Electronic Supplementary Information (ESI)

Synthesis, Crystal Structure and Luminescence Process of A Near Ultraviolet-Green to Red Spectral Converter BaY_2S_4: Eu^{2+}, Er^{3+}†

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Table S1. Cell Constants *a*, *b*, *c* (in angstroms), and V (in cubic angstroms) and Atomic Coordinates (*x*, *y*, *z*) of $BaY_{1.76}Er_{0.24}S_4$ Compound.

Compound	*a/x*	*b/y*	*c/z*	V
$BaY_{1.76}Er_{0.24}S_4$ [a]	4.0250(4)	12.2096(1)	14.4723(1)	711.23
Y1(Er1)	0.25	0.0668(1)	0.3916(5)	
Y2(Er2)	0.25	0.0785(9)	0.8976(0)	
Ba	0.25	0.2419(5)	0.1617(8)	
S1	0.75	0.0232(8)	0.7845(5)	
S2	0.75	0.0845(3)	0.5763(8)	
S3	0.75	0.1243(7)	0.0232(2)	
S4	0.75	0.2082(6)	0.3354(6)	
BaY_2S_4 [b]	4.0263	12.2134	14.484	712.248
Y1	0.25	0.0672(7)	0.3915(1)	
Y2	0.25	0.0791(1)	0.8984(6)	
Ba	0.25	0.2423(5)	0.1616(8)	
S1	0.75	0.0217(3)	0.7830(4)	
S2	0.25	0.0819(8)	0.5771(6)	
S3	0.75	0.1251(0)	0.0234(5)	
S4	0.75	0.2073(8)	0.3359(5)	

[a] Data determined from powder XRD data by using the Rietveld refinement. The compound crystallizes in No. 62 space group (*Pmnb*) within an orthorhombic symmetry. Z = 4. $\alpha = \beta = \gamma = 90^o$. The reliability factors of the refinement for $BaY_{1.76}Er_{0.24}S_4$ are R_p = 2.7 % and R_{wp} = 3.9 %.

[b] Experimental data reported by Lowe-Ma et al.

Table S2. Bond Lengths (in angstroms) of $BaY_{1.76}Er_{0.24}S_4$ Compound.

Y1(Er1)-S2	2.68221	Y2(Er2)-S2	2.68013
Y1(Er1)-S2	2.77104	Y2(Er2)-S2	2.68013
Y1(Er1)-S2	2.77104	Y2(Er2)-S3	2.73019
Y1(Er1)-S4	2.77385	Y2(Er2)-S4	2.75348
Y1(Er1)-S4	2.77385	Y2(Er2)-S3	2.76909
Y1(Er1)-S1	2.77714	Y2(Er2)-S3	2.76909
Ba-S1	3.33020	Ba-S1	3.37250
Ba-S2	3.17274	Ba-S2	3.17274
Ba-S3	3.18314	Ba-S3	3.18314
Ba-S4	3.24610	Ba-S4	3.24610

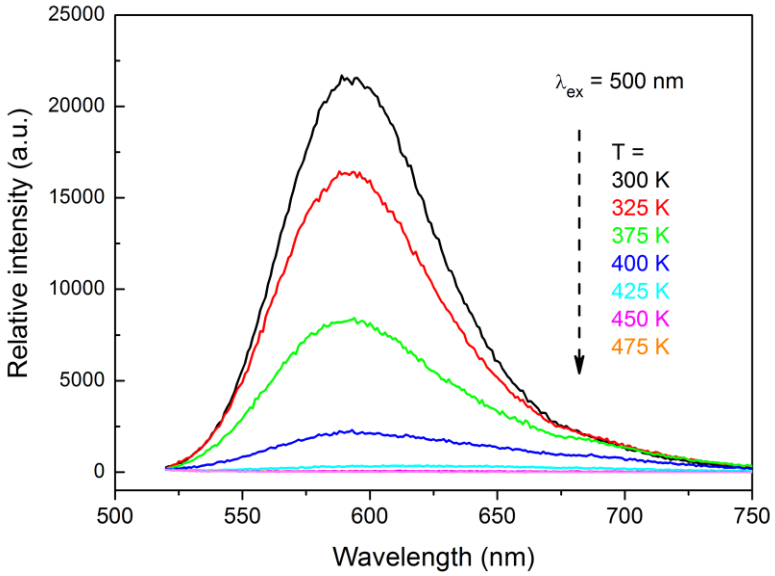

Figure S1 Temperature dependence of Eu^{2+} luminescence in BYS: $0.0025Eu^{2+}$ sample.

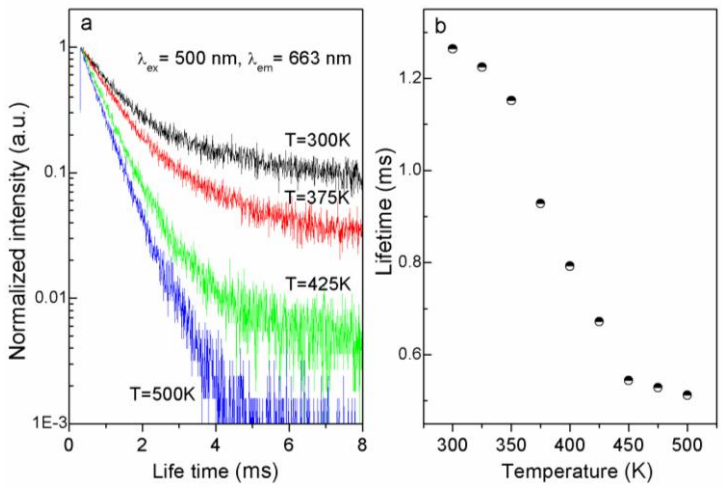

Figure S2 (a) Luminescence decay curves of BYS: $0.0025Eu^{2+}$, $0.24Er^{3+}$ phosphor under the excitation of 500 nm at range of 300 - 500 K and (b) the temperature dependent lifetimes of the Er^{3+} emission.

