

Supporting Information

Concentration-Driven Selectivity of Energy Transfer Channels and Color Tunability in Ba₃La(PO₄)₃: Tb³⁺, Sm³⁺ for Warm White LEDs

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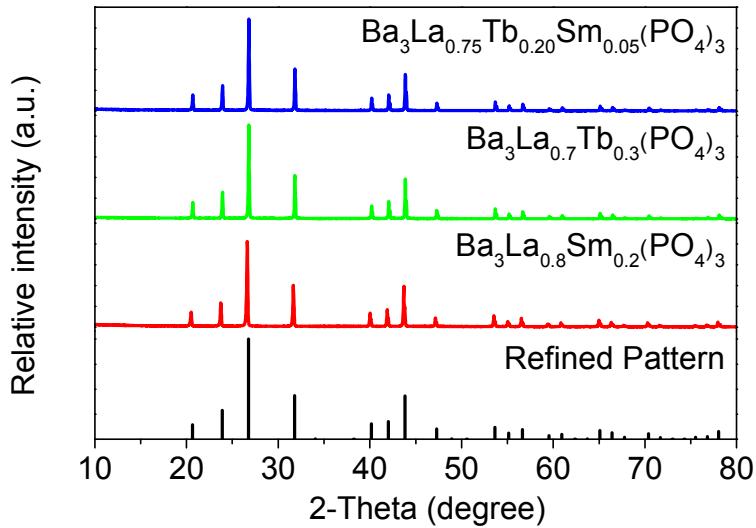


Figure S1. Representative XRD patterns of samples $\text{Ba}_3\text{La}_{0.8}\text{Sm}_{0.2}(\text{PO}_4)_3$, $\text{Ba}_3\text{La}_{0.7}\text{Tb}_{0.3}(\text{PO}_4)_3$ and $\text{Ba}_3\text{La}_{0.75}\text{Tb}_{0.20}\text{Sm}_{0.05}(\text{PO}_4)_3$ at RT.

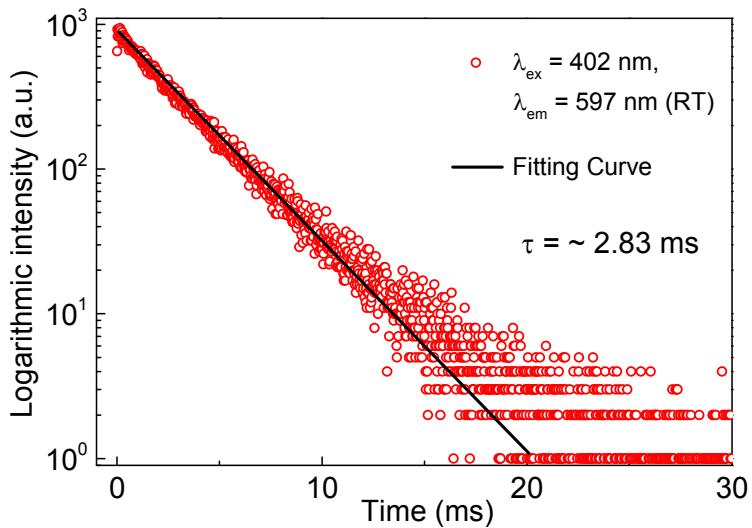


Figure S2. The luminescence decay curve ($\lambda_{\text{ex}} = 402 \text{ nm}$, $\lambda_{\text{em}} = 597 \text{ nm}$) of sample $\text{Ba}_3\text{La}_{0.995}\text{Sm}_{0.005}(\text{PO}_4)_3$ at RT and the corresponding fitting curve.

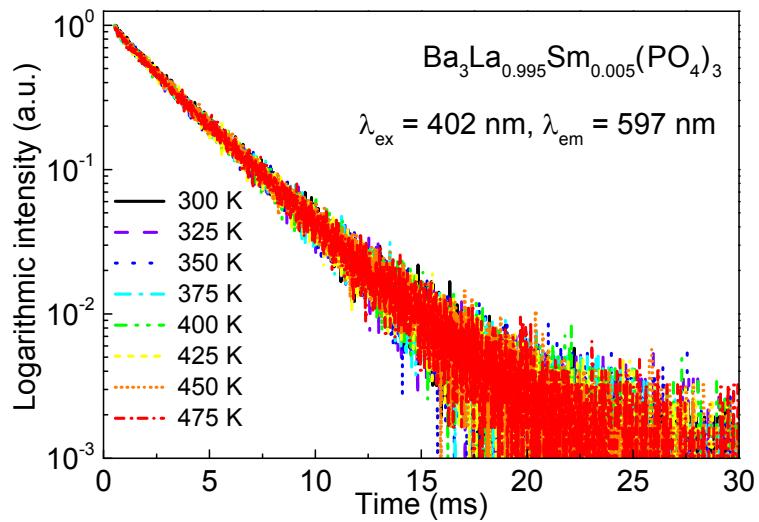


Figure S3. The temperature-dependent luminescence decay curves ($\lambda_{\text{ex}} = 402 \text{ nm}$, $\lambda_{\text{em}} = 597 \text{ nm}$) of sample $\text{Ba}_3\text{La}_{0.995}\text{Sm}_{0.005}(\text{PO}_4)_3$ in a temperature range of $300 - 475 \text{ K}$.

