Achieving Excitation Wavelength-Power-Dependent Colorful Luminescence via Multiplexing of Dual Lanthanides in Fluorine Oxide Particles for Multilevel Anticounterfeiting

Chenyang Zhao[a], Zikai Meng[a], Zhen Guo[a], Zhenbin Wang[a,b,*], Jiajia Cao[a], Jihua Zhu[a,b], Cunhua Ma[a,b], Mingjin Zhang[a,b*], Weisheng Liu[a,b,c*]

[a] School of Chemistry and Chemical Engineering, Qinghai Normal University, Xining 810008 China

[b] Academy of Plateau Science and Sustainability, People's Government of Qinghai Province & Beijing Normal University, Xining, 810016,China

[c] Key Laboratory of Nonferrous Metal Chemistry and Resources Utilization of Gansu Province and State Key Laboratory of Applied Organic Chemistry, College of Chemistry and Chemical Engineering, Lanzhou University, Lanzhou, 730000, China

*Corresponding author:wangzhbqhnu@163.com

mingjinzh@126.com

liuws@lzu.edu.cn

Tel.: +86 / (0)971-5213524

Table S1. Atomic lattice occupied parameter of $Y_7O_6F_9$:Er^{3+},Eu^{3+}.

Atom	Wyckoff	*x/a*	*y/b*	*z/c*	Fraction	U_{iso}
Y_1/+3	*8d*	0.7133	0.0359	0.25	1	0.025
Y_1/+3	*8d*	0.2931	0.1079	0.2855	1	0.025
Y_1/+3	*8d*	0.7118	0.1790	0.2350	1	0.025
Y_1/+3	*4c*	0.2909	1/4	0.2920	1	0.025
O_1/-2	*4b*	1/2	0	0.4700	1	0.025
O_2/-2	*8d*	0.4640	0.0719	0.0120	1	0.025
O_3/-2	*8d*	0.4690	0.1425	0.9920	1	0.025
O_4/-2	*8d*	0.4560	0.2169	0.0110	0.5	0.025
F_1/-1	*8d*	0.4560	0.2169	0.0110	0.5	0.025
F_2/-1	*4a*	0	0	0.0770	1	0.025
F_3/-1	*8d*	0.0360	0.0642	0.4220	1	0.025
F_4/-1	*8d*	0.9330	0.1300	0.1130	1	0.025
F_5/-1	*8d*	0.0870	0.1924	0.3800	1	0.025
F_6/-1	*4c*	0.8910	1/4	0.1670	1	0.025

Table S2. Four kinds of Y^{3+} coordination information and bond lengths of $Y_7O_6F_9$:Er^{3+},Eu^{3+}.

Y_1	Y_2	Y_3	Y_4
Y_1-O_1:	Y_2-O_3:	Y_3-O_3:	Y_4-O_4/F_1:
Y_1-O_2:	Y_2-O_2:	Y_3-F_5:	Y_4-O_4/F_1:
Y_1-F_1:	Y_2-O_2:	Y_3-O_4/F_1:	Y_4-O_4/F_1:
Y_1-F_1:	Y_2-O_3:	Y_3-F_5:	Y_4-O_4/F_1:
Y_1-O_2:	Y_2-F_3:	Y_3-F_4:	Y_4-F_6:
Y_1-O_1:	Y_2-F_4:	Y_3-O_3:	Y_4-F_6:
—	Y_2-F_4:	Y_3-O_4/F_1:	—
Average:	Average:	Average:	Average:

Table S3. Valence states, coordination numbers and ionic radii of matrix elements and doping ions.

Ion	Charge	coordination	Ionis Radius
Y	+3	VI	0.90
		XII	0.96
Eu	+3	VI	0.95
		XII	1.01
Er	+3	VI	0.89
		XII	0.95

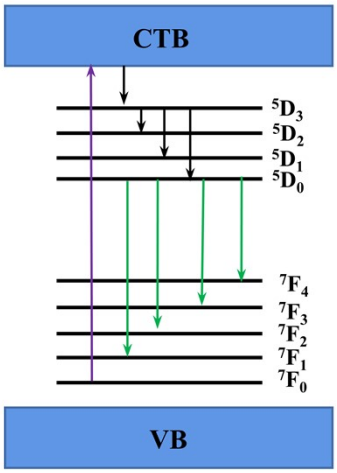

Figure S1. Schematic diagram of PersL mechanism of $Y_7O_6F_9$: Eu^{3+}.

