

Supporting Information

High-intensity first near-infrared emission through energy migration in multilayered upconversion nanoparticles

Xuegang Zheng ^{a,b}, Ying Chen ^{a,b}, Meijuan Liu ^{a,b}, Shusheng Pan ^{a,b}, Zhiyu Liu ^{a,b}, Dekang Xu ^c,
Hao Lin ^{a,b,*}

^a School of Physics and Materials Science, Guangzhou University, Guangzhou 510006, P. R. China

^b Research Center for Advanced Information Materials, Huangpu Research & Graduate School of Guangzhou University, Guangzhou 510555, P. R. China

^c School of Chemistry and Materials Engineering, Huizhou University, Huizhou 516007, P. R. China

*Corresponding Author

Dr. Hao Lin

E-mail: linhao@gzhu.edu.cn

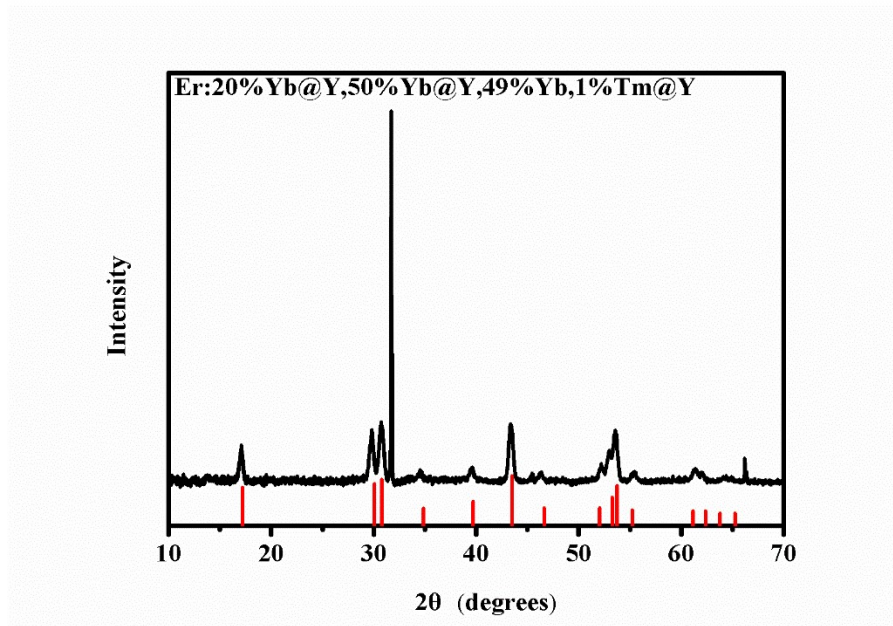


Fig. S1. XRD patterns of NaErF₄:20%Yb@NaYF₄:50%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ UCNPs, and the vertical red lines are the standard diffraction patterns of β-NaYF₄ (JCPDS 16-0334).

