Electronic Supplementary Information (ESI)

A new single-component $KCaY(PO_4)_2:Dy^{3+}$, Eu^{3+} nanosized phosphor with high color-rendering index and excellent thermal resistance for warm-white NUV-LED

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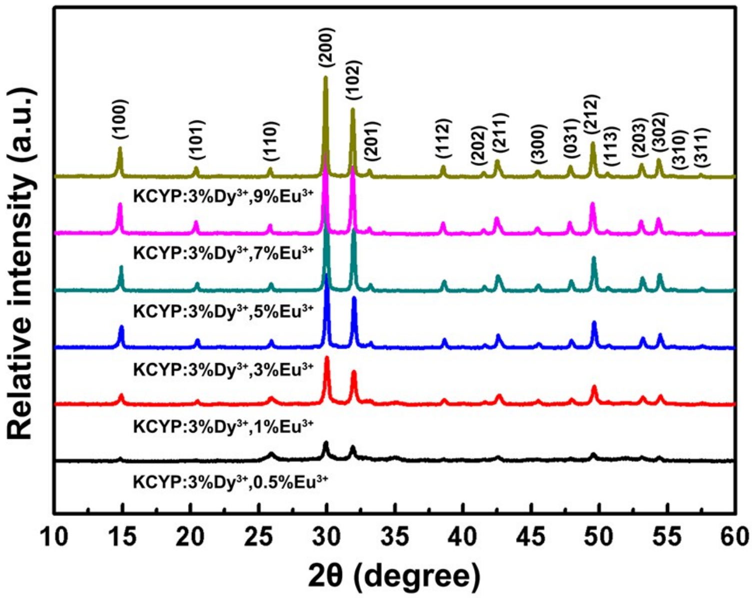

Fig. S1 Powder XRD patterns of the as-synthesized KCYP:3%Dy^{3+}, *n*%Eu^{3+} specimens with various Eu^{3+} doping contents (*n* = 0.5, 1, 3, 5, 7, and 9).

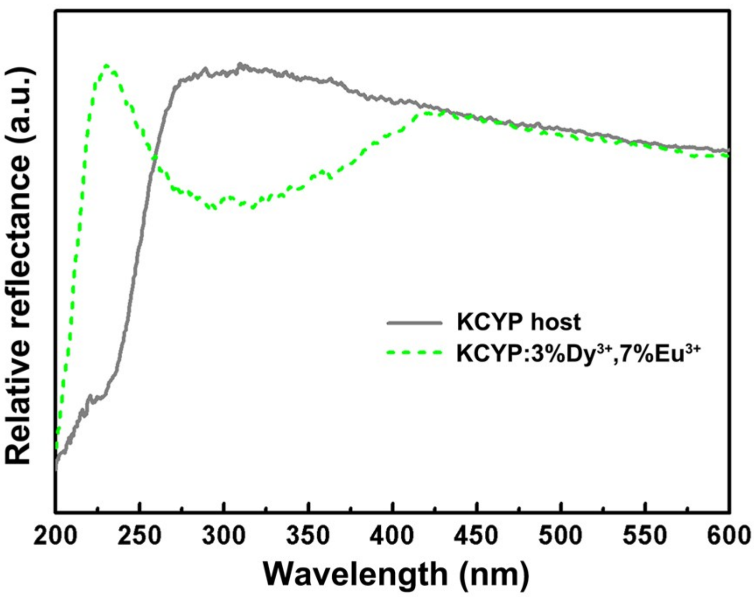

Fig. S2 Diffuse reflection spectra of the KCYP host (gray line) and the KCYP:3%Dy^{3+}, 7%Eu^{3+} sample (green dash line).

