Supporting Information

High stability modified $CsPb(ClBr)_3$@glass@PS for wide color gamut Mini-led backlight display

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1. Experimental Section

1.1 Materials

Silicon dioxide (SiO_2, Sinopharm, 99%), germanium dioxide (GeO_2, Meryer, 99.999%), boron oxide (B_2O_3, Aladdin, 99.9%), aluminum oxide (Al_2O_3, Aladdin, 99.9%), lithium carbonate (Li_2CO_3, Aladdin, 99.99%), potassium carbonate (K_2CO_3, Meryer, 99%), cesium carbonate (Cs_2CO_3, Meryer, 99.9%), lead chloride ($PbCl_2$, Meryer, 99%), lead bromide ($PbBr_2$, Meryer, 99%), sodium chloride (NaCl, Aladdin, 99%), sodium bromide (NaBr, Aladdin, 99%), polystyrene (PS, Ruixiang Plastic Co., LTD), $CaAlSiN_3$: Eu^{2+} phosphor (CASN: Eu^{2+}, Hangzhou Yingke new material Co., LTD)

1.2 Properties of $CsPb(Cl/Br)_3$@Glass

Firstly, the glass raw materials and $CsPb(Cl/Br)_3$ perovskite precursor were meticulously mixed in a grinding bowl, then transferred into a crucible, and melted at 1300°C for 20 minutes to attain uniform molten glass, the molten glass was rapidly quenched in water. Secondly, the water-quenched glass was dried at 80°C and subsequently ground. Finally, the ground glass samples underwent a heat treatment process at temperatures ranging from 450°C to 490°C for 8 h.

1.3 Synthesis of $CsPb(Cl/Br)_3$@glass@PS film and CASN: Eu^{2+}@PS film

Taking green film as an example. Firstly, mixed the $CsPbBr_3$@glass powder and PS powder in different proportions. Secondly, placed mixture on a plate vulcanizer to heat up and press the film. Finally, taken out after cooling. The proportion of green film were 20%, 40%, 60%, 80% (the proportion of red film was 10%). The heating temperature was 220°C, the heating time was 20 minutes, and the cooling time was 15 minutes.

1.4 Fabrication of WLED

The prepared green-emitting $CsPbBr_3$@glass and commercial phosphor of CASN: Eu^{2+} were mixed with evenly according to the proportion. And then homogeneously dispersed in the mixture of silica gel (gel A: gel B = 3:1), and then dropped on the

InGaN blue chip.

1.5 Fabrication of $CsPbBr_3$@glass@PS film and CASN: Eu^{2+}@PS film display device

The light-emitting layer composed of the blue-chip and the light guide plate was put on the top of the reflective layer, and then the $CsPbBr_3$@glass@PS composite film and CASN: Eu^{2+}@PS film were put on the light guide plate as the light conversion layer. Fabrication a wide colour gamut display device by using a commercial TFT LCD (Thin Film Transistor Liquid Crystal Display) backlight.

1.6 Characterization

X-Ray diffraction (XRD) was measured using Bruker D8 Advance measurements, wherein Cu Kα radiation was working environment at voltage 40 kV and current 40 mA in the boundary of 10–60° (2θ) at the velocity of 0.03° s^{-1}. Transmission electron microscopy (TEM), High Resolution Transmission Electron Microscopy (HRTEM) images and energy-dispersive X-ray spectroscopy (EDX) were measured using a FEI Tecnai G2F20S-TWIN transmission electron microscope. The ultraviolet-visible (UV-Vis) spectrum was measured by PerkinElmer 750 (UV-Vis) spectrometer in the boundary of 200–800 nm (λex = 365 nm). The PL spectra was measured by a Horiba Jobin Yvon Fluromax-4P Spectrofluorometer (λex = 365 nm). The Fourier-transform infrared spectroscopy (FTIR) spectrum was measured by Nicolet iS50 FT-IR between the wave number range of 400 cm^{-1} and 4000 cm^{-1}. The temperature-dependent fluorescence spectra were measured using a THMS 600 fluorescence spectrophotometer with temperature control. Using time-correlated single-photon counting (TCSPC) lifetime spectroscopy system and nanosecond-pulsed diode laser (nano LED-370) as a single wavelength excitation light source, the lifetime of PL was measured. Differential Scanning Calorimeter (DSC, Germany NETZSCH, DSC214) was used for thermal characterization of $CsPbBr_3$@Glass at a heating rate of 10°C /min from room temperature to 700 °C in Ar atmosphere. X-ray photoelectron spectroscopy (XPS) was collected using an Axi Ultra DLD spectrometer with single-colorAl Ka radiation as the excitation source.