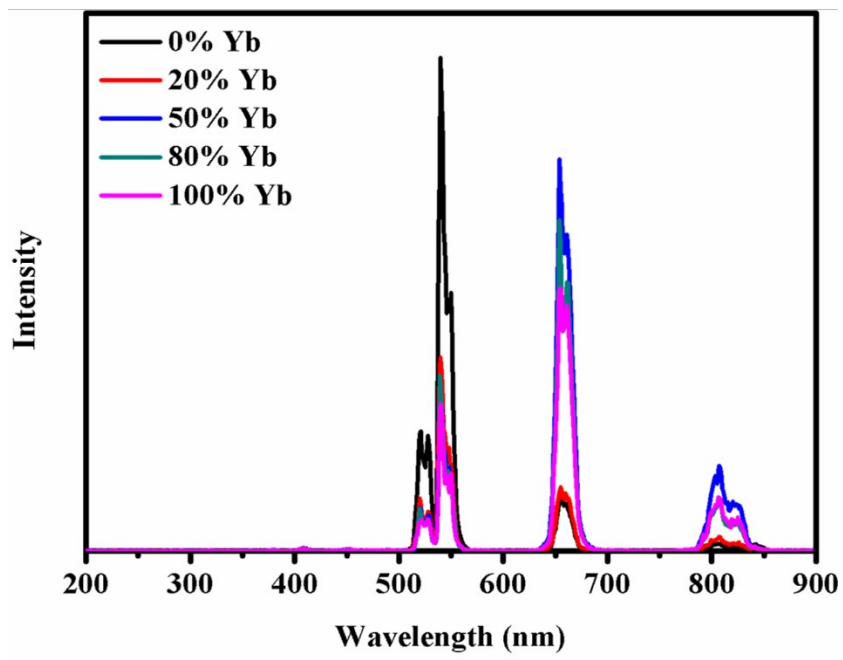


Fig. S2. UC luminescence spectra of NaErF₄:20%Yb@NaYF₄:x%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ ($x = 0, 20, 50, 80, 100$) UCNPs under 980 nm excitation.

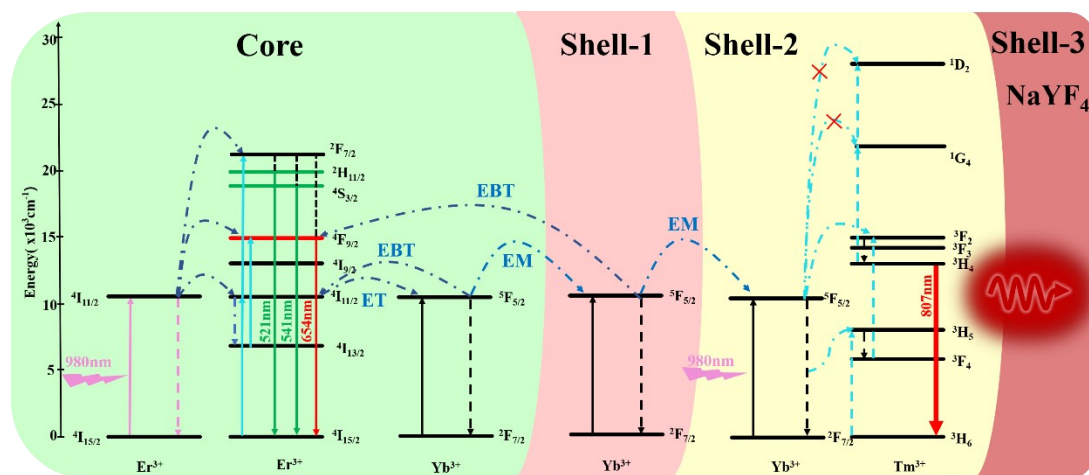


Fig. S3. Schematic energy-level diagram and the proposed energy transfer mechanisms of the NaErF₄:Yb@NaYF₄:Yb@NaYF₄:Yb,Tm@NaYF₄ core/shell/shell/shell UCNPs under 980 nm excitation.