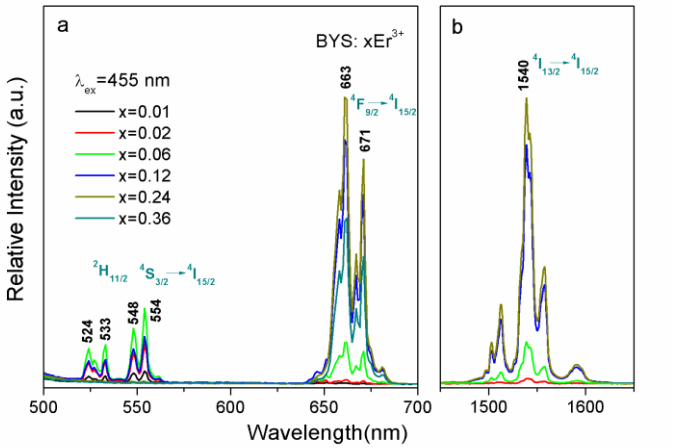

Figure S3 Visible (a) and near-infrared (b) emission spectra of $BaY_{2-x}S_4$: xEr^{3+} phosphor as a function of the concentration of Er^{3+} ions upon the excitation of 455 nm.

Figure S3 shows the photoluminescence (PL) spectra of the $Ba_{2-x}Y_2S_4$: x%Er^{3+} phosphors with x=0.01, 0.02, 0.06, 0.12, 0.24 and 0.36 obtained at room temperature by using an excitation wavelength (λ_{ex}) of 455 nm. Under this excitation condition, four emission peaks at 524, 548, 661, and 1540 nm can be distinguished. They are associated with the radiative Er^{3+} ions de-excitation from the states $^2H_{11/2}$, $^4S_{3/2}$, $^4F_{9/2}$, and $^4I_{13/2}$ to the ground state $^4I_{15/2}$, respectively. In the most dilute Er^{3+}-containing (x = 0.01) BaY_2S_4, the PL is prominent at 554 nm, the peaks at 661 and 1540 nm are almost negligible. With increasing Er^{3+} concentration, the green emission intensities initially increase and then reach a maximum at around x = 0.06; over this value, it slowly reduces, while the red and infrared ones continue to increase and finally get a maximum at approximately x = 0.24, at which the green emission nearly disappears. The reduction for the green emission with increasing Er^{3+} concentration can be justified by the cross relaxation $^4F_{5/2} + {}^4I_{15/2} \rightarrow {}^4F_{9/2} + {}^4I_{13/2}$ (see Figure 10), which results in the increase of 663 nm ($^4F_{9/2} \rightarrow {}^4I_{15/2}$) and 1540 nm ($^4I_{13/2} \rightarrow {}^4I_{15/2}$) luminescence of Er^{3+} ions.

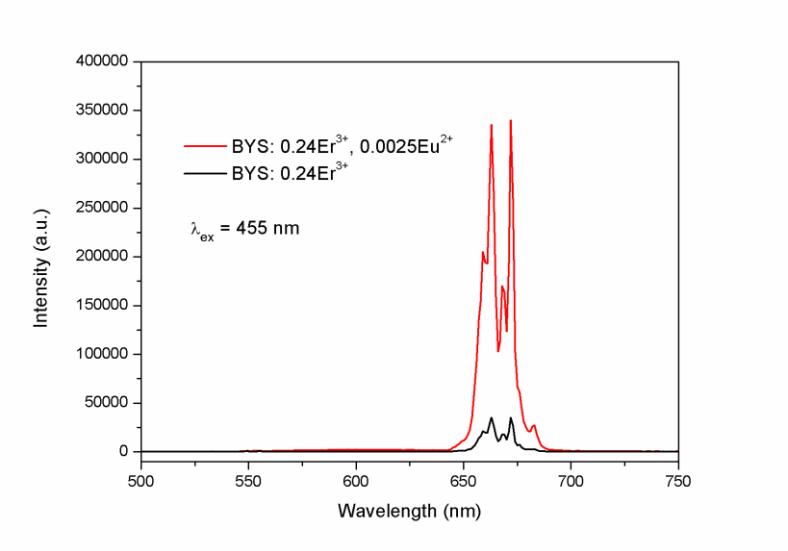

Figure S4 Emission spectra of BaY_2S_4: $0.24Er^{3+}$ and BaY_2S_4: $0.24Er^{3+}$, $0.0025Eu^{2+}$ phosphors upon the excitation of 455 nm. Integrated red emission intensity of Er^{3+} enhances about tenfold by introduction of Eu^{2+} ions.