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Electronic Supplementary Information (ESI†)

Inorganic red perovskite quantum dots integrated blue chip: a promising candidate for high color-rendering in w-LED†

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Experimental Details

Materials

Cesium carbonate (Cs_2CO_3, Aldrich, 99.9%), lead bromide ($PbBr_2$, ABCR, 98%), lead iodide (PbI_2, ABCR, 99.999%), 1-octadecene (ODE, Aldrich, 90%), oleic acid (OA, Sigma-Aldrich, 90%) oleylamine (OAm, Acros Organics, 80%–90%), YAG:Ce^{3+} yellow (YAG04, Intematix) and silicon resin (Dow Corning OE-6631 A and B) were used during the studies.

Synthesis of inorganic red perovskite $CsPb(Br_{0.3}I_{0.7})_3$ (R-PQDs) via hot injection method

Preparation of Cs oleate precursor

In a typical synthesis of the Cs oleate precursor, 0.407 g of Cs_2CO_3, 1.25 mL of OA, and 20 mL of ODE were mixed in a three-necked bottle with 50 mL capacity. Moister and oxygen contents involved in the solutions were removed under vacuum condition at 120 °C for 1 h. Thereafter, the temperature of the above mixture solution was increased to 150 °C for 20 minutes under N_2 environment until Cs_2CO_3 was fully dissolved in oleic acid. The obtained Cs-

oleate precursor solution was then stored in a refrigerator and used to synthesize perovskite quantum dots.

Synthesis of R-PQDs

In a typical synthesis of the $CsPb(Br_{0.3}I_{0.7})_3$ R-PQDs (Cs, 20 mL of ODE, 0.808 g of $PbBr_2$, 0.2408 g PbI_2, 2.6 mL of OA, and 2.6 mL of OAm were mixed in a 50 mL three-necked bottle. Water and oxygen contents in the mixture solutions were removed under vacuum condition at at 120 °C for 30 min. Thereafter temperature of the solution was increased to 190 °C in a N_2 environment and maintained the temperature for the 10 min approximately. Further, 1.6 mL of Cs-oleate precursor, which was pre-heated at 120 °C, was injected into the prepared solution. After 5 s, the three-necked bottle was placed in an ice bath and cooled to room temperature. The crude solution was collected via centrifugation at 9000 rpm at 10 °C and finally the precipitate was dispersed in a hexane solution**.** Moreover, other compositions were prepared by following the same procedure as stated above with different constituents of $PbBr_2$ and PbI_2.

Fabrication of inorganic R-PQD integrated YAG: Ce phosphor-based White LEDs

In the light emitting diode (LED) packaging procedure, 0.25 mL of R-PQDs (10 mg/mL) in hexane solution was mixed with 0.5 g of silicon resin B. The resulting mixture was then heated to 40 °C for 1 h to remove the solvent. A half equal of silicon resin A (0.25 g) and red PQDs (0.025 g) were mixed with the previously prepared red QD silicon resin B mixture. The mixture was dropped onto a blue chip and thermally cured for 2 h at 100 °C in an oven after the bubbles were removed. The electroluminescent properties of the fabricated devices were determined by

using an integrating sphere spectroradiometer system (LHS-1000, Everfine) with an analyzer system (Everfine Photo-EINFO Co., Ltd.).