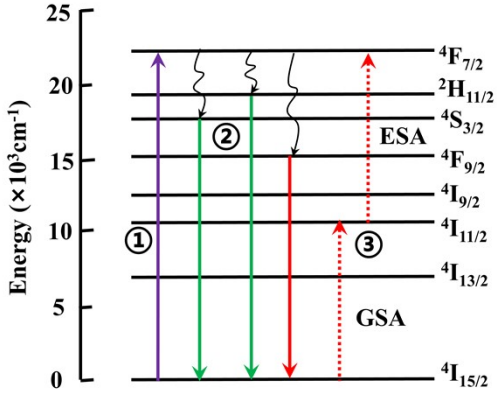

Figure S2. Energy level diagrams of Er^{3+}, Eu^{3+} ions, as well as proposed UC mechanisms. Step ① and ② indicate photoluminescence process, and

step ② and ③ represent up-conversion luminescence process.

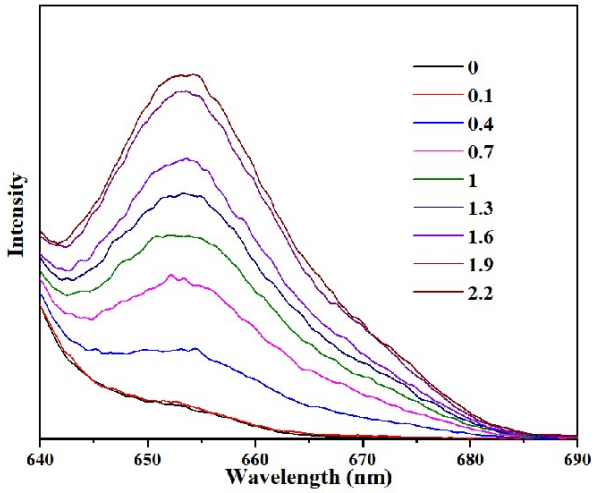

Figure S3. The emission spectra of $Y_7O_6F_9$:Er^{3+},Eu^{3+} with different 980 nm laser power under the excitation of 254 nm and 980 nm (650 – 700 nm).

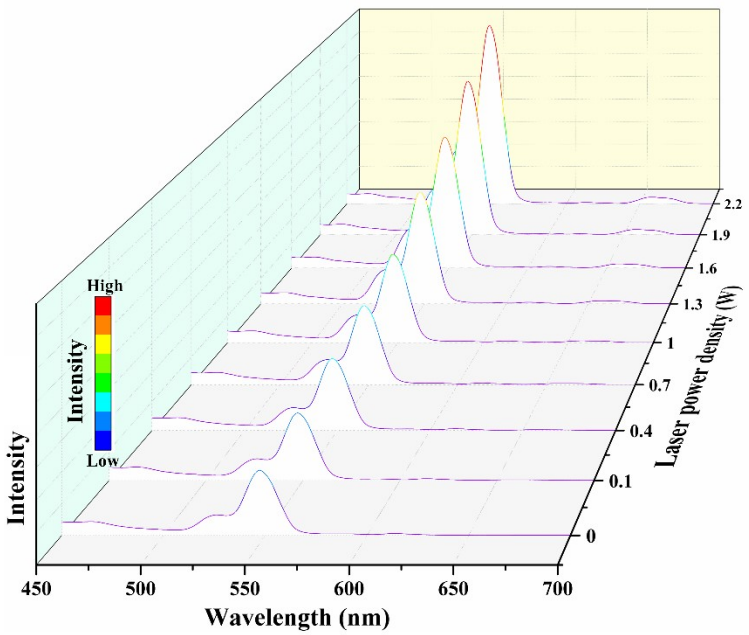

Figure S4. The emission spectra of $Y_7O_6F_9$:Er^{3+},Eu^{3+} with different power under the excitation of 365 nm and 980 nm.

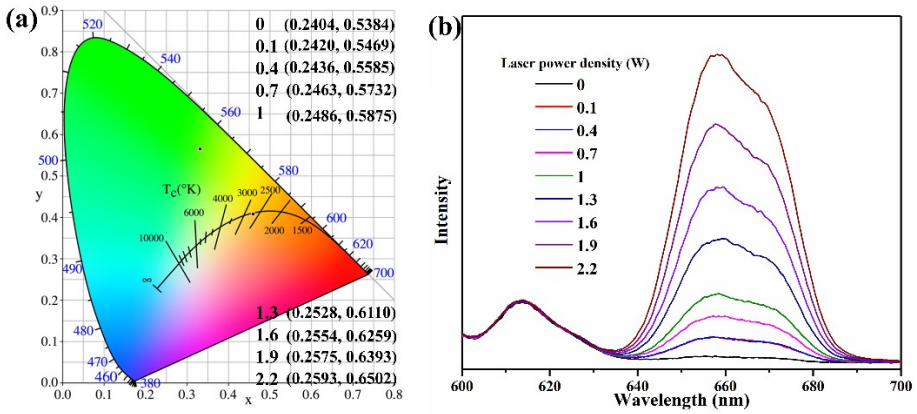

Figure S5. (a) The CIE coordinates. (b) The emission spectra under the simultaneous excitation of 365 nm and 980 nm (600 nm-700 nm).