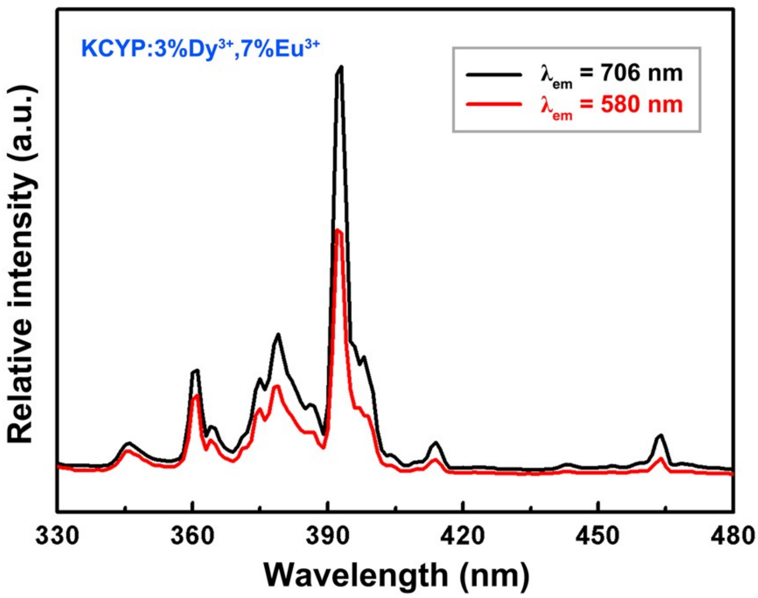

Fig. S3 Comparison of PLE spectra of the KCYP:3%Dy^{3+}, 7%Eu^{3+} sample upon different monitoring wavelength.

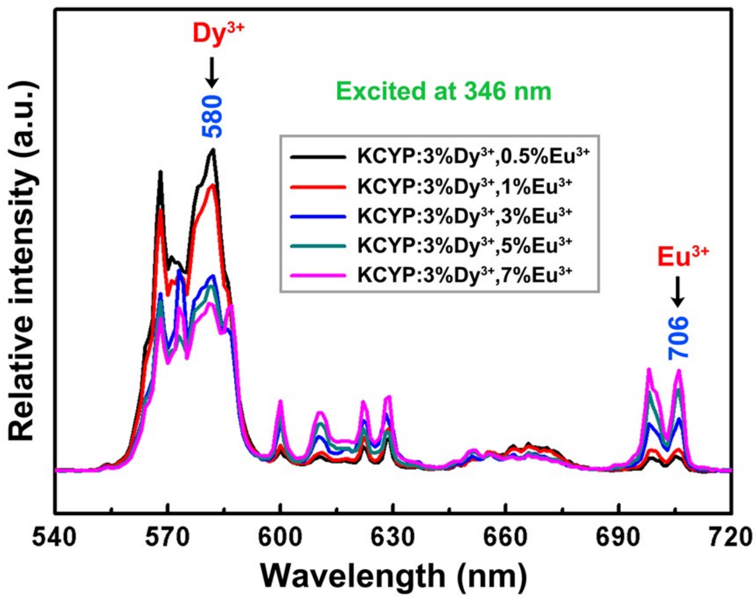

Fig. S4 PL spectra (λ_{ex} = 346 nm) of the KCYP:3%Dy^{3+}, *n*%Eu^{3+} nanophosphor with changed *n* values (*n* = 0.5, 1, 3, 5, and 7).

Table S1. Time-resolved fluorescence dynamics of the KCYP:Dy^{3+}, Eu^{3+} nanosized phosphor.

Samples	τ_1 (μs)	τ_2 (μs)	τ_{ave} (μs)
KCYP:3%Dy^{3+}	121 (13%)	796 (87%)	708
KCYP:3%Dy^{3+}, 0.5%Eu^{3+}	114 (15%)	740 (85%)	646
KCYP:3%Dy^{3+}, 1%Eu^{3+}	108 (18%)	688 (82%)	584
KCYP:3%Dy^{3+}, 3%Eu^{3+}	100 (22%)	668 (78%)	543
KCYP:3%Dy^{3+}, 5%Eu^{3+}	93 (25%)	650 (75%)	511
KCYP:3%Dy^{3+}, 7%Eu^{3+}	82 (28%)	642 (72%)	485

Table S2. CIE 1931 chromaticity coordinates and correlated color temperature (CCT) of the KCYP:Dy^{3+}, Eu^{3+} nanoscale phosphor.

