Supporting information for

Highly efficient and stable green-emitting mesoporous silica (MP)-$(Cs_{0.4}Rb_{0.6})PbBr_3$ perovskite composite for application in optoelectronic device

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Materials

All chemicals were used without purification. Cesium carbonate (Cs_2CO_3, 99.9%), lead (II) bromide ($PbBr_2$, 98%), 1-octadecene (ODE, 90%), oleic acid (OA, 65.0-88.0%), oleylamine (OLA, 70%), and toluene (99.8%) were purchased from Sigma Aldrich. The mesoporous silica (SBA-15) and polydimethylsiloxane (PDMS, Sylgard 184) were purchased from ACS material and Dow Corning respectively.

Synthesis of the $(Cs_{1-x}Rb_x)PbBr_3$

To prepare Cs-oleate solution, 1.228 mmol Cs_2CO_3 and Rb_2CO_3 calculated from the stoichiometric ratio was loaded into a 40 mL vial in a glovebox. 1.25 mL 1- (ODE) and 15 mL (OA) were also loaded into the vial. The mixture was stirred at 120 °C for 30 min and the temperature was then increased to 150 °C. 0.376 mmol (0.138 g) $PbBr_2$ and 10 mL 1-ODE were then loaded into the vial and stirred for 1 h at 120 °C in an oil bath. 1 mL OLA and 1 mL OA were injected into the vial at 120 °C. The temperature was then increased with a heating ratio of around 2 °C/min and 0.8 mL Cs-oleate solution was quickly injected at 180 °C. After 5 seconds, the mixed solution was cooled in an ice bath. The residue was removed by centrifugation at 8000 rpm for 15 min. The $(Cs_{0.4}Rb_{0.6})PbBr_3$ perovskite NCs were then purified by

centrifugation at 8000 rpm for 15 min using 5 mL toluene. The sample was then re-dispersed in solvent.

Preparation of MP-($Cs_{0.4}Rb_{0.6}$)$PbBr_3$ composite

The mesoporous silica with an average pore diameter of 7-10 nm was dried at 60 °C under vacuum. 0.1 g of mesoporous silica and 2 mL of the prepared ($Cs_{0.4}Rb_{0.6}$)$PbBr_3$ perovskite NCs solution with concentrations of 0.030 M and 0.012 M (($Cs_{0.4}Rb_{0.6}$)$PbBr_3$, 17.5 mg mL^{-1} and 7 mg mL^{-1}) in toluene, respectively, were mixed and stirred for 10 h at room temperature (RT). The mixture was filtered with a 0.2 μm pore sized filter. The obtained sample was then dried at 50 °C for 30 min in a vacuum oven.

Fabrication of white LEDs

$Sr_2Si_5N_8:Eu^{2+}$ red phosphor 0.005 g was added in 9.9 g of PDMS with ratio of 10:1 (elastomer base 9 g:curing agent 0.9 g) wt% and mixed using vortex mixer. 0.14 g of the mixture and 0.01 g of the prepared MP-$Cs_{0.4}Rb_{0.6}PbBr_3$ powder were mixed. After then, air bubbles were removed in the vacuum oven for 3 min at RT. The mixture was placed on 450 nm InGaN blue LED chips and cured at 100ºC for 35 min.

Characterization

The crystalline phase of the ($Cs_{1-x}Rb_x$)$PbBr_3$ perovskite with different ratios of Cs/Rb NCs was identified using X-ray diffraction (XRD, D-MAX 2500, Rigaku, Tokyo, Japan) and a CuKα target with a $10^o \leq \theta \leq 50^o$ alignment. High-resolution transmission electron microscopy (HRTEM) and energy dispersive spectroscopy (EDS) mapping were measured with a JEM2100F with an accelerating voltage of 200 kV. X-ray photoelectron spectra (XPS) were analyzed using an X-ray photoelectron spectrometer (ULVAC-PHI, Inc) with an excitation source of Al-Kα radiation (1486.7 eV). The photoluminescence quantum yield (PLQY) was examined for compounds using an Absolute PL Quantum Yield Spectrometer (HAMAMATSU C11347). The electroluminescence (EL) properties of MP-($Cs_{0.4}Rb_{0.6}$)$PbBr_3$ on the surface of the InGaN blue LED chip for white light generation were measured using the optically coupled isolator (OPI-150-Optel-precision) system.

