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Supporting information

A zero-thermal-quenching perovskite-like phosphor with ultra-narrow-band blue-emitting for wide color gamut backlight display application

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Table S1 Crystallographic parameters obtained from XRD Rietveld refinement for BGKPOF:0.06Eu^{2+} sample.

Formula	$K_2BaPO4F:0.015Eu^{2+}$
Space group	I 4/mcm (140) - tetragonal
a=b (Å)	7.0418(7)
c (Å)	11.2835(7)
$\alpha=\beta=\gamma$ (deg)	90
Z	4
V ($Å^3$)	559.53
Rwp%	8.79
Rp%	6.39
χ^2	2.547

Table S2 The final refined atomic coordinates and occupancy for the as-obtained KBPOF:0.015Eu^{2+} sample.

atom	x	y	z	U_{iso}
K1	0.50000(0)	0.50000(0)	0.75000(0)	0.01023
Ba1	0.17743(0)	0.32257(0)	0.50000(0)	0.01150
P1	0.50000(0)	0	0.25000(0)	0.00821
O1	0.37550(1)	0.12450(0)	0.32754(3)	0.01524
F1	0.50000(0)	0.50000(0)	0.50000(0)	0.01305

Table S3 Main bond lengths (Å) and average bond length (R_{av}) of KBPOF:1.5%Eu^{2+} sample.

Vector	Length	Vector	Length
Ba1−F1	2.820(9)	K1−F1	2.592(5)
Ba1−F1	2.820(9)	K1−F1	2.592(5)
Ba1−O1	2.920(0)	K1−O1	2.770(8)
Ba1−O1	2.920(0)	K1−O1	2.906(2)
Ba1−O1	2.920(0)	K1−O1	2.906(2)
Ba1−O1	2.920(0)	K1−O1	2.906(2)
Ba1−O1	2.920(0)	K1−O1	2.770(8)
Ba1−O1	2.920(0)	K1−O1	2.906(2)
Ba1−O1	2.920(0)		
Ba1−O1	2.920(0)		

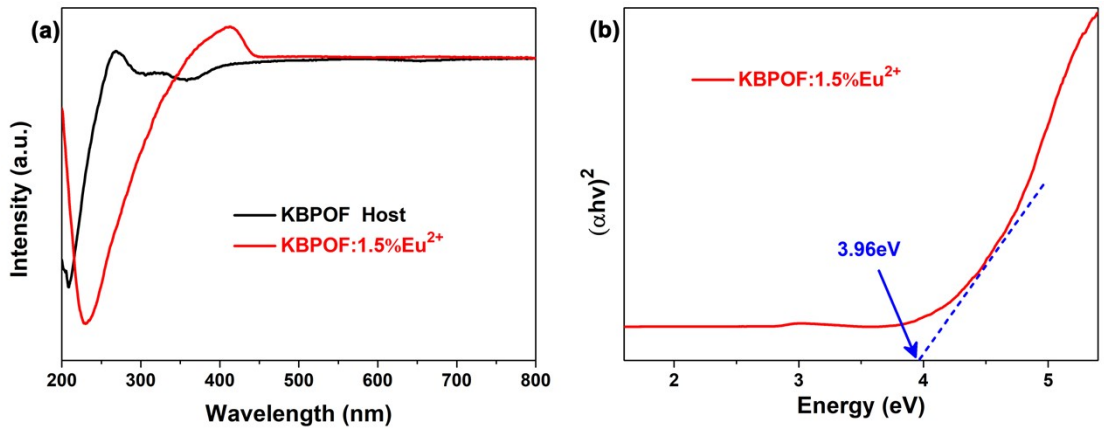

Fig. S1 (a) Diffuse reflectance spectra of the KBPOF host and KBPOF:1.5%Eu^{2+} sample, (b) the extrapolation of band gap energy of KBPOF:1.5%Eu^{2+} sample.