2. Supporting Figures and Tables

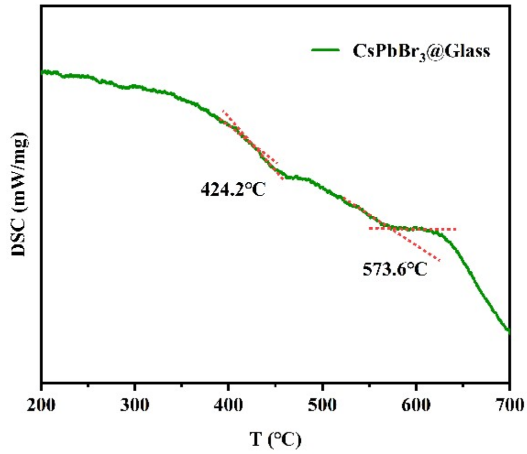

Figure S1. DSC curve of $CsPbBr_3$@Glass without heat-treatment.

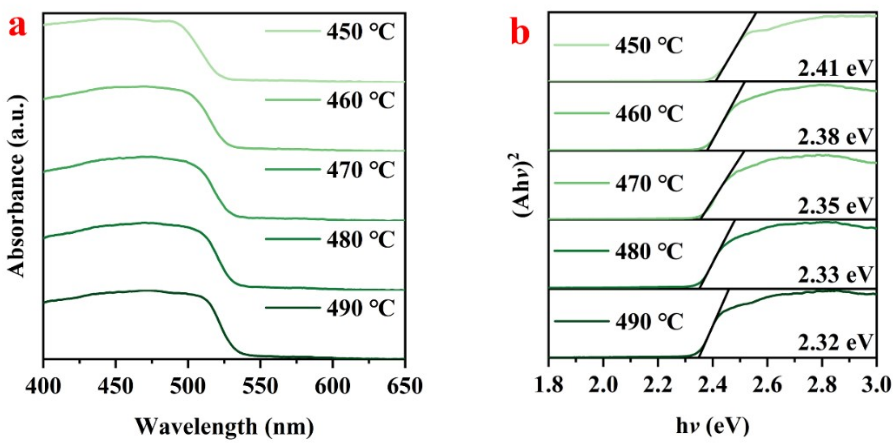

Figure S2(a) Absorption spectra and (b) The spectra plotted as $(Ah\nu)^2$-(hv) of $CsPbBr_3$@Glass samples with different heat treatment temperature.

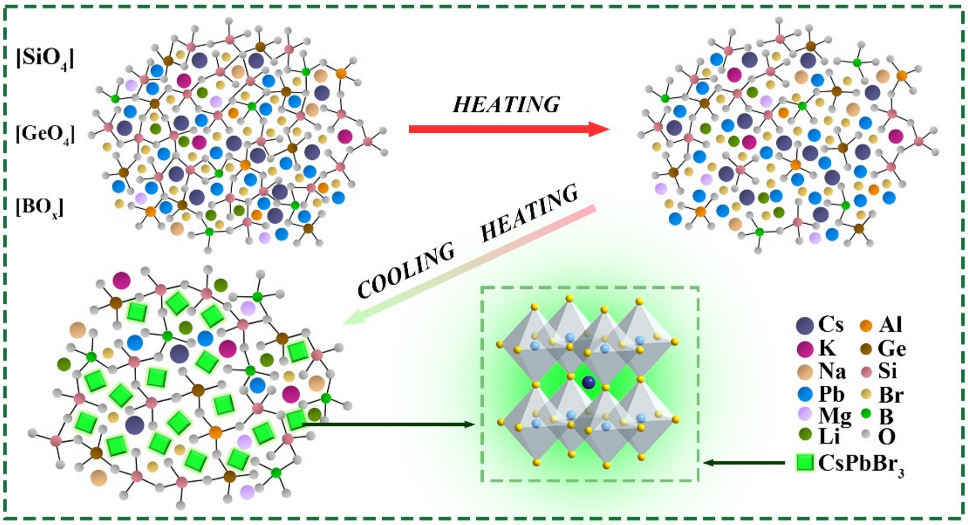

Figure S3 The crystallization mechanism of $CsPbBr_3$ PNCs in germane-silicate glass.

