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Hydrothermal synthesis of $BaLu_2F_8:Ln^{3+}$ crystals: Phase/morphology evolution, energy transfer and tunable multicolor luminescence

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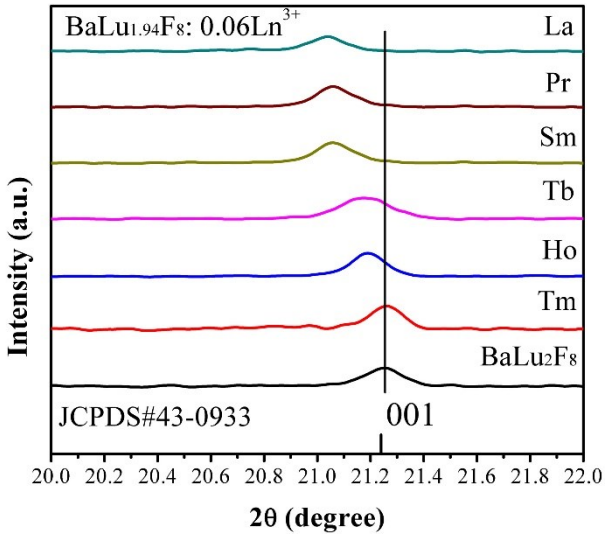

Fig. S1 XRD patterns of pure $BaLu_2F_8$ and $BaLu_{1.94}F_8$:0.06Ln^{3+} from 20^0 to 22^0 (Ln = Tm, Ho, Tb, Sm, Pr, La).

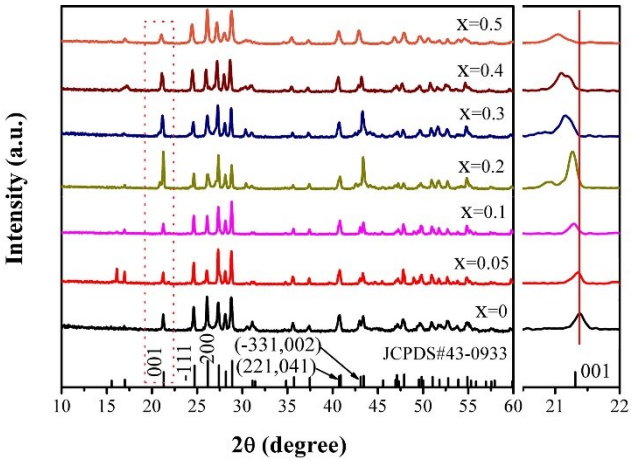

Fig. S2 XRD patterns of $BaLu_{2(1-X)}F_8$:2xYb^{3+} (x = 0, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5) and the magnified diffraction peak corresponding to (001) crystal plane.

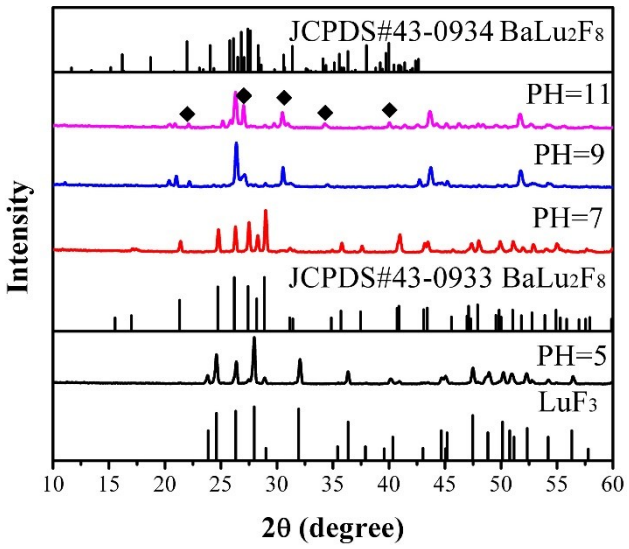

Fig. S3 XRD patterns of $BaLu_2F_8$ crystals using $NaBF_4$ as fluoride source under different pH values condition.