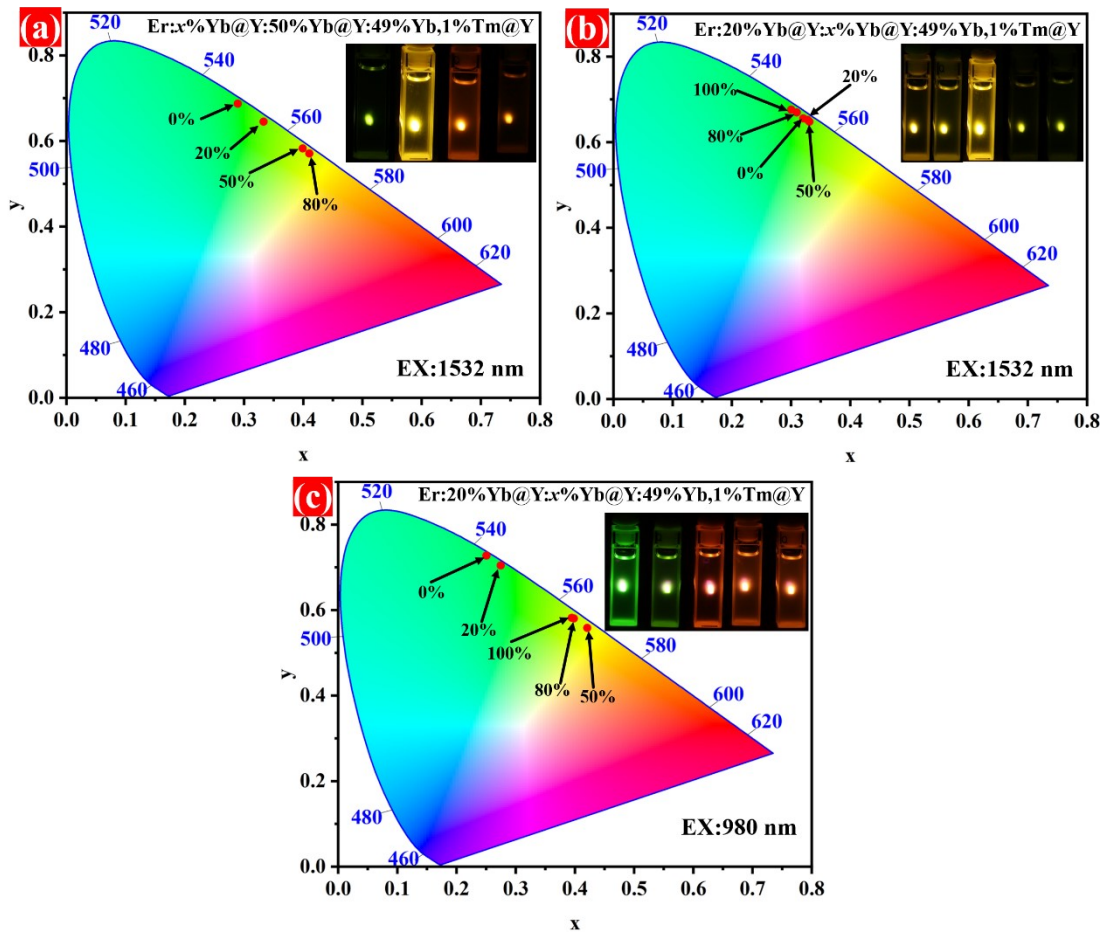


Fig. S4. The CIE diagram and corresponding emission photographs of NaErF₄:x%Yb@NaYF₄:50%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ (x = 0, 20, 50, 80) and NaErF₄:20%Yb@NaYF₄:x%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ (x = 0, 20, 50, 80, 100) UCNPs under (a-b) 1532 nm and (c) 980 nm excitations.

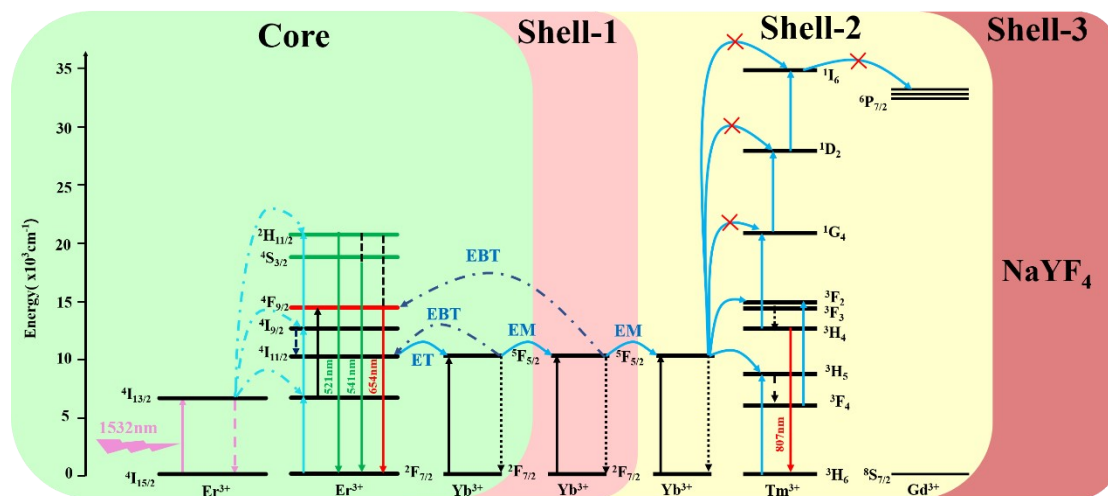


Fig. S5. Schematic energy-level diagram and the proposed energy transfer mechanisms of the NaErF₄:Yb@NaYF₄:Yb@NaGdF₄:Yb,Tm@NaYF₄ core/shell/shell/shell UCNPs under 1532 nm excitation.