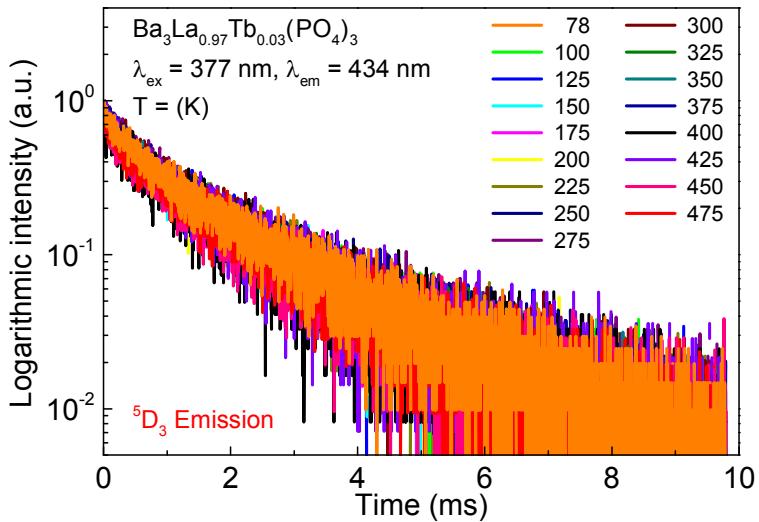


Figure S4. The temperature-dependent luminescence decay curves ($\lambda_{\text{ex}} = 377 \text{ nm}$, $\lambda_{\text{em}} = 434 \text{ nm}$) of ${}^5\text{D}_3$ levels of Tb^{3+} ions in the temperature range of $78 - 475 \text{ K}$.

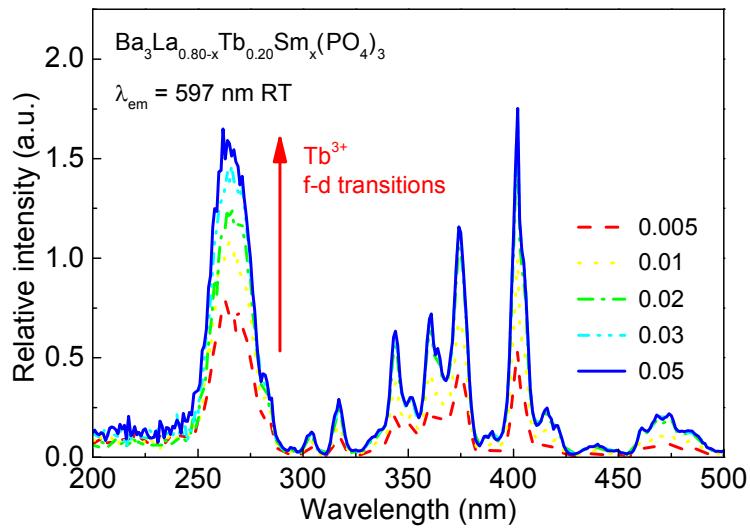


Figure S5. The excitation ($\lambda_{\text{em}} = 597$ nm) spectra of samples $\text{Ba}_3\text{La}_{0.80-x}\text{Tb}_{0.20}\text{Sm}_x(\text{PO}_4)_3$ ($x = 0.005 - 0.05$) at RT.