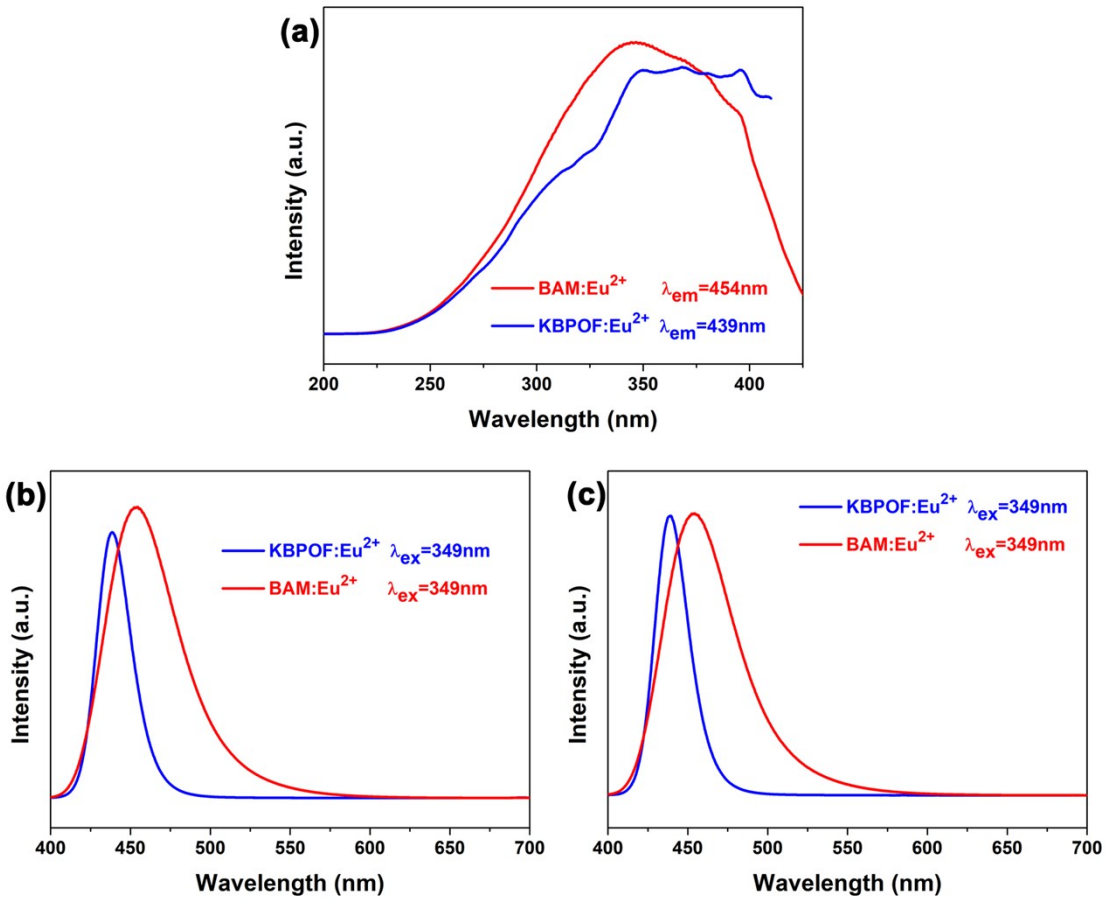

Fig. S2 Comparison of the (a) excitation and (b, c) emission spectra between the KBPOF:1.5%Eu^{2+} sample and commercial BAM:Eu^{2+} ($BaMgAl_{10}O_{17}$:Eu^{2+}) phosphor under identical measurement conditions.

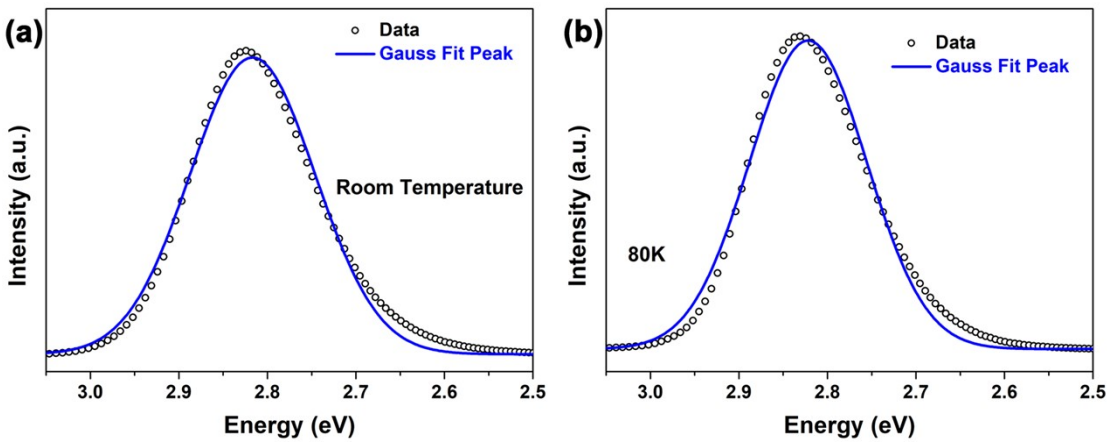

Fig. S3 Gaussian fitting of the emission band (λ_{ex}=380nm) recorded at (a) room temperature and (b) 80 K.

