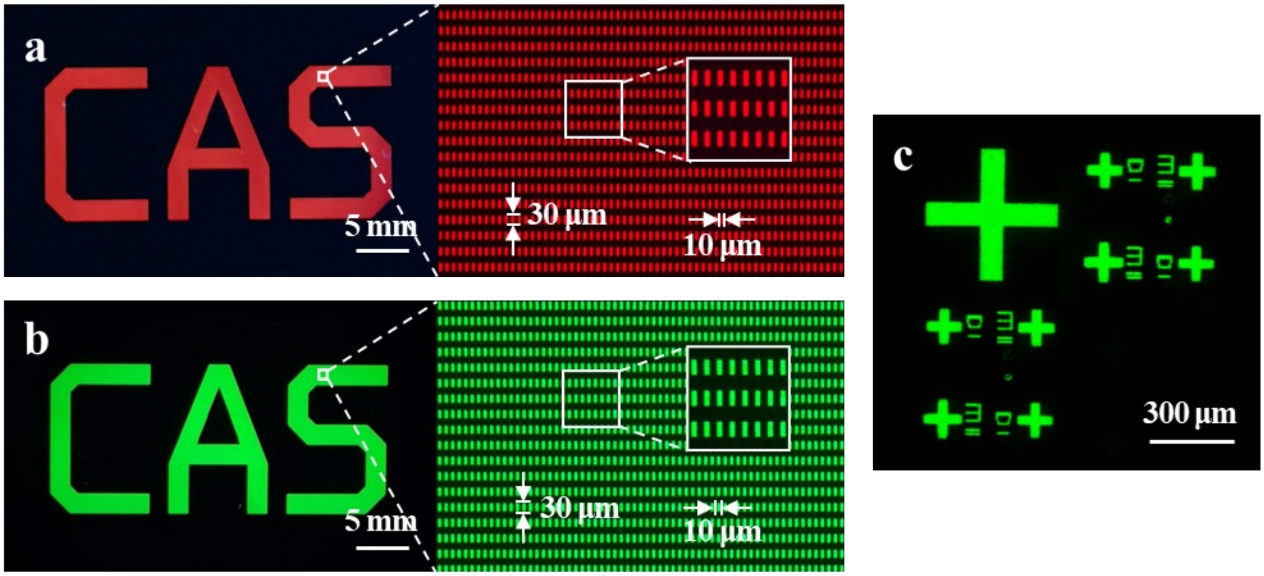

Fig.S3 (a)(b) "CAS" fluorescence photo of patterned perovskite quantum dots and its partial magnification. (c)Fluorescent image of the aligned markers.