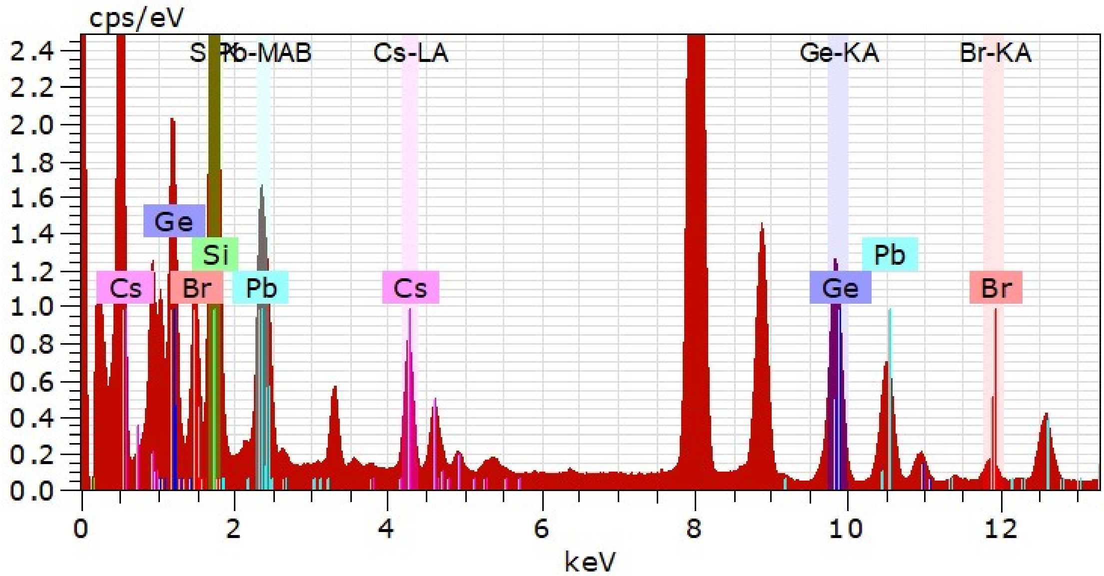

Figure S4 EDX spectrum of the as-prepared glass sample, showing the existence of Cs, Pb, Br, Si and Ge elements.

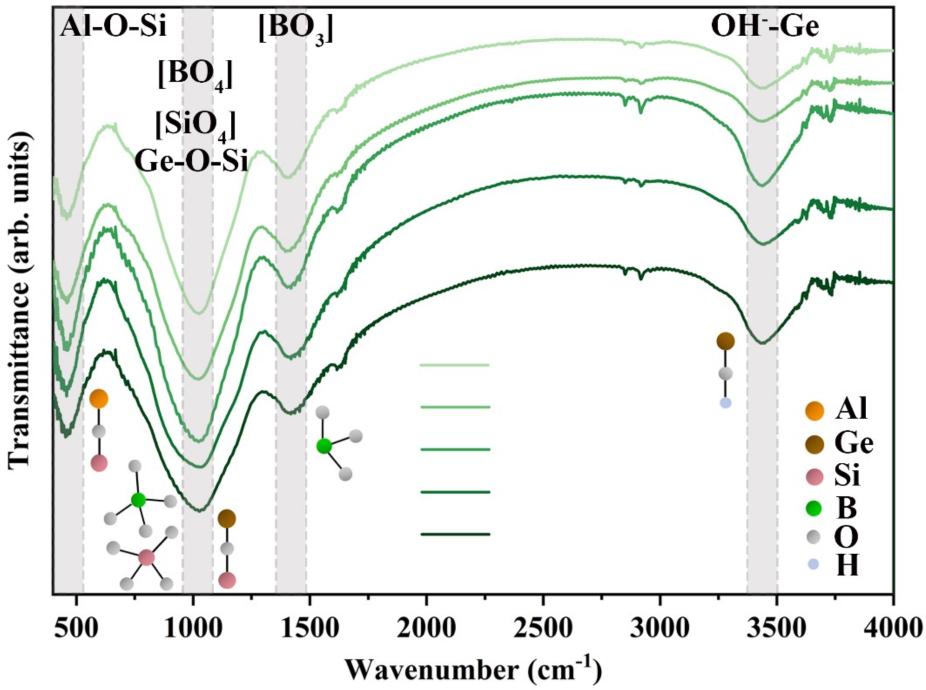

Figure S5 FTIR spectra of $CsPbBr_3$@Glass with different heat treatment temperature.