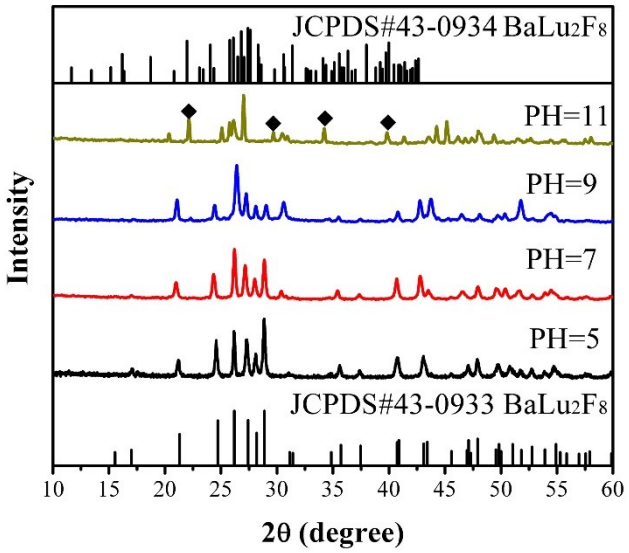

Fig. S4 XRD patterns of $BaLu_2F_8$ using NaF as fluoride source under different pH values condition.

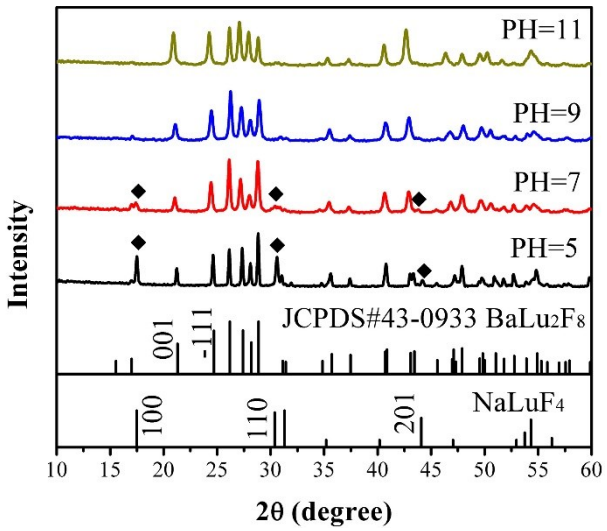

Fig. S5 XRD patterns of $BaLu_2F_8$ using NH_4F as fluoride source under different pH values condition.

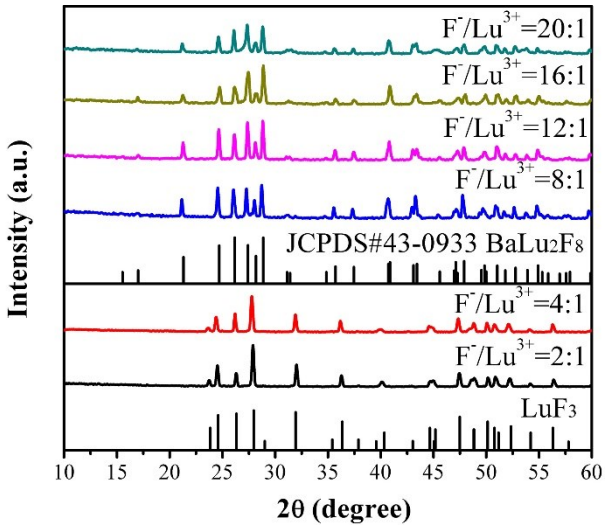

Fig. S6 XRD patterns of $BaLu_2F_8$ using $NaBF_4$ as fluoride source with the different ratios of F^-/Lu^{3+} at pH = 5.