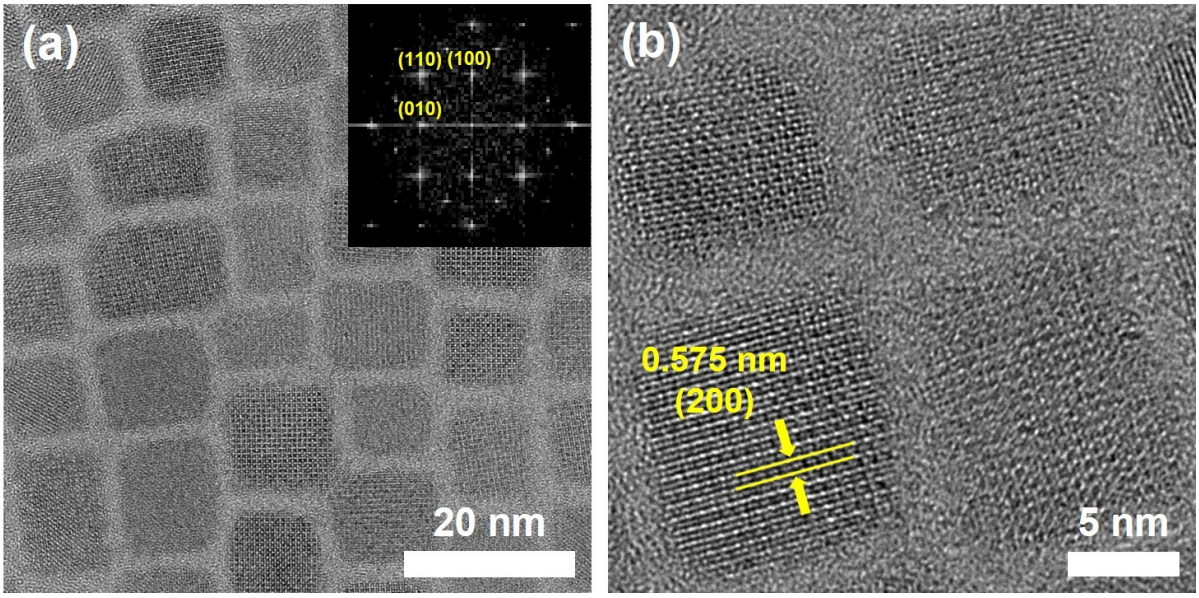

Figure S1. *Y.H. Song et al*.

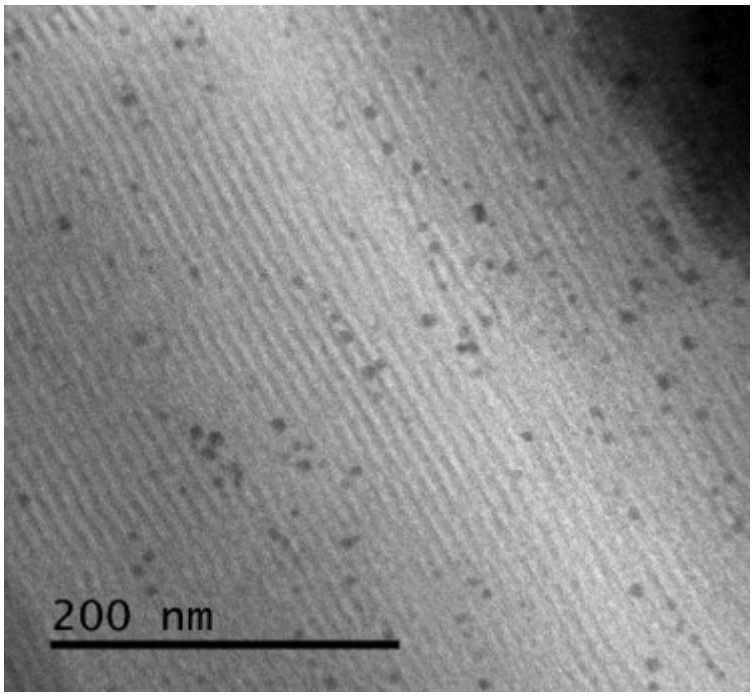

Figure S2. *Y.H. Song et al*.