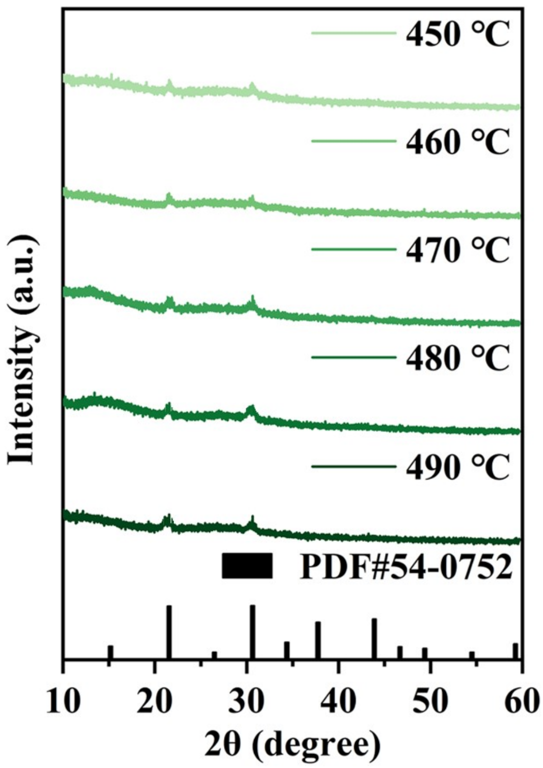

Figure S6 XRD patterns of $CsPbBr_3$@Glass with different heat treatment temperature.

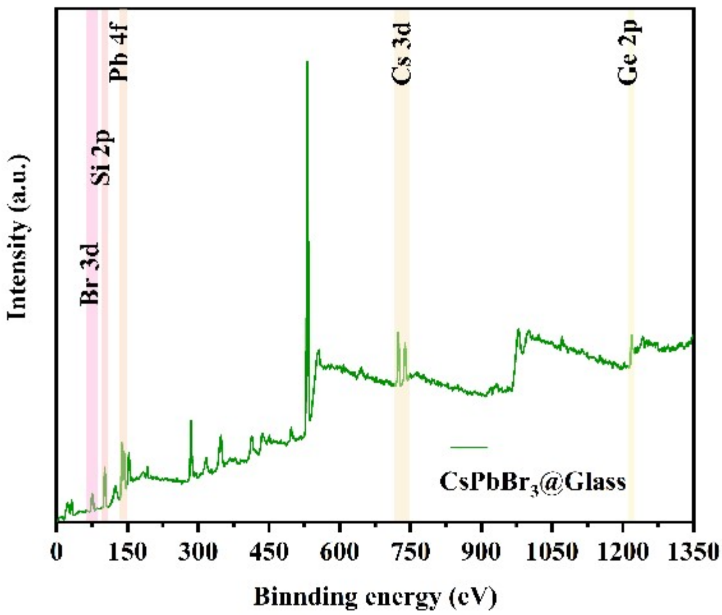

Figure S7 XPS survey spectra of $CsPbBr_3$@Glass.