Sample composition	CIE coordinates (x, y)	CCT (K)
KCYP:3%Dy^{3+}, 0.5%Eu^{3+}	(0.354, 0.377)	4781
KCYP:3%Dy^{3+}, 1%Eu^{3+}	(0.373, 0.378)	4199
KCYP:3%Dy^{3+}, 3%Eu^{3+}	(0.403, 0.372)	3338
KCYP:3%Dy^{3+}, 7%Eu^{3+}	(0.427, 0.369)	2766
KCYP:3%Dy^{3+}, 9%Eu^{3+}	(0.464, 0.366)	2131

Table S3. Full set of eight CRIs and the average Ra value of the KCYP:3%Dy^{3+}, 7%Eu^{3+} sample.

CRI	R1	R2	R3	R4	R5	R6	R7	R8	Ra
Sample	90	89	67	81	96	84	75	71	81.6

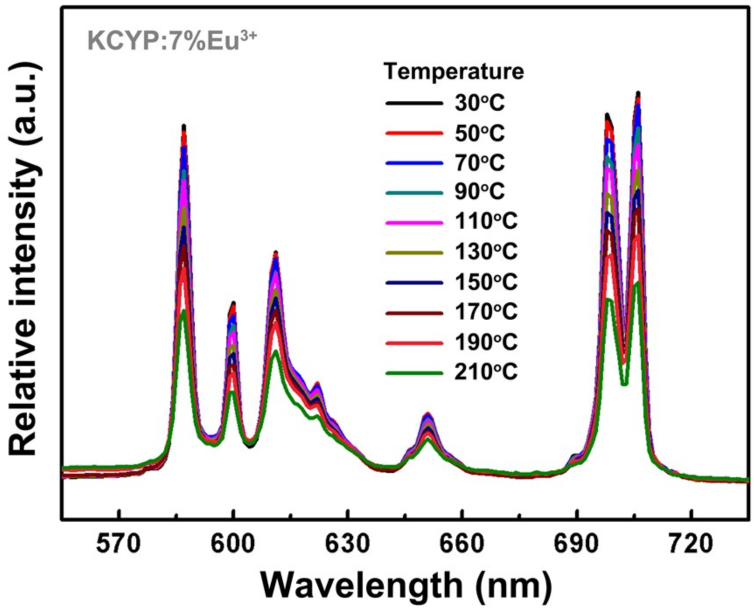

Fig. S5 Emission spectra (λ_{ex} = 391 nm) of the KCYP:7%Eu^{3+} sample at temperature between 30 and 210 °C.

Table S4. Comparison of optical properties and temperature characteristic of some reported $MCaLn(PO_4)_2$ (M^+ = Na, K; Ln^{3+} = Y, Gd) based phosphors with excellent performance.

Phosphors	Preparation method	Emission color	^{a}CCT (K)	^{b}CRI (Ra)	$^cI_{150}$ (%)	^dE_a (eV)	References
NCYP:Eu	Solid-state reaction (1250 °C)	Blue	–	–	65	0.201	1
KCGP:Eu	Solid-state reaction (1350 °C)	Blue	–	–	68	0.038	2
KCYP:Eu,Mn	Solid-state reaction (1250 °C)	White	> 4500	< 70	80	0.025	3
KCYP:Dy,Eu	Solution-combustion (400 °C)	Warm-white	2766	81.6	72	0.174	This work

NCYP:Eu represents $NaCaY(PO_4)_2$:1%Eu^{2+}.

KCGP:Eu represents $KCaGd(PO_4)_2$:1%Eu^{2+}.

KCYP:Eu,Mn represents $KCaY(PO_4)_2$:1%Eu^{2+}, 5%Mn^{2+}.

KCYP:Dy,Eu represents $KCaY(PO_4)_2$:3%Dy^{3+}, 7%Eu^{3+}.

[a]CCT: Correlated color temperature.

[b]CRI: Color-rendering index.

[c]I_{150}: The relative PL intensity when the temperature is increased up to 150 °C compared to the initial intensity at room temperature and the values may change a little because of the difference in the measurement method and the activator concentration.

[d]E_a: Activation energy.

References

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