Table S1 ICP testing results of $BaLu_{1.94}F_8$: $0.06Tb^{3+}$, $BaLu_{1.78}F_8$: $0.2Yb^{3+}$, $0.02Er^{3+}$ and $BaLu_{1.358}F_8$: $0.6Yb^{3+}$, $0.02Er^{3+}$, $0.022Tm^{3+}$ samples.

	$BaLu_{1.94}F_8$:$0.06Tb^{3+}$	$BaLu_{1.78}F_8$:$0.2Yb^{3+}$,$0.02Er^{3+}$	$BaLu_{1.358}F_8$:$0.6Yb^{3+}$,$0.02Er^{3+}$,$0.022Tm^{3+}$
Raw material molar ratio	3% Tb^{3+}	10% Yb^{3+} 1% Er^{3+}	30% Yb^{3+} 1% Er^{3+} 1.1% Tm^{3+}
ICP testing results	2.43% Tb^{3+}	9.11% Yb^{3+} 0.67% Er^{3+}	27.41% Yb^{3+} 0.69% Er^{3+} 0.76% Tm^{3+}

Table S2 Chromaticity coordinates (x, y) of the $BaLu_{1.94}F_8$:0.06Ln^{3+} crystals under 365 nm UV lump excitation.

Sample	(x)	(y)
$BaLu_{1.94}F_8$: 0.06Sm^{3+}	0.515	0.471
$BaLu_{1.94}F_8$: 0.06Eu^{3+}	0.441	0.426
$BaLu_{1.94}F_8$: 0.06Tb^{3+}	0.246	0.474
$BaLu_{1.94}F_8$: 0.06Dy^{3+}	0.225	0.290
$BaLu_{1.94}F_8$: 0.06Er^{3+}	0.287	0.647
$BaLu_{1.94}F_8$: 0.06Tm^{3+}	0.158	0.084

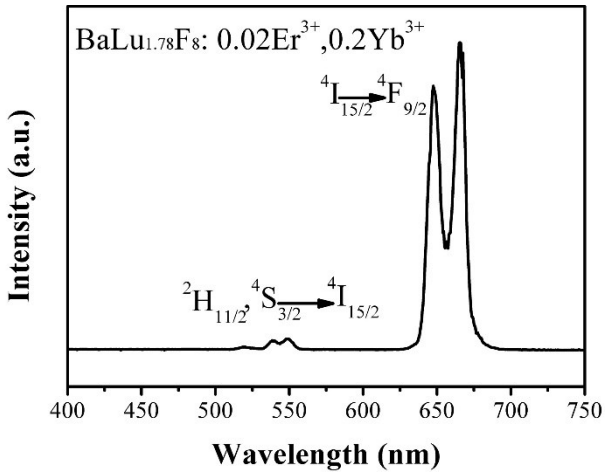

Fig. S7 UC emission spectra of $BaLu_{1.78}F_8$: 0.2 Yb^{3+}, 0.02Er^{3+} with the excitation at 980 nm of 3 W/cm^2.

