Supporting information for

Ag nanowires enhanced upconversion emission of $NaYF_4$:Yb,Er nanocrystals via the directly assemble method

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Detailed synthesis procedure for 30 nm β-$NaYF_4$:Yb,Er nanocrystals.[1]

For the synthesis of α-$NaYF_4$:Yb, Er nanocrystals, 0.78 mmol $Y(CF_3COO)_3$, 0.20 mmol, 0.02 mmol and 1.00 mmol CF_3COONa were added into a three-necked flask contained 10 mmol OA, 10 mmol OM, and 20 mmol ODE. The solution was heated to 140 °C under vacuum and kept for about 15 min to fully eliminate the species with low boiling point. Then, the solution was heated to 295 °C quickly and reacted for 30 min under the protection of Ar. After the solution was cooled down to room temperature, 50 mL alcohol was added to decrease the solubility of the products. And the precipitation was collected after centrifugation at 7500 rpm for 15 min. Then, the products were dispersed in cyclohexane and re-precipitated by the adding of alcohol to wash out the excess organic species surrounded the nanoparticles. The final products were dissolved in cyclohexane solution for further use.

For the synthesis of 20 nm β-$NaYF_4$:Yb, Er nanocrystals, α-$NaYF_4$:Yb, Er nanocrystals were used as starting materials and dissolved in 20 mmol OA and ODE. After the adding of 1 mmol CF_3COONa, the solution was heated and maintained at 140 °C under vacuum for about 15 min. Then the mixture reacted under Ar atmosphere at 320 °C for 30 min. After the solution was cooled down to room temperature, β-$NaYF_4$:Yb, Er nanocrystals were collected by the same procedure as that of getting α-$NaYF_4$:Yb, Er nanocrystals.

Detailed synthesis procedure for Ag nanowires.[2]

0.75 mmol $AgNO_3$ were dissolved in 3 mL ethylene glycol (EG) to form solution a, and 1.1 mmol PVP were dissolved in another 3 mL EG as solution b. 5 mL EG were heated to 160 °C, then solution a and b was dripped into the solution within 8 min. The reaction mixture was refluxed at 160 °C for 45 min. After the solution was cooled down to room temperature, 100 mL H_2O were added and the products were collected by centrifugation. And the final products were dispersed in alcohol for further use.

Detailed synthesis procedure for Ag and Au nanoparticles.[3]

For the synthesis of Ag nanoparticles, 1 mmol $AgNO_3$ was dissolved in 15 g OM and 15 g ODE after ultrasonic treatment for 15 min. The solution was heated to 150 °C and maintained for 30 min. After the solution was cooled down to room temperature, 50 mL alcohol was added to decrease the solubility of the products. The precipitation

was collected after centrifugation at 7500 rpm for 15 min, and redispersed in cyclohexane for further use.

For the synthesis of Au nanoparticles, the procedure is similar, with the using of $HAuCl_4$ instead of $AgNO_3$.

Instrument details.

UC emission spectra of the composite assemblies are measured with LabRAM HR-800 Raman microscope (HORIBA Jobin Yvon) equipped with an external 980 nm diode laser imported by optical fiber (oblique illumination) and a 3D automatically movable platform. And for the mapping acquisition, the exposure time was set to 1 s for each acquiring point.

Luminescent images were taken under a Nikon ECLIPSE Ti inverted microscope with a 60× objective lens. Similar to the spectra characterization, the oblique illumination was realized by a fiber induced external diode laser of 980 nm, and the optical filter set is optimized with transmission of green light.

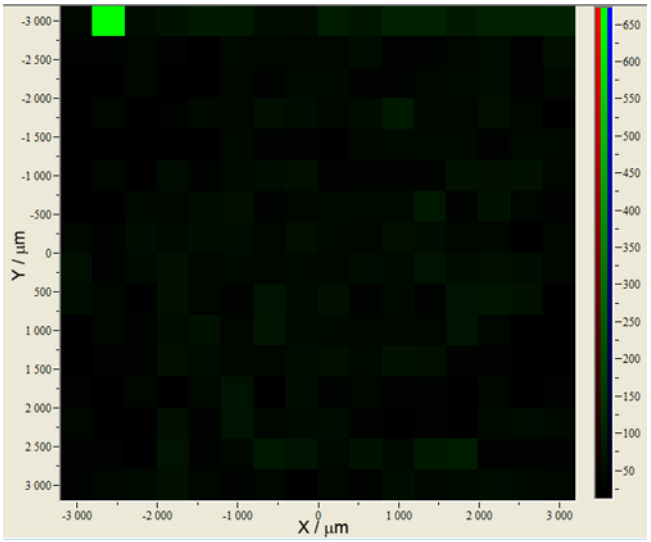

Fig. S1 Mapping profile from green emission of $NaYF_4$:Yb,Er nanocrystal assembly in a large area.