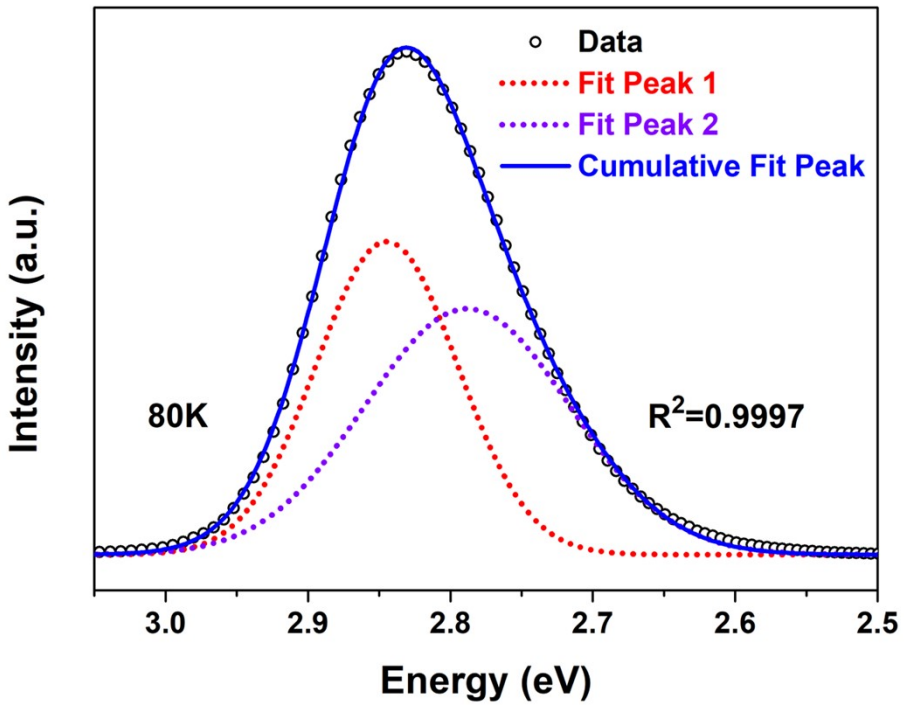

Fig. S4 Gaussian fitting of the emission band (λ_{ex}=380nm, recorded at 80 K) for the KBPOF:1.5%Eu^{2+} phosphor.

Table S4 Ionic radius, average bond length, β_{ploy} and ε_{cfs} for K(1) and Ba(1) sites.

	Ba(1)		K(1)	
CN	10		8	
r	Ba^{2+}	Eu^{2+}	K^{+}	Eu^{2+}
	1.52	1.35	1.51	1.25
R_{av}	2.900(2)		2.793(9)	
DI	0.0109		0.0402	
D_r	11.2%		17.2%	