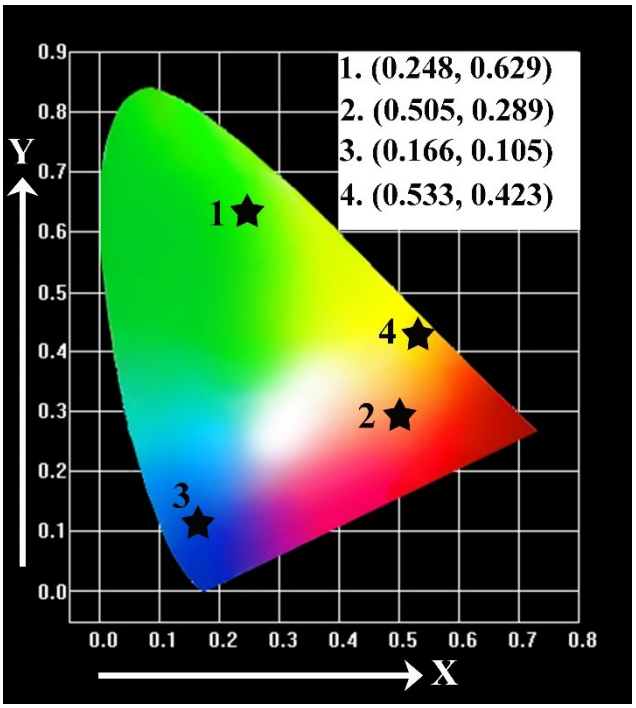

Fig. S8 The corresponding CIE chromaticity coordinates to $BaLu_{2-x}F_8$: xLn^{3+}: (1) $BaLu_{1.98}F_8$: $0.02Er^{3+}$, (2) $BaLu_{1.78}F_8$: $0.2Yb^{3+}$, $0.02Er^{3+}$, (3) $BaLu_{1.398}F_8$: $0.6Yb^{3+}$, $0.002Tm^{3+}$ and (4) $BaLu_{1.76}F_8$: $0.2\ Yb^{3+}$, $0.04\ Ho^{3+}$.

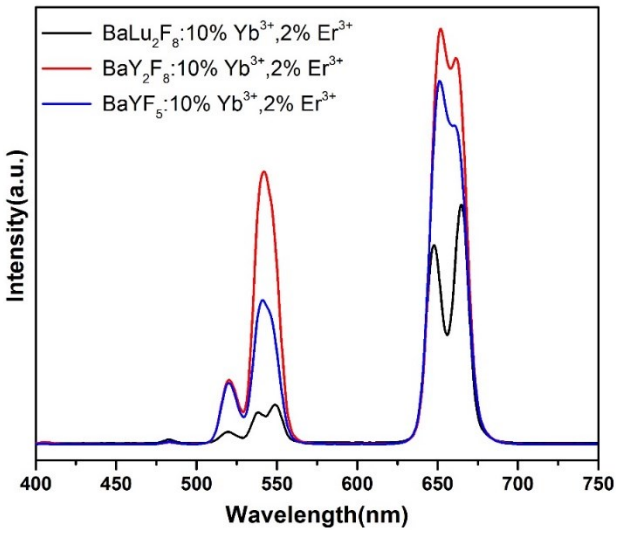

Fig. S9 UC spectra of Yb^{3+}/Er^{3+} co-doped $BaLu_2F_8$, BaY_2F_8 and $BaYF_5$, respectively.

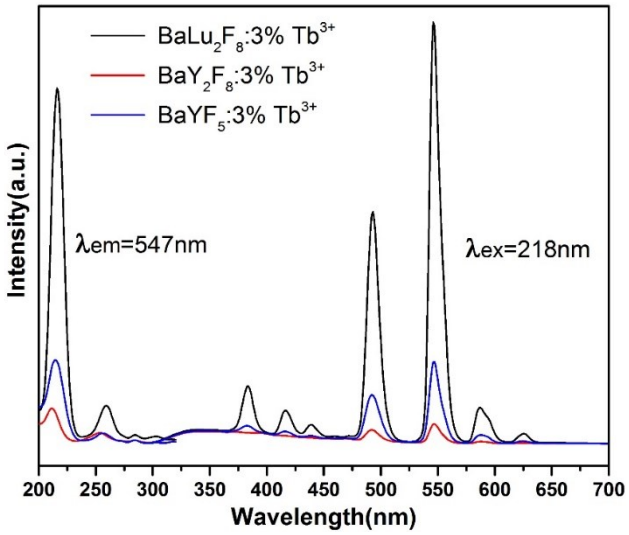

Fig. S10 DC spectra of Tb^{3+} doped $BaLu_2F_8$, BaY_2F_8 and $BaYF_5$, respectively.