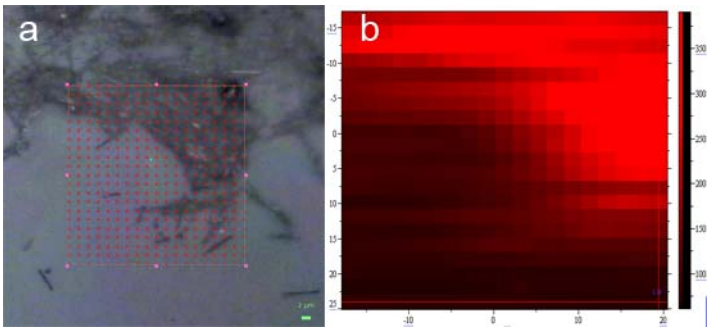

Fig. S2 Optical microscopy image and mapping profile from red emission of Ag(nanowire)-$NaYF_4$:Yb,Er(nanocrystal) assembly.

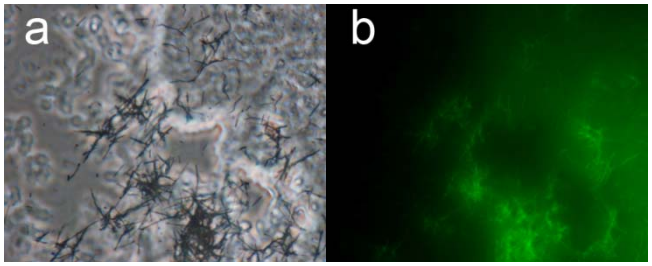

Fig. S3 Optical microscopy image and the corresponding upconversion luminescent image of Ag(nanowire)-$NaYF_4$:Yb,Er(nanocrystal) assembly under the excitation of 980 nm diode laser (with a 60× objective lens).

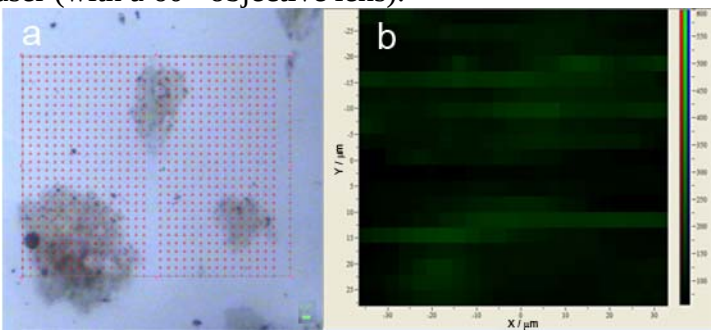

Fig. S4 Optical microscopy image (grey aggregates are Ag nanoparticles) and mapping profile from green emission of Ag nanoparticles-$NaYF_4$:Yb,Er assembly.

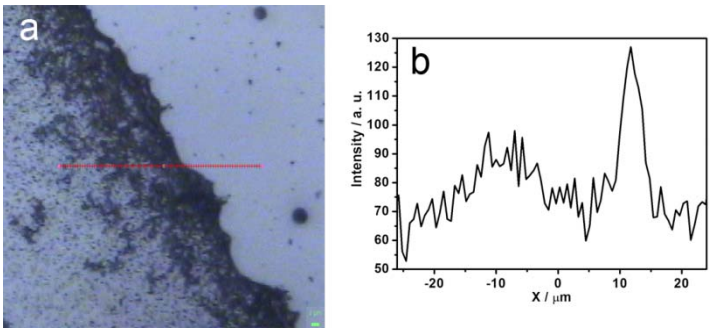

Fig. S5 Optical microscopy image (black aggregates are Au nanoparticles) and linear mapping profile of Au nanoparticles-$NaYF_4$:Yb,Er assembly.

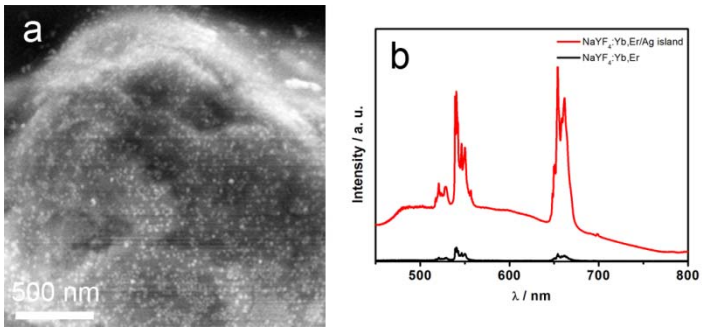

Fig. S6 SEM image and upconversion spectrum of $NaYF_4$:Yb,Er nanocrystals on Ag island (larger Ag particle).

1. H. X. Mai, Y. W. Zhang, R. Si, Z. G. Yan, L. D. Sun, L. P. You and C. H. Yan, *J. Am. Chem. Soc.*, 2006, **128**, 6426.
2. Y. G. Sun, B. Gates, B. Mayers and Y. N. Xia, *Nano Lett.*, 2002, **2**, 165.
3. C. M. Shen, C. Hui, T. Z. Yang, C. W. Xiao, J. F. Tian, L. H. Bao, S. T. Chen, H. Ding and H. J. Gao, *Chem. Mater.*, 2008, **20**, 6939.