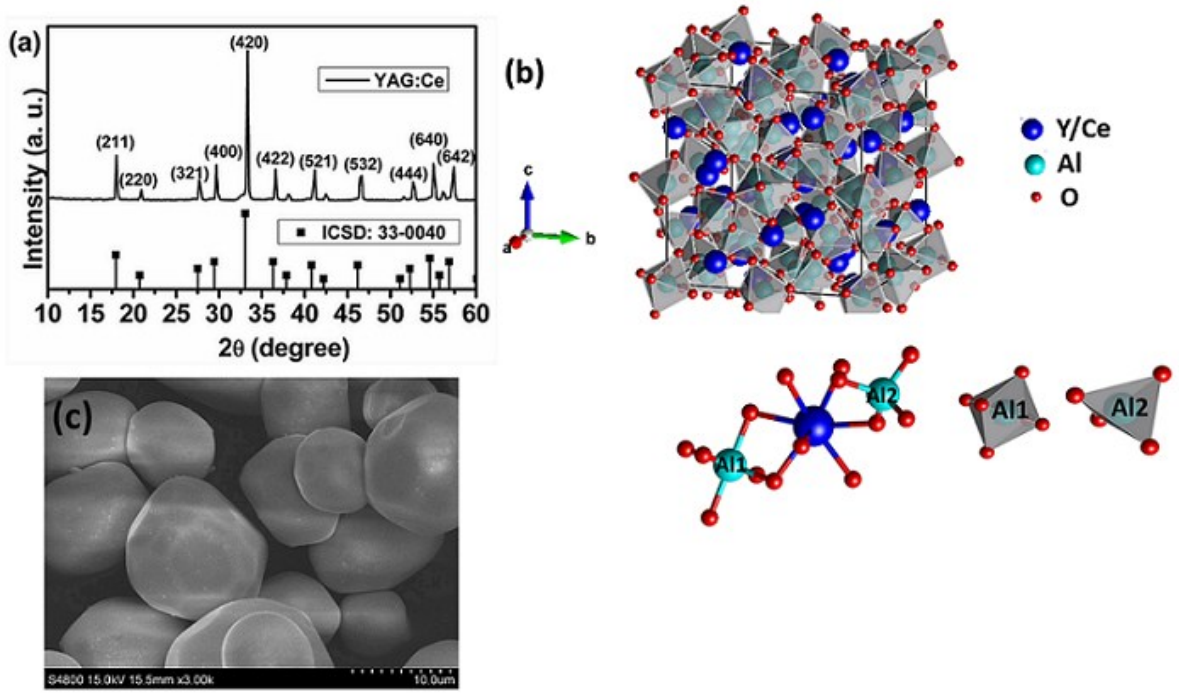

Fig. S1 (a) XRD patterns of commercial YAG:Ce, (b) polyhedral represenation of structral units in YAG:Ce and (c) SEM micrograph of YAG:Ce.

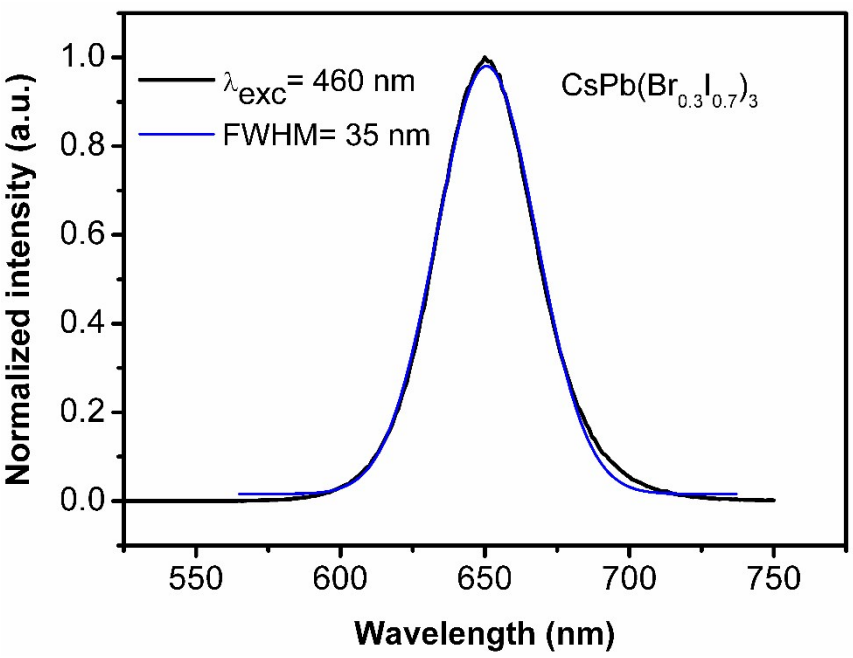

Fig. S2 Typical Gauss peak fitting and corresponding FWHM of $CsPb(Br_{0.3}I_{0.7})_3$ R-PQDs (650 nm peak max.) under 460 nm excitation wavelength.