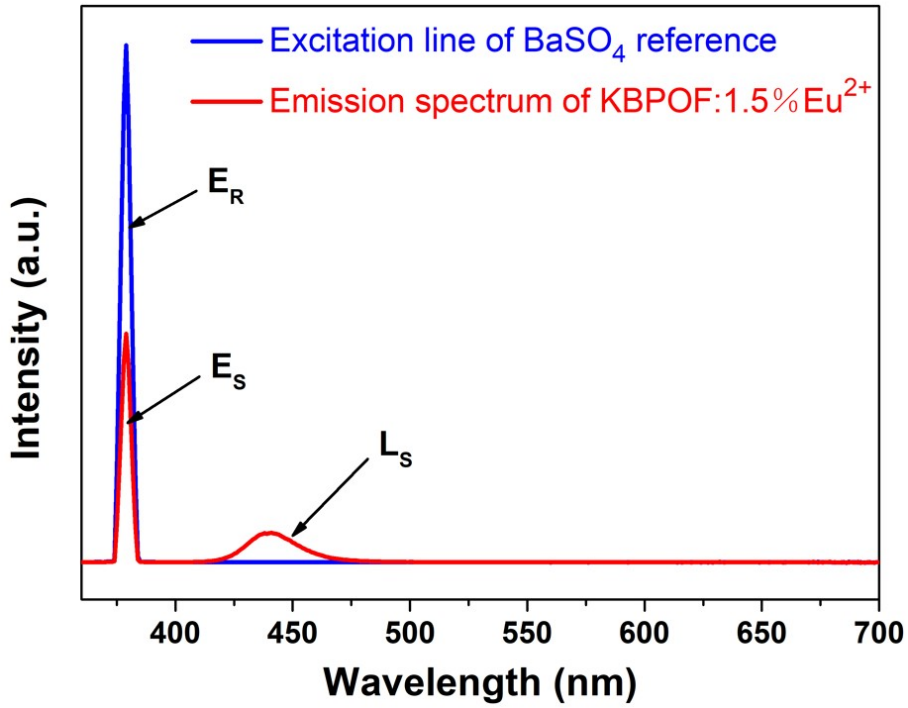

Fig. S5 Excitation and emission spectra of $BaSO_4$ reference sample and KBPOF:1.5%Eu^{2+} phosphor collected by a spectrofluorometer equipped with an integrating sphere.

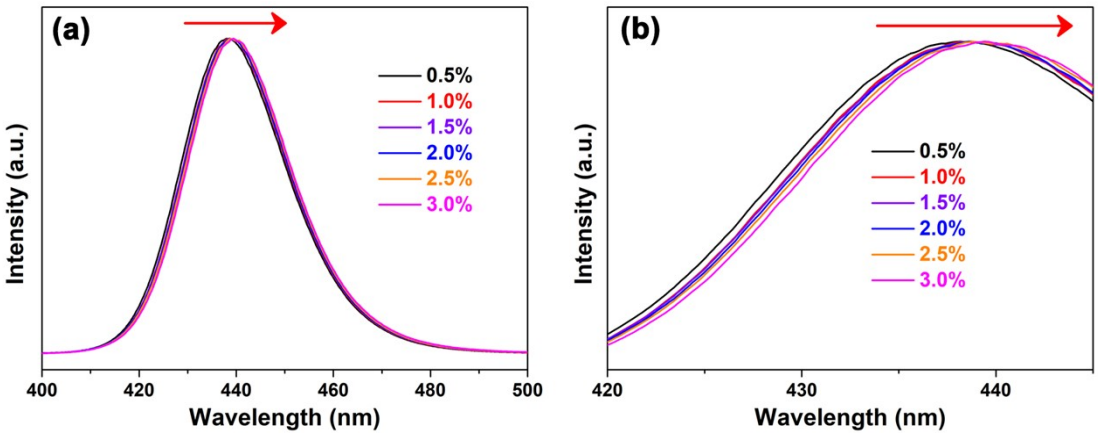

Fig. S6 (a) Normalized emission spectra and (b) magnified normalized emission spectra of the KBPOF:xEu^{2+} samples under 380 nm excitation.

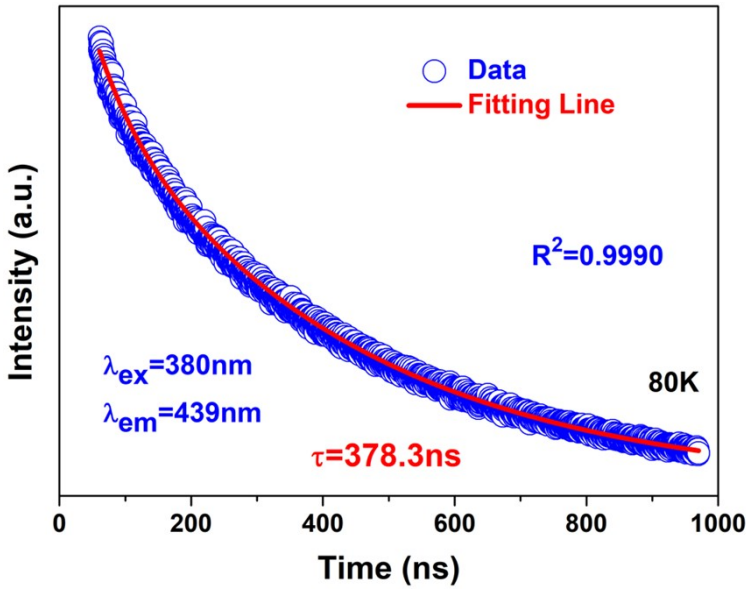

Fig. S7 Decay curve of the KBPOF:1.5%Eu^{2+} phosphor recorded at 80 K.