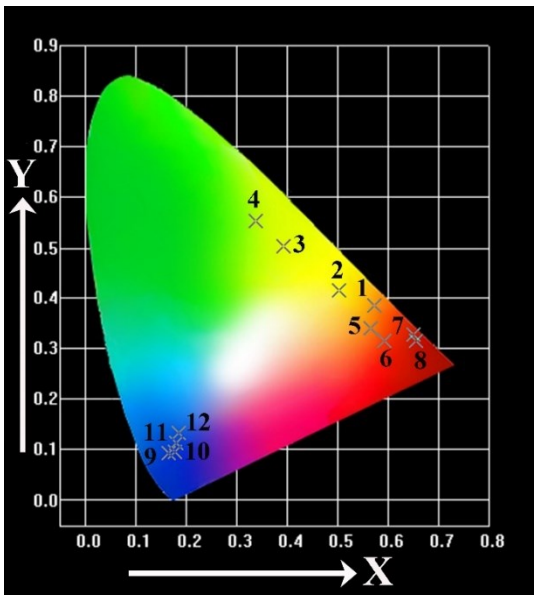

Fig. S11 CIE chromaticity diagrams of $BaLu_{1.978-x}F_8$: xYb^{3+}, $0.02Er^{3+}$, $0.002Tm^{3+}$ (point 1-4 corresponding to x = 0.4, 0.6, 0.8 and 1.0), $BaLu_{1.98-x}F_8$: xYb^{3+}, $0.02\ Er^{3+}$ (point 5-8 corresponding to x = 0.4, 0.6, 0.8 and 1.0) and $BaLu_{1.998-x}F_8$: xYb^{3+}, $0.002Tm^{3+}$ (point 9-12 corresponding to x = 0.4, 0.6, 0.8 and 1.0), respectively.

Table S3 Chromaticity coordinates (x, y) of the crystals in $BaLu_2F_8$: Yb^{3+}, Er^{3+}, Tm^{3+}) system under 980 nm-laser excitation with 3 W/cm^2.

Samples	(x)	(y)
$BaLu_{1.578}F_8$:0.4Yb^{3+},0.02Er^{3+}, 0.002Tm^{3+}	0.573	0.386
$BaLu_{1.378}F_8$:0.6Yb^{3+},0.02Er^{3+},0.002Tm^{3+}	0.502	0.415
$BaLu_{1.178}F_8$: 0.8Yb^{3+},0.02Er^{3+},0.002Tm^{3+}	0.393	0.502
$BaLu_{0.978}F_8$: 1Yb^{3+},0.02Er^{3+},0.002Tm^{3+}	0.338	0.552
$BaLu_{1.58}F_8$: 0.4 Yb^{3+}, 0.02 Er^{3+}	0.564	0.339
$BaLu_{1.38}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}	0.592	0.314
$BaLu_{1.18}F_8$: 0.8 Yb^{3+}, 0.02 Er^{3+}	0.651	0.328
$BaLu_{0.98}F_8$: 1 Yb^{3+}, 0.02 Er^{3+}	0.655	0.315
$BaLu_{1.598}F_8$: 0.4 Yb^{3+}, 0.002 Tm^{3+}	0.165	0.093
$BaLu_{1.398}F_8$: 0.6 Yb^{3+}, 0.002 Tm^{3+}	0.178	0.147
$BaLu_{1.198}F_8$: 0.8 Yb^{3+}, 0.002 Tm^{3+}	0.180	0.112
$BaLu_{0.998}F_8$: 1 Yb^{3+}, 0.002 Tm^{3+}	0.185	0.132
$BaLu_{1.379}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.001 Tm^{3+}	0.599	0.370
$BaLu_{1.378}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.002 Tm^{3+}	0.510	0.425
$BaLu_{1.374}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.006 Tm^{3+}	0.362	0.557
$BaLu_{1.37}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.01 Tm^{3+}	0.331	0.569
$BaLu_{1.366}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.014 Tm^{3+}	0.288	0.535
$BaLu_{1.362}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.018 Tm^{3+}	0.290	0.510
$BaLu_{1.358}F_8$: 0.6 Yb^{3+}, 0.02 Er^{3+}, 0.022 Tm^{3+}	0.264	0.500