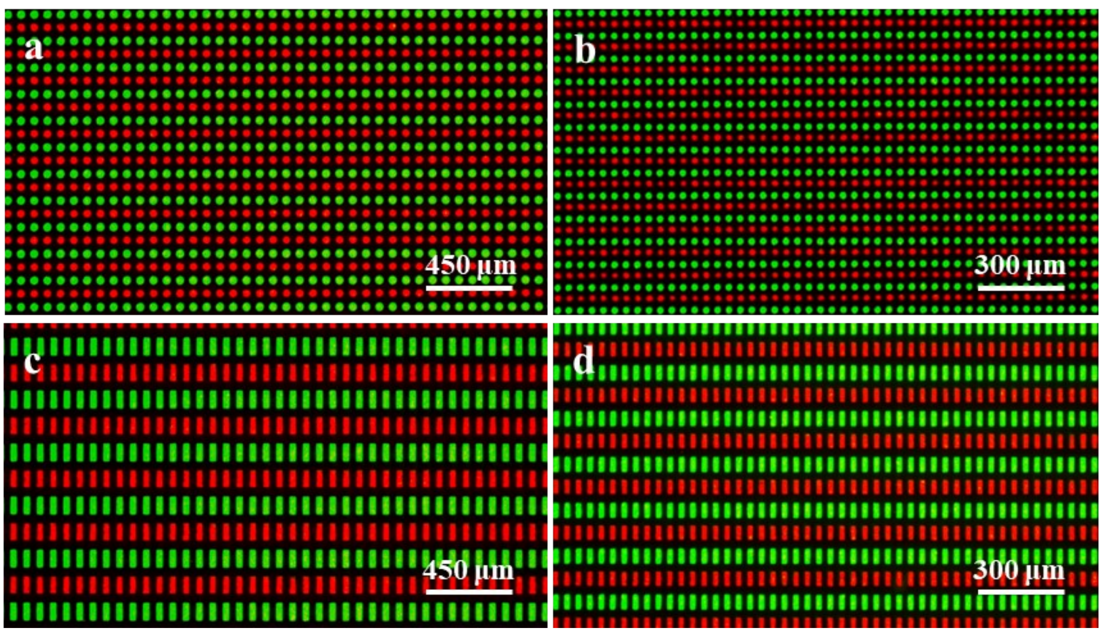

Fig.S4 (a)-(d) Fluorescence images of monochromatic patterned perovskite quantum dots as circles with diameters of 40μm、20μm and rectangles with dimensions of 90×30μm、60×20μm, respectively.

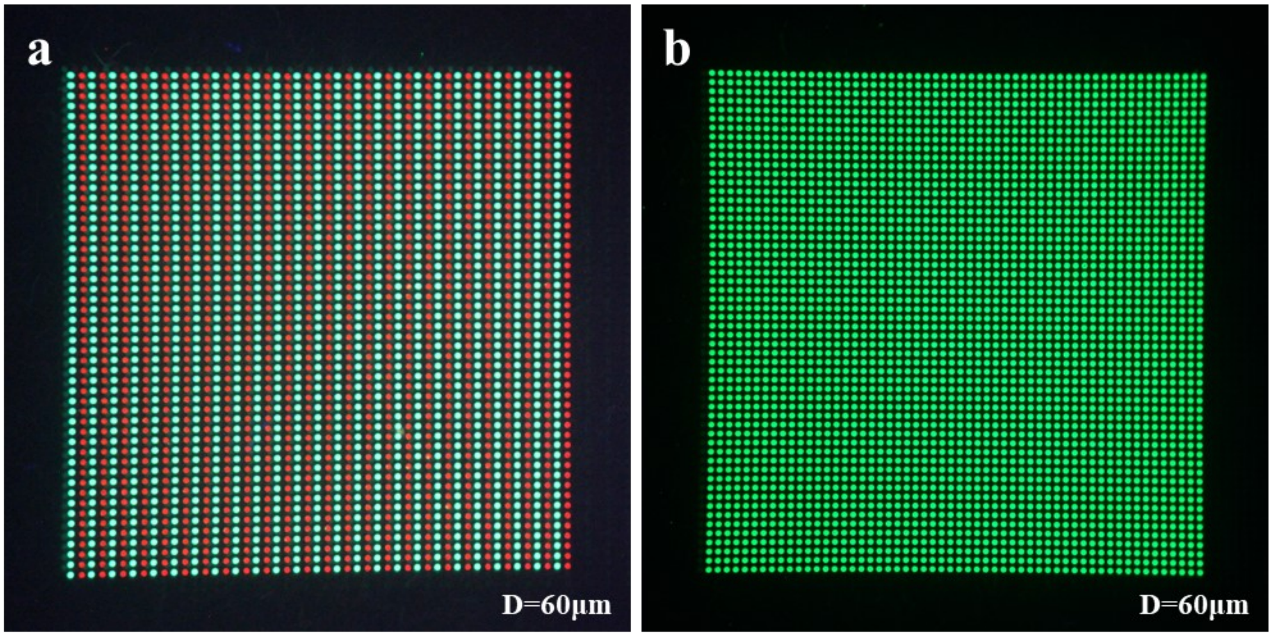

Fig.S5 (a) Optical microscope image of dual-color patterned perovskite quantum dots excited by UV light. (b) Optical microscope image of monochromatic patterned perovskite quantum dots excited by UV light.