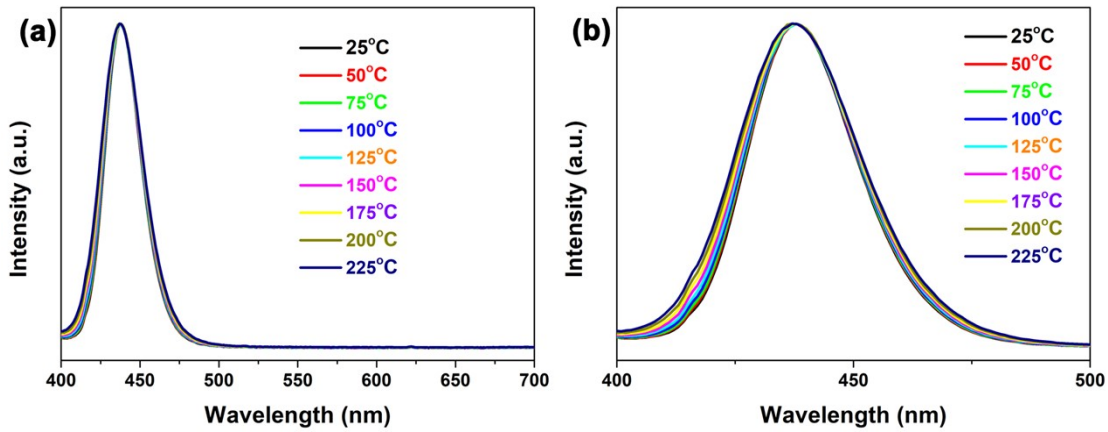

Fig. S8 (a) Normalized temperature-dependent emission spectra and (b) magnified normalized temperature-dependent emission spectra of the KBPOF:1.5%Eu^{2+} sample under 380 nm excitation.

Table S5 Reliability factors and crystallographic parameters obtained from XRD Rietveld refinement for the KBPOF:1.5%Eu^{2+} sample at different temperatures.

T (°C)	χ^2	*Rwp*%	*Rp*%	a=b (Å)	c (Å)
25	3.693	7.07	5.16	7.0418(7)	11.2835(7)
75	3.719	7.14	5.26	7.0508(6)	11.2970(0)
125	3.675	7.14	5.19	7.0590(3)	11.3080(8)
175	3.519	7.07	5.24	7.0675(3)	11.3200(7)
225	3.753	7.25	5.34	7.0768(8)	11.3328(9)

