

Supporting information

S1. Upconversion Mechanism

The schematic of the populating and UCL processes for the green and red emissions was drawn in Figure S1. In Yb^{3+} and Er^{3+} co-doped systems, Yb^{3+} ions act as sensitizers and Er^{3+} ions as activators. The green and red UCL both occur via a two-step energy transfer from the Yb^{3+} to the Er^{3+} . First, the Er^{3+} ion is excited from the ground state $^4\text{I}_{15/2}$ to the excited state $^4\text{I}_{11/2}$ via energy transfer (ET) of neighboring Yb^{3+} and Er^{3+} . Subsequent nonradiative relaxations of $^4\text{I}_{11/2}$ - $^4\text{I}_{13/2}$ populate the $^4\text{I}_{13/2}$ level. In the second-step excitation, the same laser pumps the excited-state atoms from the $^4\text{I}_{11/2}$ to the $^4\text{F}_{7/2}$ levels via ET and excited-state absorption (ESA), or from the $^4\text{I}_{13/2}$ to $^4\text{F}_{9/2}$ states via phonon-assisted ET. The populated $^4\text{F}_{7/2}$ may mostly nonradiatively relax to two lower levels: $^2\text{H}_{11/2}$ and $^4\text{S}_{3/2}$, which produce two green upconversion emissions. The populated $^4\text{F}_{9/2}$ level of the Er^{3+} ion most relaxes radiatively to the ground state $^4\text{I}_{15/2}$ level, which causes red emissions.

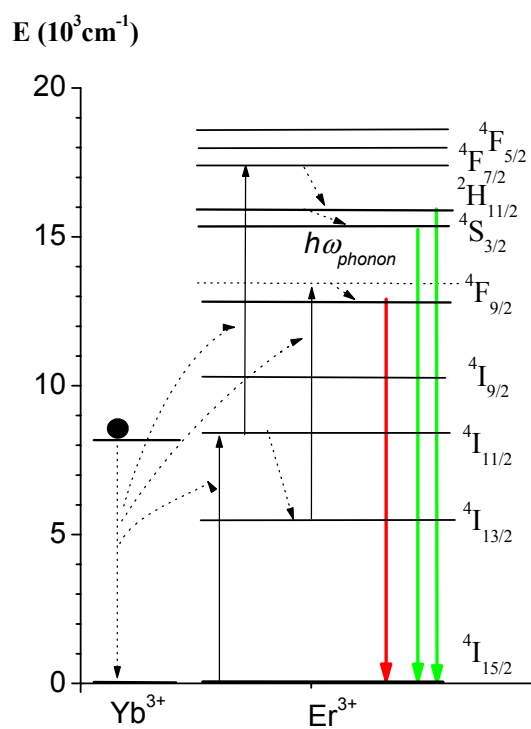


Figure S1 Upconversion population processes in Yb, Er codoped system under 980-nm laser-diode excitation.

S2. R_{HS} deduced at different conditions

Table S1. The R_{HS} values of $\text{NaYF}_4:\text{Yb}^{3+},\text{Er}^{3+}$ and $\text{NaYF}_4:\text{Yb}^{3+},\text{Er}^{3+}@\text{Ag}$ NPs in powders

Power Density(W/mm^2)	R_{HS} of NaYF_4 in powder	R_{HS} of $\text{NaYF}_4@$ Silver in powder
0.52	0.301887	0.441767
1	0.350063	0.61453
1.44	0.400794	0.74876
2	0.461505	0.873939
2.48	0.513187	1.022209
2.92	0.550917	1.140845
3.44	0.603927	1.237279
3.96	0.665154	1.361868
4.44	0.715277	1.438503
5	0.766843	1.555951
5.36	0.813674	1.612383
5.8	0.854898	1.669049
6.24	0.911843	1.792619
6.72	0.984386	1.866111
7.16	1.0304	1.93661
7.68		2.037462

Table S2. The R_{HS} values of $\text{NaYF}_4:\text{Yb}/\text{Er}$ and $\text{NaYF}_4:\text{Yb}/\text{Er}@\text{Silver}$ NPs in water

Power Density(W/mm^2)	R_{HS} of NaYF_4 in water	R_{HS} of $\text{NaYF}_4@$ Silver in water
3.96	0.258696	0.273891
5	0.25611	0.275723
5.8	0.264016	0.273973
6.72	0.26183	0.277136
7.68	0.257585	0.268888
8.64	0.257436	0.273714
9.56	0.262309	0.273782
10.56	0.260779	0.27621
11.56	0.260766	0.274112
12.64	0.256829	0.282844
13.6	0.26271	0.289084
14.56	0.263017	0.290598
15.52	0.258301	0.305525