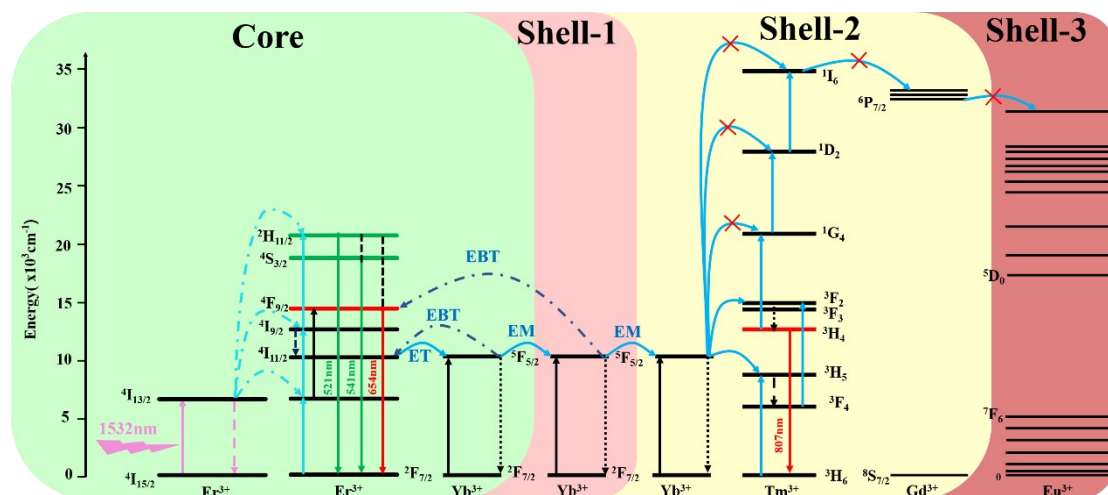


Fig. S6. Schematic energy-level diagram and the proposed energy transfer mechanisms of the NaErF₄:Yb@NaYF₄:Yb@NaGdF₄:Yb,Tm@NaYF₄:Eu core-shell-shell-shell UCNPs under 1532 nm excitation.