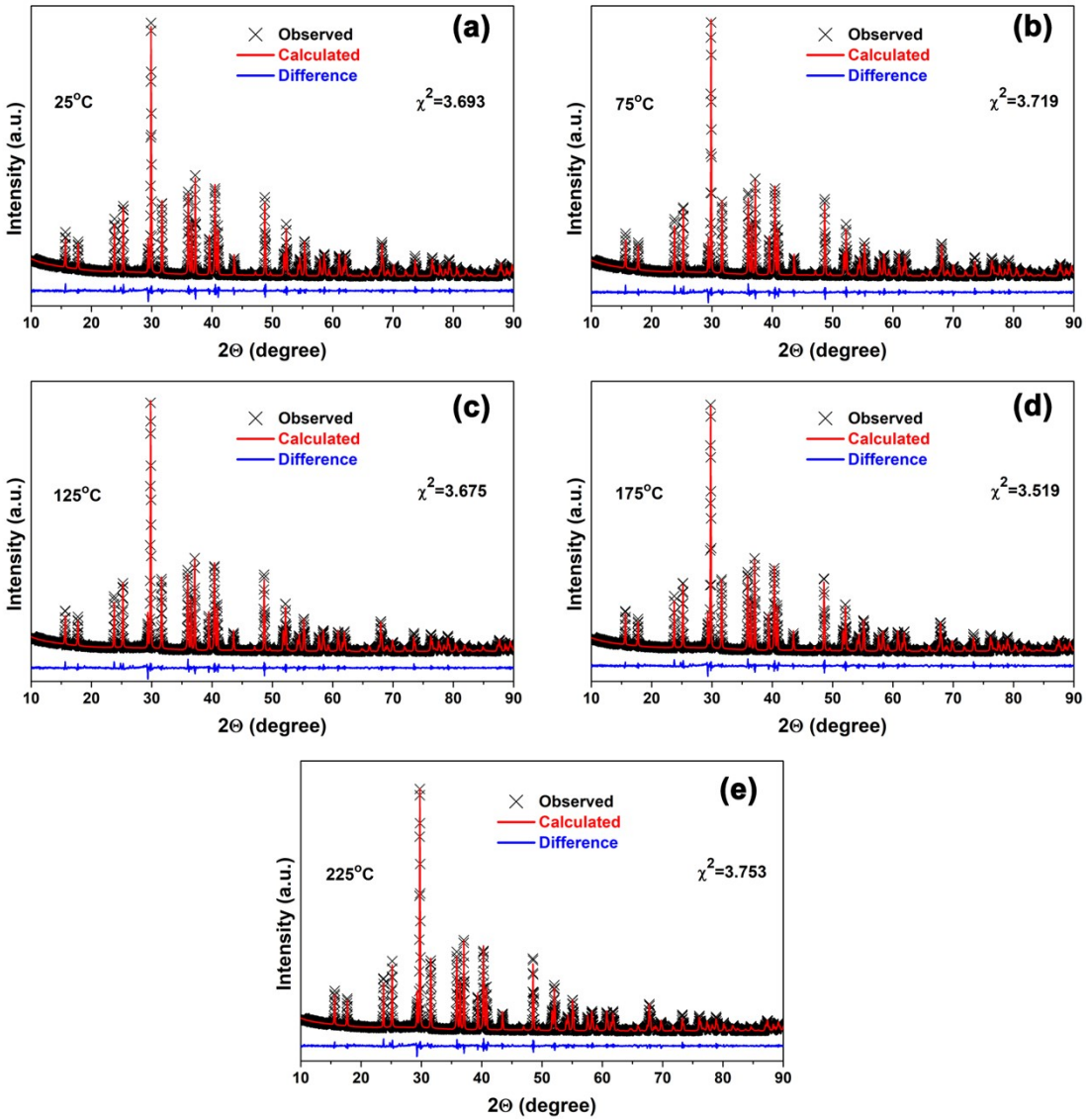

Fig. S9 XRD refinement results of the KBPOF:1.5%Eu^{2+} sample at different temperature: (a) 25 °C, (b) 75 °C, (c) 125 °C, (d) 175 °C and (e) 225 °C.

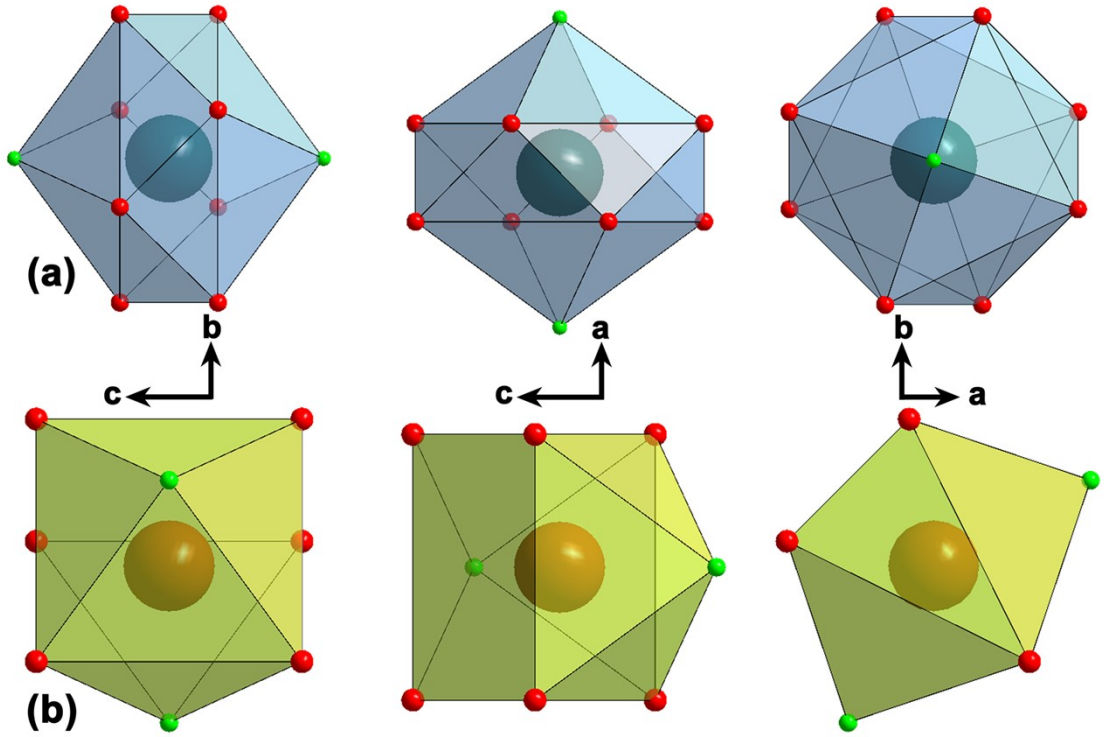

Fig. S10 (a) BaO_8F_2 and (b) KO_6F_2 coordination polyhedrons viewed along the *a*-axis, *b*-axis and *c*-axis direction, respectively.