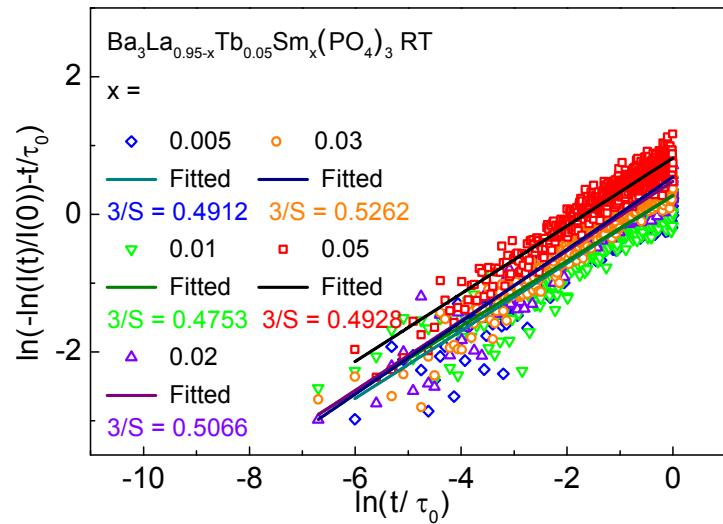


Figure S6. The straight lines evolved from the luminescence decay curves ($\lambda_{\text{ex}} = 377$ nm, $\lambda_{\text{em}} = 434$ nm) of $\text{Ba}_3\text{La}_{0.95-x}\text{Tb}_{0.05}\text{Sm}_x(\text{PO}_4)_3$ ($x = 0 - 0.05$) at RT and the corresponding fitting curves.

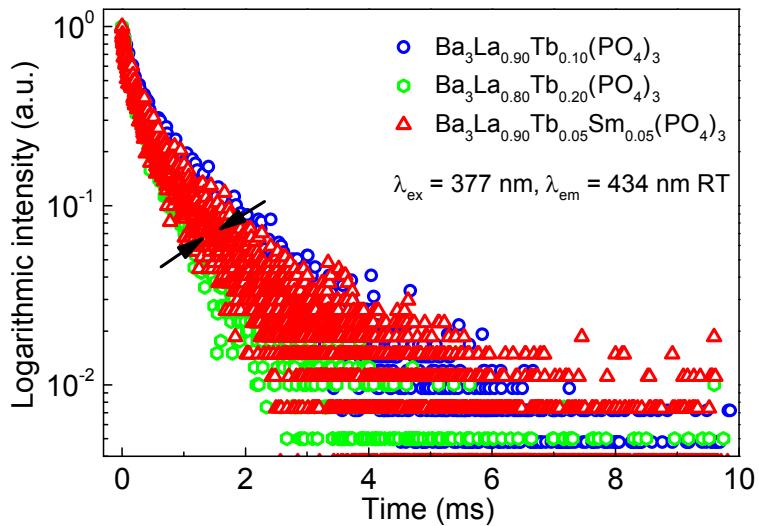


Figure S7. The comparison between the luminescence decay curves ($\lambda_{\text{ex}} = 377 \text{ nm}$, $\lambda_{\text{em}} = 434 \text{ nm}$) of $\text{Ba}_3\text{La}_{1-y}\text{Tb}_y(\text{PO}_4)_3$ ($y = 0.10, 0.20$) and $\text{Ba}_3\text{La}_{0.90}\text{Tb}_{0.05}\text{Sm}_{0.05}(\text{PO}_4)_3$ at RT.

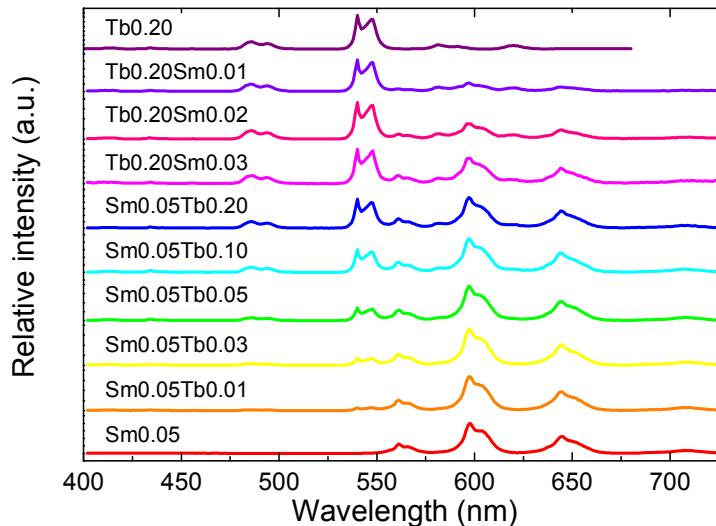


Figure S8. The emission ($\lambda_{\text{ex}} = 377 \text{ nm}$) spectra of two sets of co-doped samples $\text{Ba}_3\text{La}_{0.80-x}\text{Tb}_{0.20}\text{Sm}_x(\text{PO}_4)_3$ ($x = 0 - 0.05$) and $\text{Ba}_3\text{La}_{0.95-y}\text{Tb}_y\text{Sm}_{0.05}(\text{PO}_4)_3$ ($y = 0 - 0.20$).

Table S1. The concentrations of Sm^{3+} ions (C_A), obtained energy transfer microparameters C_{DA} and coefficients of determination of fitting procedures (R_{adj}^2) via Inokuti-Hirayama model.