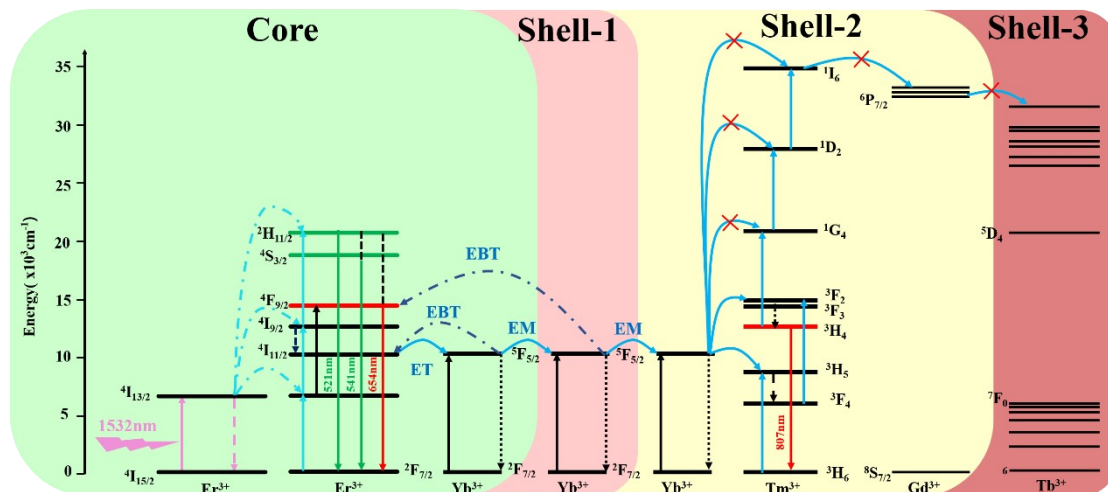


Fig. S7. Schematic energy-level diagram and the proposed energy transfer mechanisms of the NaErF₄:Yb@NaYF₄:Yb@NaGdF₄:Yb,Tm@NaYF₄:Tb core-shell-shell-shell UCNPs under 1532 nm excitation.

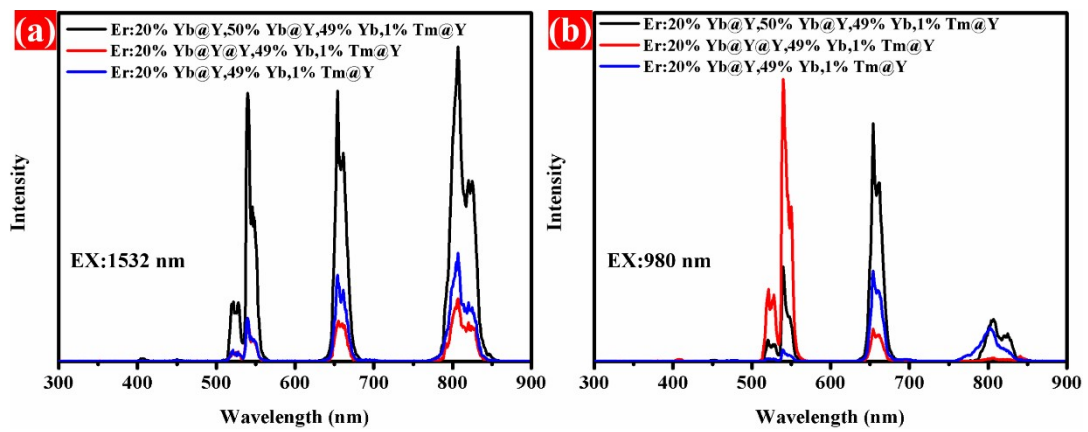


Fig. S8. UC luminescence spectra of NaErF₄:20%Yb@NaYF₄:50%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄, NaErF₄:20%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ and NaErF₄:20%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ UCNPs under (a) 1532 nm and (b) 980 nm excitations.

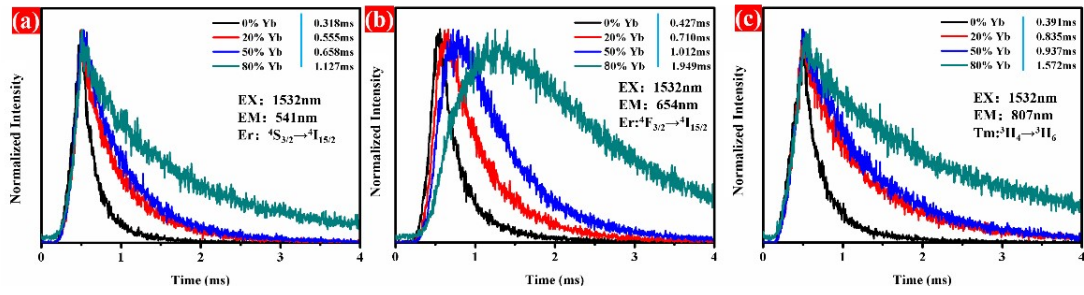


Fig. S9. Decay curves of (a) Er³⁺:⁴S_{3/2}→⁴I_{15/2} (541 nm), (b) Er³⁺:⁴F_{9/2}→⁴I_{15/2} (654 nm) and (c) Tm³⁺:³H₄→³H₆ (807 nm) emissions in NaErF₄:x%Yb@NaYF₄:50%Yb@NaYF₄:49%Yb,1%Tm@NaYF₄ (x = 0, 20, 50, 80) UCNPs under 1532 nm excitation, respectively.