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# Magnetic field modulated upconversion luminescence in $NaYF_4$: Yb, Er nanoparticles

P. Chen,[a] H. Jia,[a] Z. Zhong,[b] J. Han, [*b] Q. Guo,[a] J. Zhou,[c] X. Liu,[*a] J. Qiu[*ad]

[a] Department of Materials Science and Engineering, Zhejiang University, Hangzhou 310027, China

[b] Wuhan National High Magnetic Field Center, Huazhong University of Science and Technology, Wuhan 430074, China

[c] College of Materials Science and Engineering, China Jiliang University, Hangzhou 310018, China.

[d] State Key Laboratory of Luminescent Materials and Devices, South China University of Technology, Guangzhou 510640, China

**Contents:**

## 1. Experimental Section

$Y(Ac)_3 \cdot 4H_2O$ (99.99%), $Yb(Ac)_3 \cdot 4H_2O$ (99.99%), $Ho(Ac)_3 \cdot 4H_2O$ (99.99%) were purchased from Ansheng inorganic materials center Ganzhou in China. NaOH, $NH_4F$, 1-octadecene (ODE), and oleic acid (OA), SYLGARD silicone elastomer 184, curing agent were purchased from Sigma-Aldrich. Cyclohexane was purchased from Wako Pure Chemical Industries, Ltd. All of the chemicals were used as starting materials without further purification.

### 1.1 Synthesis of lanthanide doped $NaYF_4$ nanoparticles.

The $NaYF_4$: 18% Yb, 2% Er nanoparticles were prepared by the co-precipitation method.[1] In a typical procedure, 3.80 mL $Y(Ac)_3 \cdot 4H_2O$ , 0.36 mL $Yb(Ac)_3 \cdot 4H_2O$, 0.04 mL $Er(Ac)_3 \cdot 4H_2O$ were mixed with 6 mL of OA and 14 mL of ODE in a 50 mL three-neck round-bottom flask. The resulting mixture was heated to 155 °C for 30 min to form a clear solution and then cooled down to room temperature. Thereafter, 10 mL of methanol solution containing 1.8 mmol $NH_4F$ and 2.0 mmol NaOH was added, and the solution was stirred at 50 °C for 30 min. After methanol was evaporated, the solution was heated to 290 °C under Ar flow with vigorous stirring for 90 min and then cooled down to room temperature. The obtained nanoparticles were precipitated by ethanol, collected by centrifugated, washed with ethanol for several times, and finally re-dispersed in cyclohexane. The $NaYF_4$: 2% Er nanoparticles were synthesized by the same method with the volume of $Y(Ac)_3 \cdot 4H_2O$ and $Er(Ac)_3 \cdot 4H_2O$ are 3.96 mL and 0.04 mL, respectively.

**1.2 Synthesis of nanoparticles/PDMS composites.**

The prepared nanoparticles were dispersed in 15 mL cyclohexane solution. The mixture liquid of SYLGARD silicone elastomer 184, curing agent and dispersed nanoparticle solution with the volume ratio of 10: 1: 1 were mixed for an hour, then aged overnight and heated at 85 °C for an hour to form a transparent solid.

**1.3 X-Ray Diffraction (XRD) and High-resolution Transmission Electron Microscopy (HRTEM)**

X-ray diffraction pattern of the dry powder was obtained on a RIGAKU D/MAX 2550/PC diffractometer (Japan) using Cu Kα radiation (λ = 1.5406 Å). HRTEM analysis was performed on a FEG-TEM (Tecnai G2 F30 S-Twin, Philips-FEI, Netherlands) operated at 300 kV.

**1.4 Measurement of UC luminescence spectra under pulse magnetic field**

The luminescence spectra of nanoparticles were measured by the home-built luminescence spectroscopy system equipped with a pulsed magnetic field. The 975 nm laser was employed as the excitation source and coupled into a fiber to pump the nanoparticles. The nanoparticles were put at the center of the pulsed magnetic field generated by a resistive coil magnet. luminescence spectra were collected by the same fiber system with the emitted photons transmitted to the detection part and detected by a spectrometer, which is equipped with an electron multiplying charge coupled device (CCD) detector.