Sm^{3+} (at. %)	$C_A (10^{26} \text{ m}^{-3})$	$C_{DA} (10^{-54} \text{ m}^6/\text{s})$	R_{adj}^2
0.03	4.113	3.192	0.9969
0.05	6.855	4.459	0.9958
0.07	9.597	5.468	0.9956
0.10	13.71	5.438	0.9945
0.15	20.57	6.036	0.9929
0.20	27.42	7.428	0.9952

Table S2. The concentrations of Sm^{3+} ions (C_A), obtained energy transfer microparameters C_{DA} , energy migration microparameters C_{DD} and coefficients of determination of fitting procedures (R_{adj}^2) via Yokota-Tanimoto and Burshtein models.

Sm^{3+} (at. %)	$C_A (10^{26} \text{ m}^{-3})$	$C_{DA} (10^{-54} \text{ m}^6/\text{s})$	$C_{DD} (10^{-54} \text{ m}^6/\text{s})$	R_{adj}^2
Y-T model				
0.03 (Failed)	4.113	3.778	-3.514	0.9962
0.05 (Failed)	6.855	3.357	5.045	0.9953
0.07 (Failed)	9.597	4.402	2.839	0.9954
0.10 (Failed)	13.71	4.289	2.161	0.9952
0.15 (Failed)	20.57	4.675	1.702	0.9952
0.20 (Succeeded)	27.42	7.105	0.2410	0.9949
Burshtein model				
0.03 (Failed)	4.113	3.124	1.542E-14	0.9957
0.05 (Failed)	6.855	3.064	6.706	0.9954
0.07 (Failed)	9.597	4.112	2.153	0.9955
0.10 (Failed)	13.71	3.992	1.480	0.9953
0.15 (Failed)	20.57	4.357	0.9780	0.9953
0.20 (Failed)	27.42	7.017	0.01901	0.9949

Table S3. The concentrations of Tb^{3+} ions (C_A), obtained energy transfer microparameters C_{DA} and coefficients of determination of fitting procedures (R_{adj}^2) via Inokuti-Hirayama model.

Tb^{3+} (at. %)	$C_A (10^{26} \text{ m}^{-3})$	$C_{DA} (10^{-53} \text{ m}^6/\text{s})$	R_{adj}^2
0.03	4.113	4.765	0.9825
0.05	6.855	2.720	0.9877
0.08	10.97	1.870	0.9844
0.10	13.71	1.549	0.9842

Table S4. The concentrations of Tb^{3+} ions (C_A), obtained energy transfer microparameters C_{DA} , energy migration microparameters C_{DD} and coefficients of determination of fitting procedures (R_{adj}^2) via Yokota-Tanimoto and Burshtein models.

Tb^{3+} (at. %)	$C_A (10^{26} \text{ m}^{-3})$	$C_{DA} (10^{-53} \text{ m}^6/\text{s})$	$C_{DD} (10^{-54} \text{ m}^6/\text{s})$	R_{adj}^2
Y-T model				
0.03 (Failed)	4.113	5.038	-5.467	0.9825
0.05 (Failed)	6.855	2.463	4.825	0.9879
0.08 (Failed)	10.97	1.721	2.123	0.9847
0.10 (Failed)	13.71	1.612	-0.6950	0.9842
Burshtein model				
0.03 (Failed)	4.113	4.992	1.380E-14	0.9830
0.05 (Failed)	6.855	2.349	1.806	0.9869
0.08 (Failed)	10.97	1.653	0.5866	0.9840
0.10 (Failed)	13.71	1.545	8.250E-15	0.9885

Table S5. The CIE chromaticity coordinates of emission spectra ($\lambda_{ex} = 377 \text{ nm}$) of two sets of co-doped samples $\text{Ba}_3\text{La}_{0.80-x}\text{Tb}_{0.20}\text{Sm}_x(\text{PO}_4)_3$ ($x = 0 - 0.05$) and $\text{Ba}_3\text{La}_{0.95-y}\text{Tb}_y\text{Sm}_{0.05}(\text{PO}_4)_3$ ($y = 0 - 0.20$).

Samples	Chromaticity Coordinates
$\text{Ba}_3\text{La}_{0.80-x}\text{Tb}_{0.20}\text{Sm}_x(\text{PO}_4)_3$	
0	(0.311, 0.571)
0.01	(0.385, 0.527)
0.02	(0.419, 0.506)
0.03	(0.456, 0.476)
0.05	(0.477, 0.466)
$\text{Ba}_3\text{La}_{0.95-y}\text{Tb}_y\text{Sm}_{0.05}(\text{PO}_4)_3$	

0	(0.590, 0.395)
0.01	(0.572, 0.403)
0.03	(0.554, 0.412)
0.05	(0.532, 0.426)
0.10	(0.503, 0.447)
0.20	(0.485, 0.467)