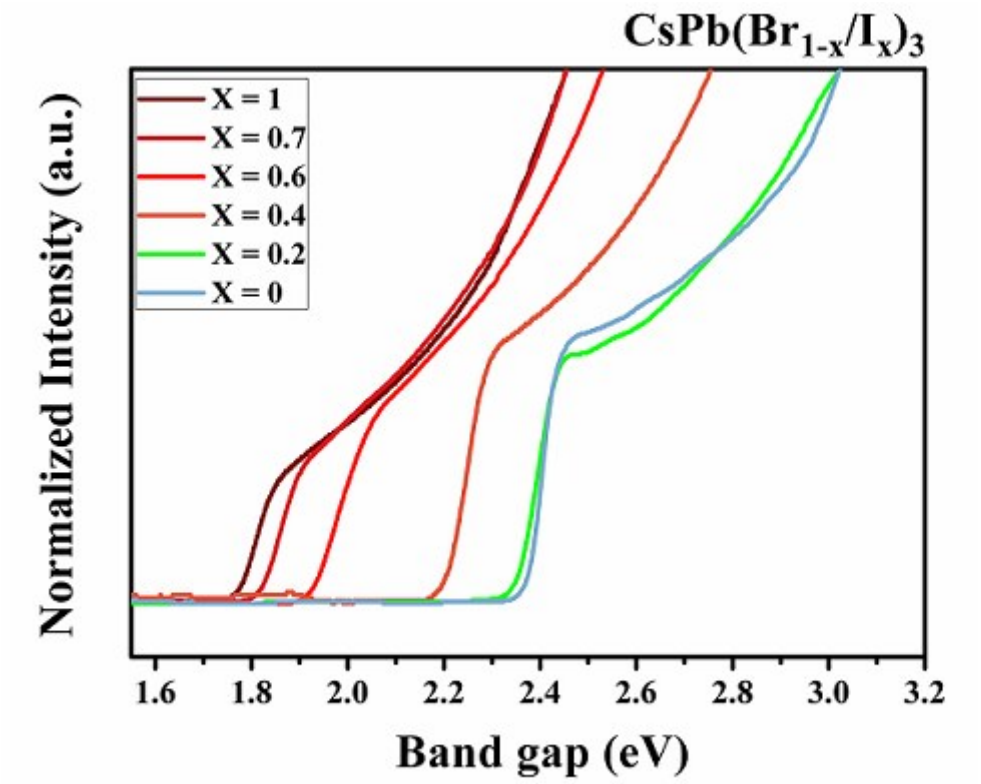

Fig. S3 optical band gap estimation of $CsPb(Br_{1-x}I_x)_3$, x=0, 0.2, 0.4, 0.6, 0.7 and 1, using the Wood-Tauc model.

Table S1: composition, emission peak maxima and their corresponding FWHM

$CsPb(Br_{1-x}I_x)_3$		
X	Wavelength (nm)	FWHM (nm)
0.5	578	35
0.6	625	35
0.7	650	35
1	690	36

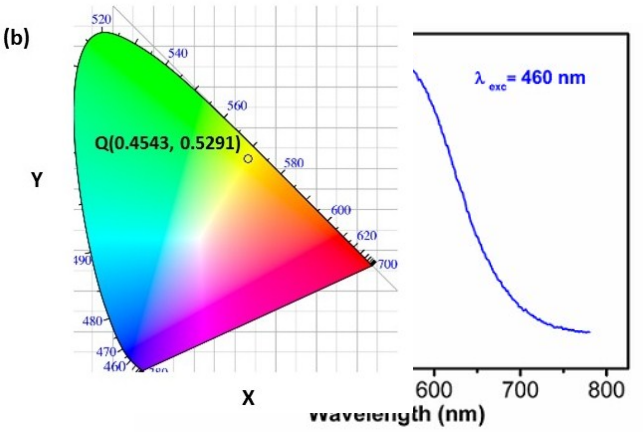

Fig. S4 (a) Excitation and emission spectra and (b) CIE coordinates of YAG:Ce phosphor.