## 2. Figure S1

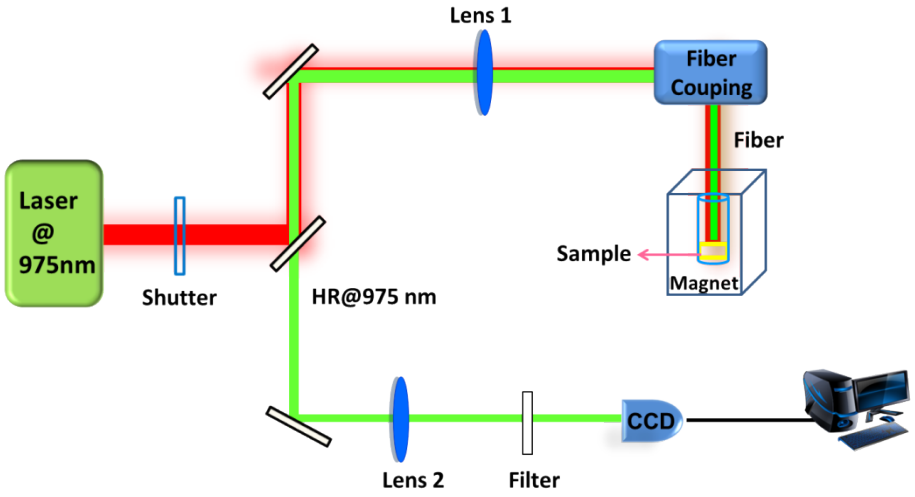


**Fig. S1** Schematic diagram of luminescence spectroscopy test system equipped with a pulsed magnetic field.

## 3. Figure S2

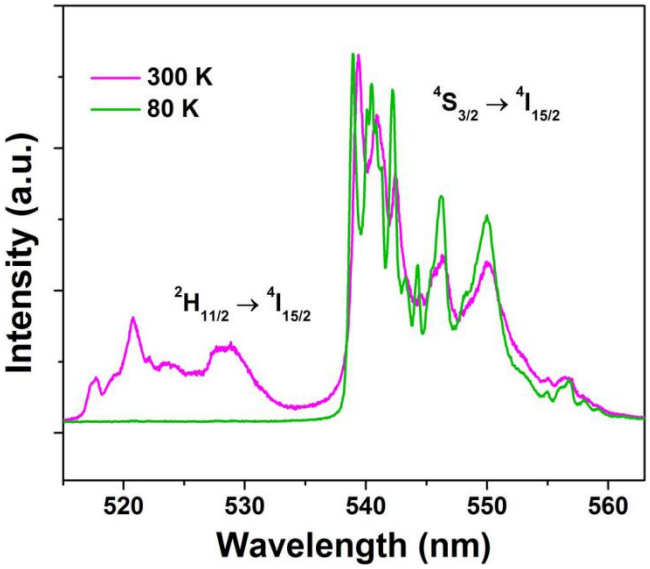


**Fig. S2** Luminescence spectra of $NaYF_4$: Yb, Er nanoparticles at room temperature and 80 K under the excitation of 975 nm.

## 4. Figure S3

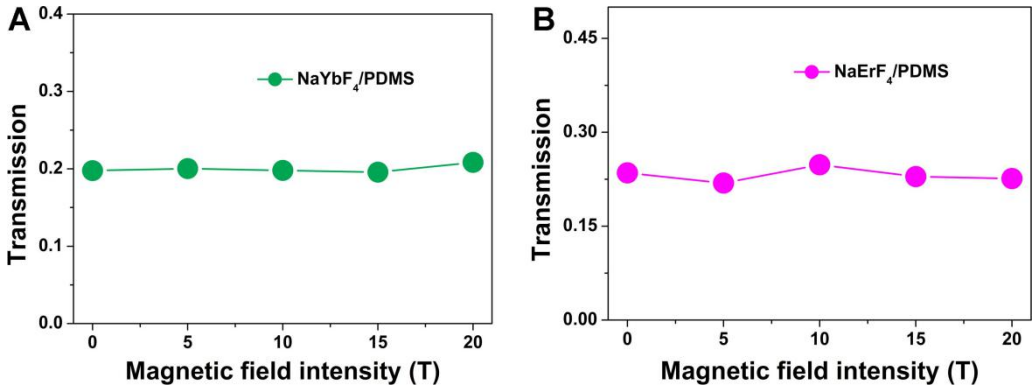


**Fig. S3** Dependence of transmittance at 975 nm of PDMS doped with $NaYbF_4$ (A) and $NaErF_4$ (B) nanoparticles on magnetic field intensity.

## 5. Figure S4

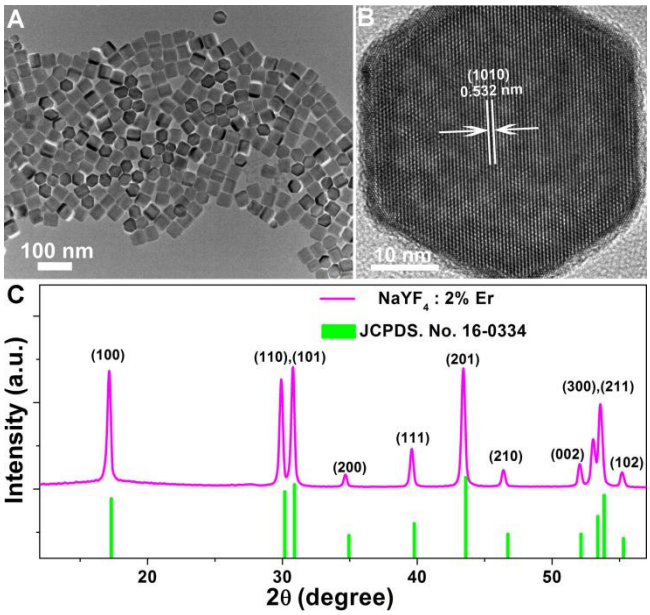


**Fig. S4** A) TEM image of $NaYF_4$: 2% Er nanoparticles. B) HRTEM image of $NaYF_4$: 2% Er nanoparticles. C) XRD patterns of $NaYF_4$: 2% Er nanoparticles.