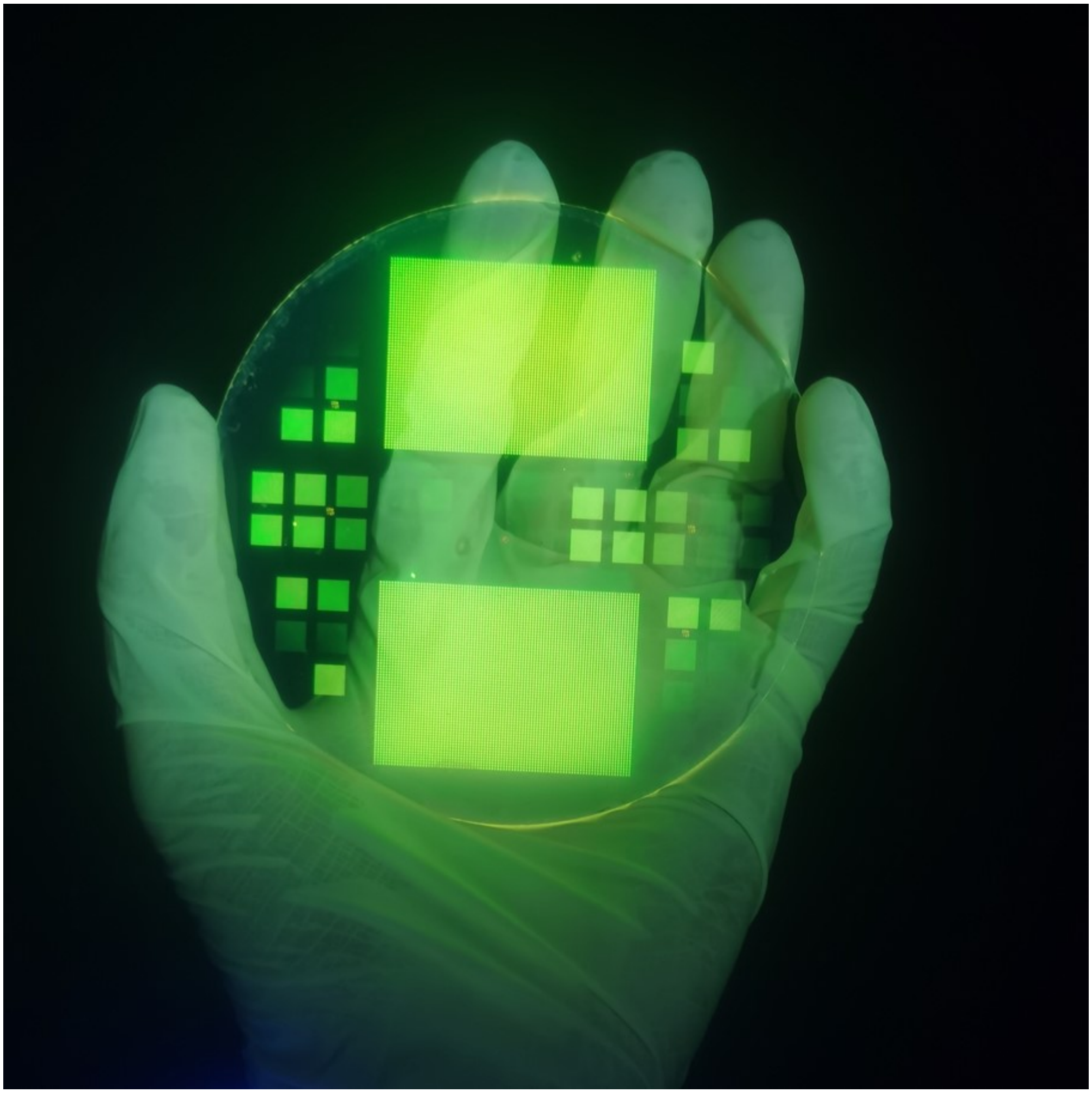

Fig.S6 the macroscopic image of the dual-color patterned QDCC on 4-inch glass excited by UV light.