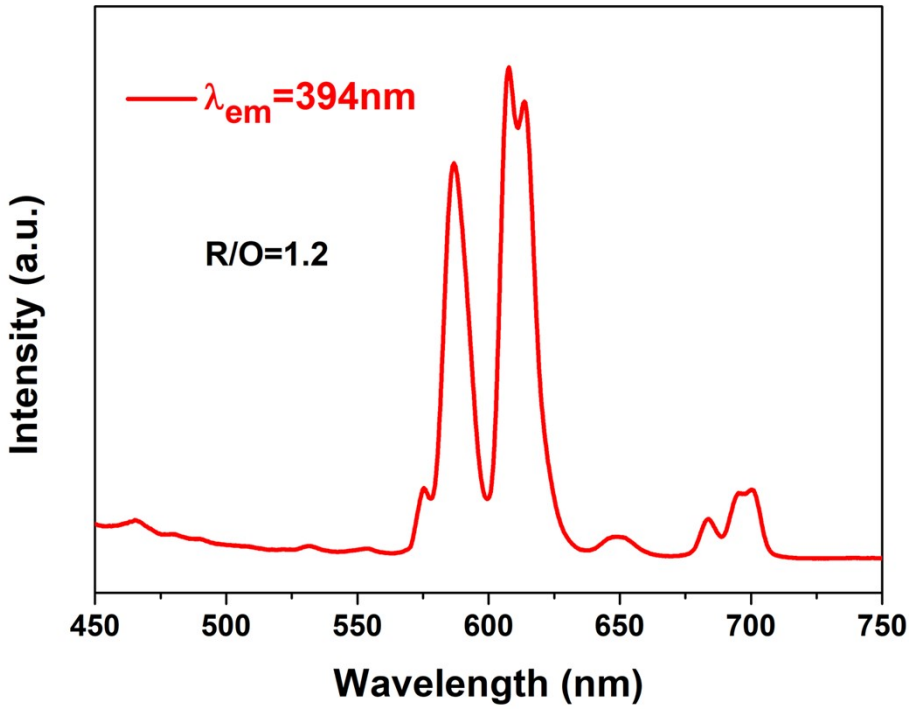

Fig. S11 Emission spectrum of the KBPOF:1.5%Eu^{3+} sample.