## 6. Figure S5

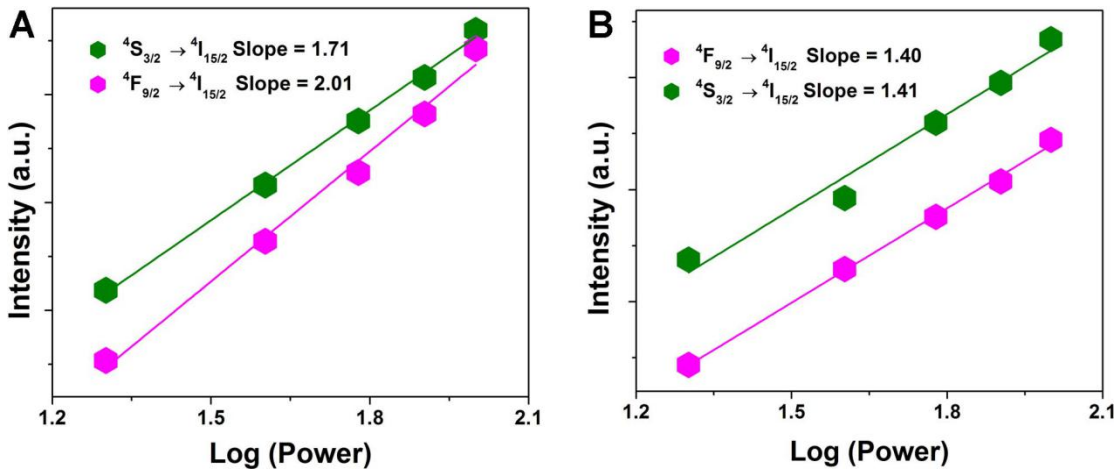


**Fig. S5** Dependences of upconversion luminescence intensity on the excitation power for $NaYF_4$: 18%Yb, 2%Er (A) and $NaYF_4$: 2%Er (B) nanoparticles.

## 7. Figure S6

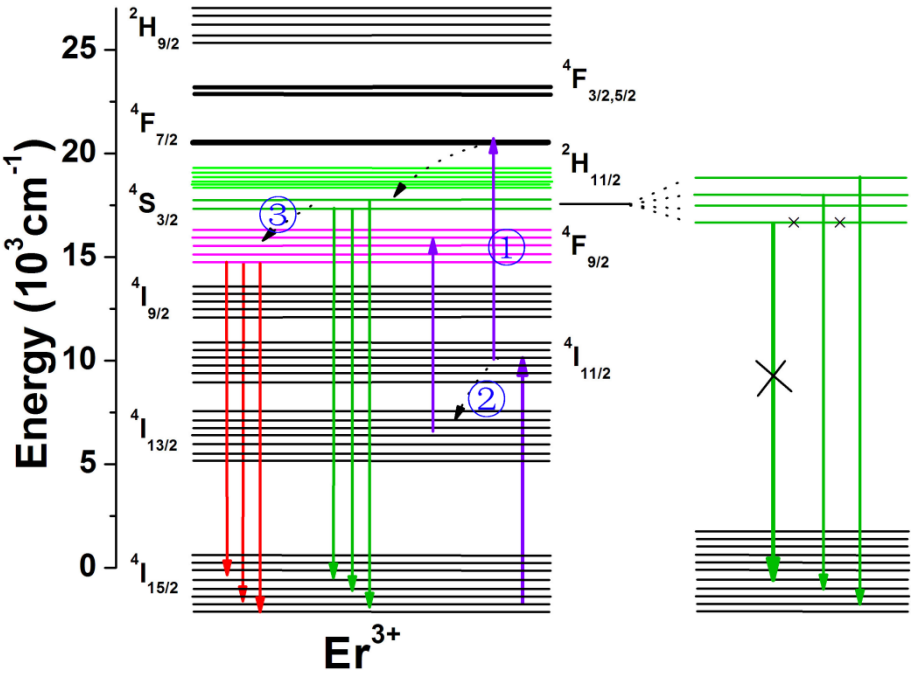


**Fig. S6** Energy level diagram of $Er^{3+}$ in $NaYF_4$ nanoparticles with the transitions might be involved in the presence of magnetic field.

## REFERENCE

1. F. Wang, Y. Han, C. S. Lim, Y.o Lu, J. Wang, J. Xu, H. Chen, C. Zhang, M. Hong, and X. Liu, *Nature*, 2010, **463**, 1061.