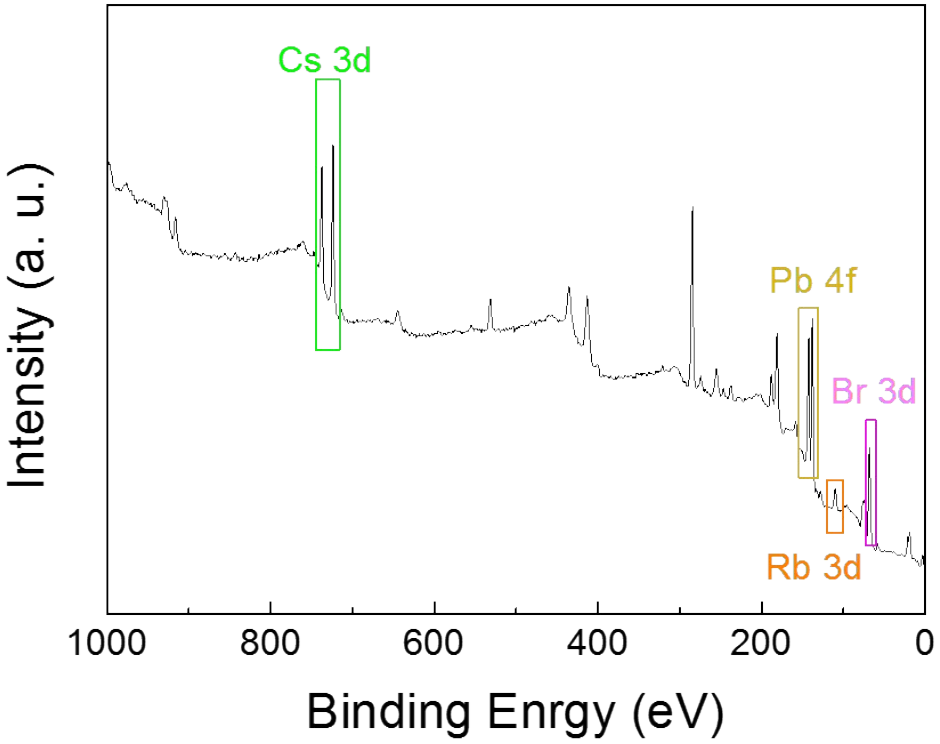

Figure S3. *Y.H. Song et al.*

Sample		$CsPbBr_3$	$(Cs_{0.7}Rb_{0.3})PbBr_3$	$(Cs_{0.4}Rb_{0.6})PbBr_3$
Precursor ratio	Cs:Rb	1:0	7:3	4:6
Elements (Conc.%)	Cs 3d	1	0.795	0.506
	Rb 3d	0	0.205	0.494
	Pb 4f	1.15	0.99	0.743
	Br 3d	3.04	2.756	2.436
XPS ratio	Cs:Rb	1:0	~8:2	~5:5

Table S1. *Y.H. Song et al.*

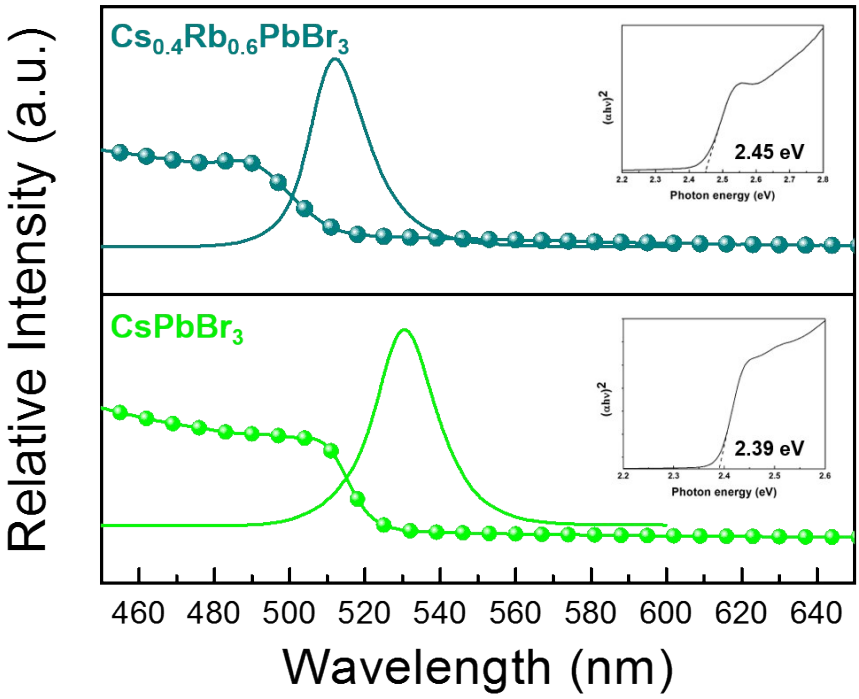

Figure S4. *Y.H. Song et al*.