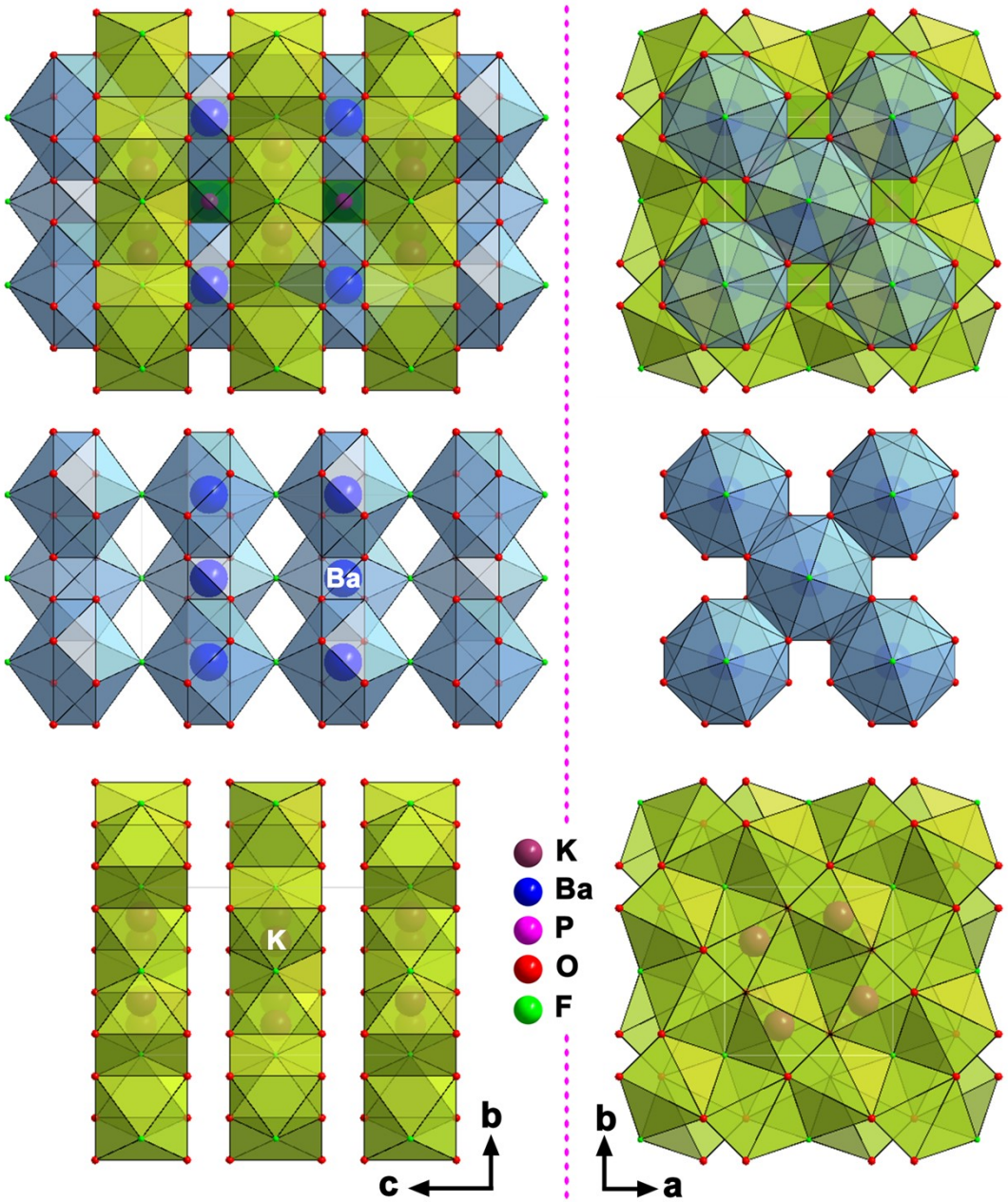

Fig. S12 BaO_8F_2, KO_6F_2, and PO_4 coordination polyhedrons viewed along (a) the *a*-axis and (c) *c*-axis direction, respectively.

Table S6 The photoelectric properties of WLED fabricated by depositing the commercial red phosphor KSF:Mn^{4+}, green phosphor β-SiAlON:Eu^{2+} and as-synthesized blue phosphor KBPOF:1.5%Eu^{2+} on a 380 nm n-UV LED chip under various drive currents.

Current (mA)	CC*T* (K)	CIE-x	CIE-y	Ra
20	5144	0.3402	0.3346	67.4
60	5506	0.3323	0.3357	66.9
120	5474	0.3330	0.3355	68.0
180	5674	0.3287	0.3357	67.7
240	5636	0.3295	0.3362	69.8
300	5692	0.3282	0.3370	70.1

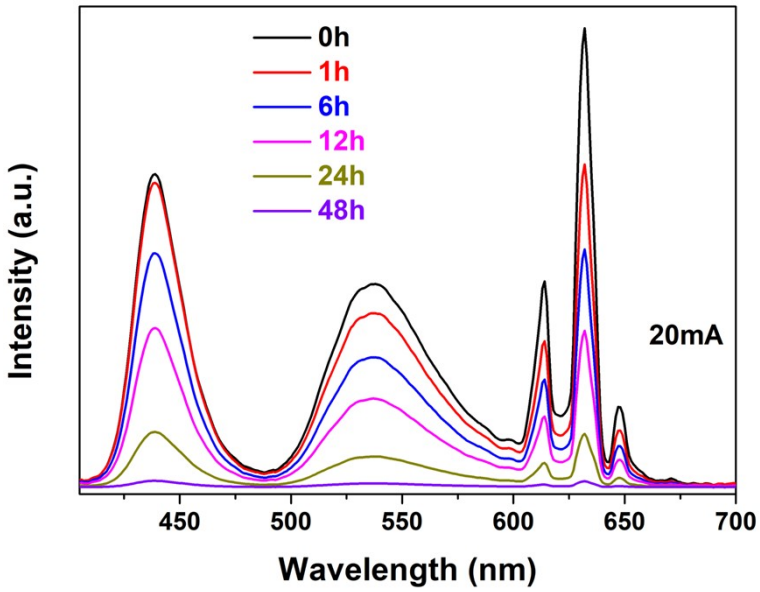

Fig. S13 EL spectra of the as-fabricated WLED device measured at different working time.