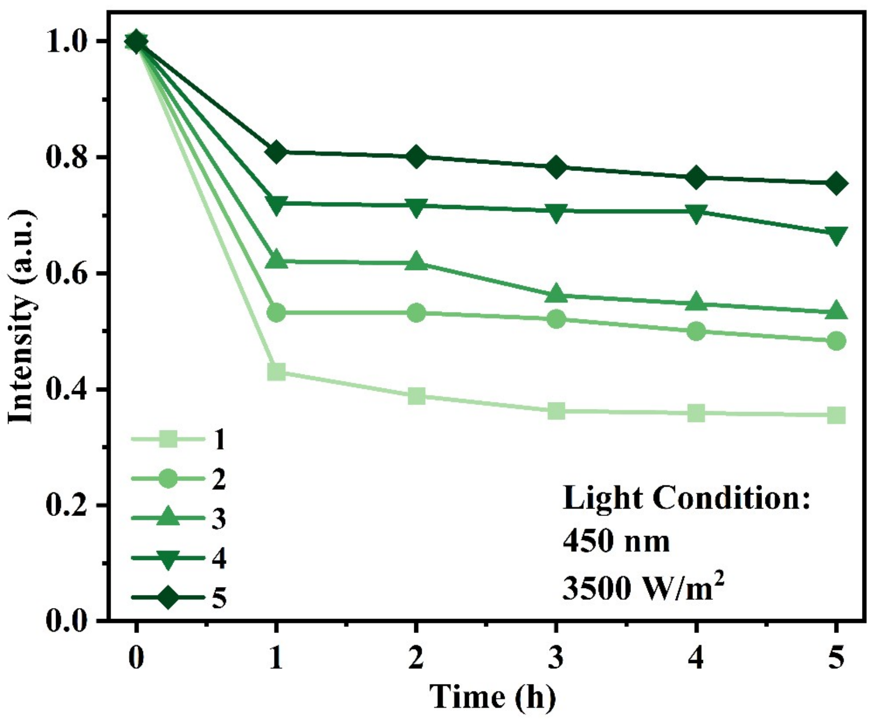

Figure S8 Comparison of blue light stability of samples pretreated under 5 different conditions under 3500 W/m^2 conditions. The five processing conditions referred to here correspond to the five graphs of Fig. 3(b, c, d, f, g) respectively. Condition one (b), condition two (c), condition three (d), condition four (f), condition five (g).

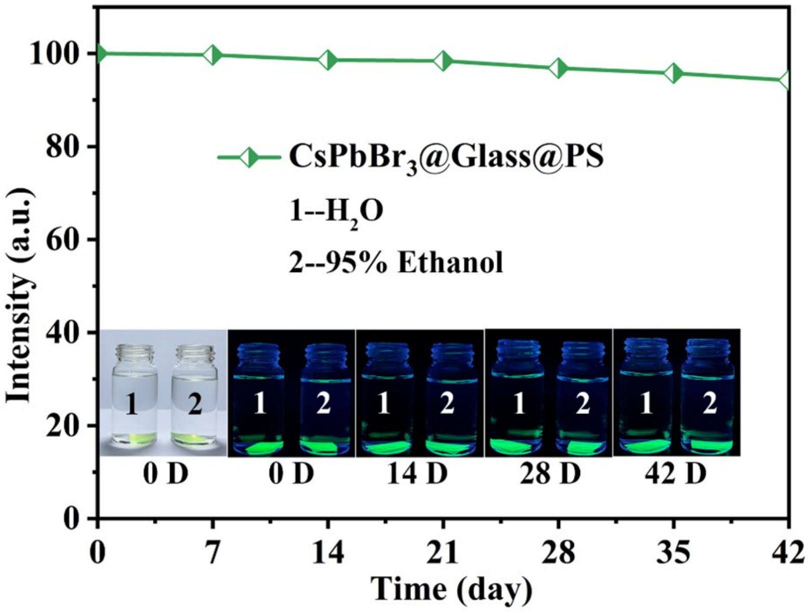

Figure S9 Stability of CsPbBr$_3$@Glass@PS in 20 ml H_2O and 20 ml 95% Ethanol.

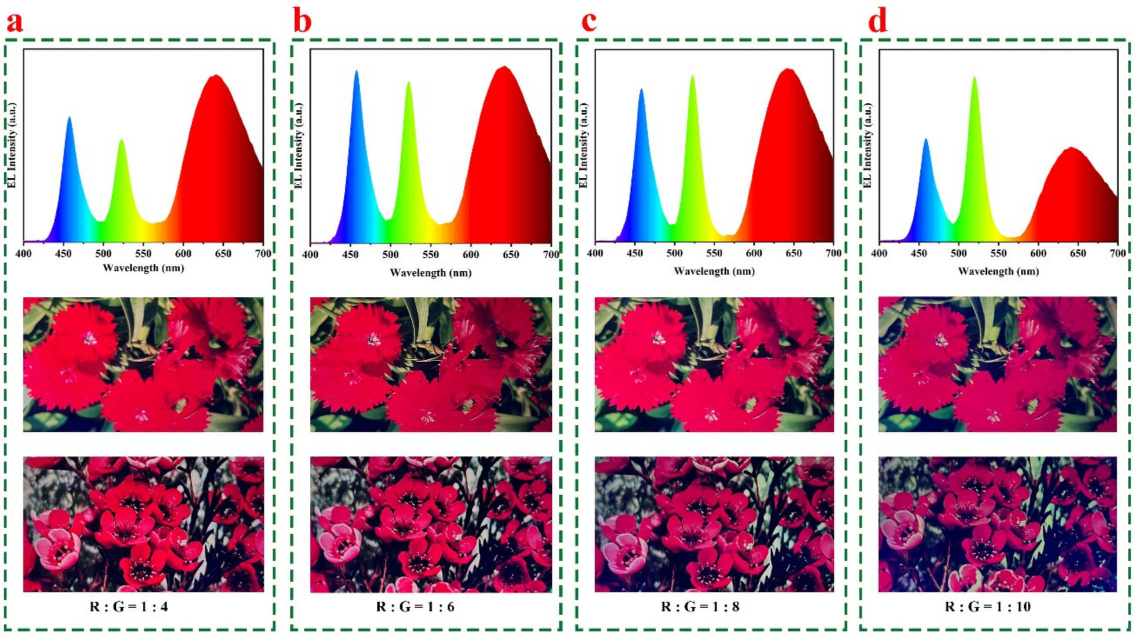

Figure S10 Electron luminescence spectra and photographs of LCD displays with different red-green ratios of this work.

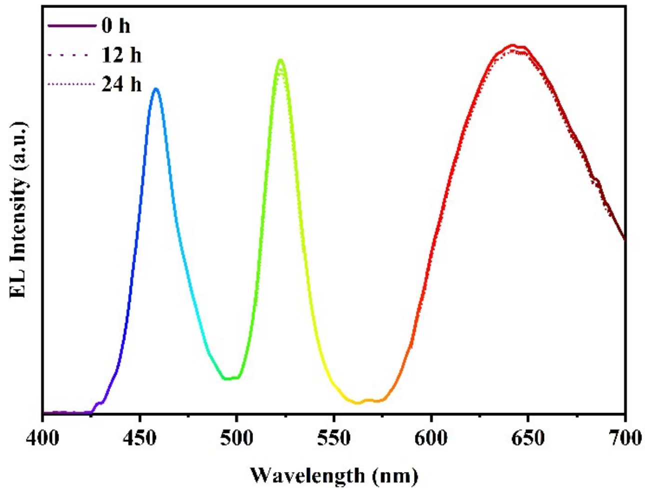

Figure S11 Backlight devices continued to use 0h, 12 h, 24 of spectral data.

Table S1. PL lifetimes data of $CsPb(ClBr)_3$@Glass.

Samples $CsPb(Cl/Br)_3$@Glass	τ_1 (ns)	τ_2 (ns)	τ_3 (ns)	Rel%-1	Rel%-2	Rel%-3	$\tau_{average}$ (ns)
$Br_{3.00}$	6.44	90.42	636.76	11.07	36.62	52.32	366.98
$Cl_{0.25}Br_{2.75}$	10.58	100.55	545.72	14.81	41.43	43.76	282.03
$Cl_{0.50}Br_{2.50}$	12.18	85.56	405.53	22.3	45.88	31.82	171.01
$Cl_{0.75}Br_{2.25}$	11.17	69.50	356.63	20.8	45.93	33.27	152.90
$Cl_{1.00}Br_{2.00}$	13.41	77.67	384.88	28	48.29	23.71	132.52
$Cl_{1.25}Br_{1.75}$	10.59	73.25	353.44	30.53	47.10	22.38	116.83
$Cl_{1.50}Br_{1.50}$	5.85	36.01	203.09	16.49	40.06	41.30	99.27

Table S2. CIE color coordinates and the calculated color gamut for Rec.2020 standard, NTSC 1953 standard and this work.

	Red	**Green**	**Blue**	**Area**
NTSC 1953	(0.62, 0.33)	(0.21,0.71)	(0.14, 0.08)	0.158 (100%)
Rec. 2020	(0.71,0.29)	(0.17,0.80)	(0.13,0.05)	0.212 (134%)
This work	(0.70,0.30)	(0.18,0.76)	(0.15,0.03)	0.195 (123%)

The area ratio was defined as the color gamut, which compares the RGB triangular area of the LCD screen with the triangular area of the NTSC 1953 standard. The definition was described as

$$\text{Color Gamut Area} = \frac{A_{screen}}{A_{standard}}$$

A_{screen} and $A_{standard}$ are the RGB triangular area of the LCD screen and that of the NTSC1953 standard, respectively, which are calculated by the equation as follow:

$$A_{screen} \text{ or } A_{standard} = \frac{1}{2}\begin{vmatrix} x_R & y_R & 1 \\ x_G & y_G & 1 \\ x_B & y_B & 1 \end{vmatrix}$$

Table S3. CIE coordinates of different Red-Green ratios of this work.

R : G	CIE x	CIE y
1 : 4	0.3763	0.3086
1 : 6	0.3549	0.3278
1 : 8	0.3304	0.3472
1 : 10	0.3026	0.3500