Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Electronic Supplementary Information

A novel excited state nanothermometry combining red-shift of charge transfer band and thermally coupled effect

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Content

Experiment

Chemicals: $Ln(NO_3)_3$ stock solutions were prepared by dissolving Y_2O_3 (99.99%, Aladdin), Er_2O_3 (99.99%, Aladdin) and Yb_2O_3 (99.99%, Aladdin) into hot nitric acid (AR, Beijing Chemical Works) in stoichiometric proportions. Na_3VO_4 (AR) and NaOH (AR) were purchased from Beijing HWRK Chem Co., LTD. The above reagents were used directly without further purification. Deionized water (12 MΩ.cm) was employed to dissolve the reagents and prepare the diluent of NaOH.

Synthesis of Er^{3+}/Yb^{3+} doped YVO_4 nanoparticles by the hydrothermal method with further calcination. Taking 2 mmol of YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles as an example, 16.4 mL of $Y(NO_3)_3$ (0.1 M), 1.2 mL of $Er(NO_3)_3$ (0.05 M) and 3.0 mL of $Yb(NO_3)_3$ (0.1 M) were mixed and stirred. 2 mmol of Na_3VO_4 dissolved in 20 mL of deionized water was dropped into the above lanthanide nitric acid mixture with stirring, and then the pH of the mixture was adjusted to 10 with NaOH aqueous solution (1 M and 5 M). After stirring for 1 h, the mixture was poured and sealed into a Teflon-lined autoclave and kept at 200 °C for 16 h. The precipitates were obtained by centrifugation, washed with deionized water and ethanol, and dried at 70 °C for 10 h. The final product was obtained after calcination at 600 °C for 2 h.

Characterization

The crystalline structures of all samples were determined by X-ray diffraction patterns on a Bruker D8 Focus diffractometer equipped with Cu Kα radiation (λ = 0.15405 nm). The morphology was obtained by a transmission electron microscope (TEM, JEM-2200FS). The Fourier transform infrared spectrum was collected by a Bruker TENSOR 27 FT-IR spectrometer. The excitation and emission spectra were recorded by an Andor SR-500i spectrometer (Andor Technology Co, Belfast, U.K.) equipped with a SR830 DSP lock-in amplifier and a CCD detector under the excitation of a xenon lamp and 980 nm diode laser. The temperature evolution experiments were carried out using a copper-constant thermocouple and temperature control system (TAP-02, orient-KOJI).

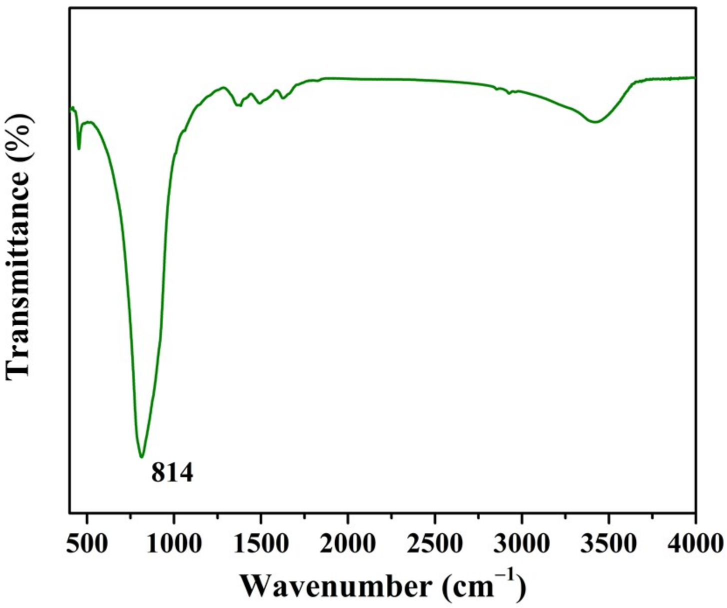

Fig. S1. Fourier transform infrared spectrum of YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles.

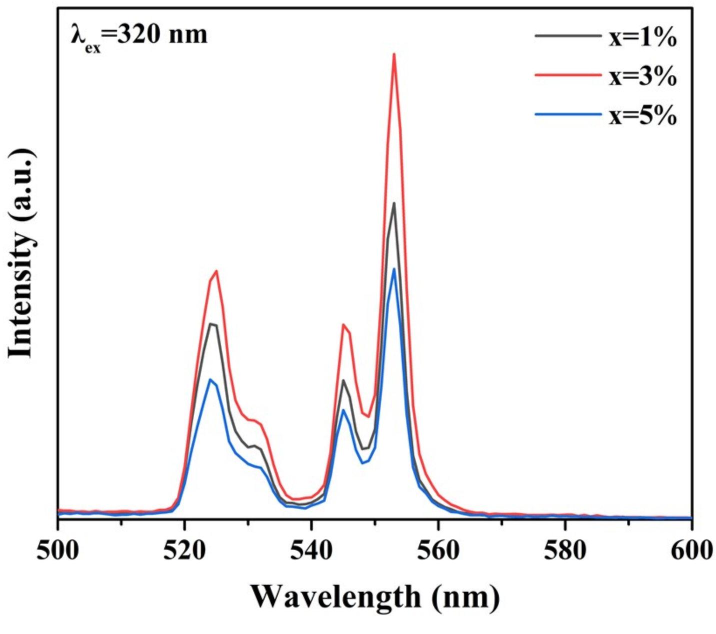

Fig. S2. Emission spectra of YVO_4: xEr^{3+}, 15%Yb^{3+} nanoparticles under the 320 nm excitation.

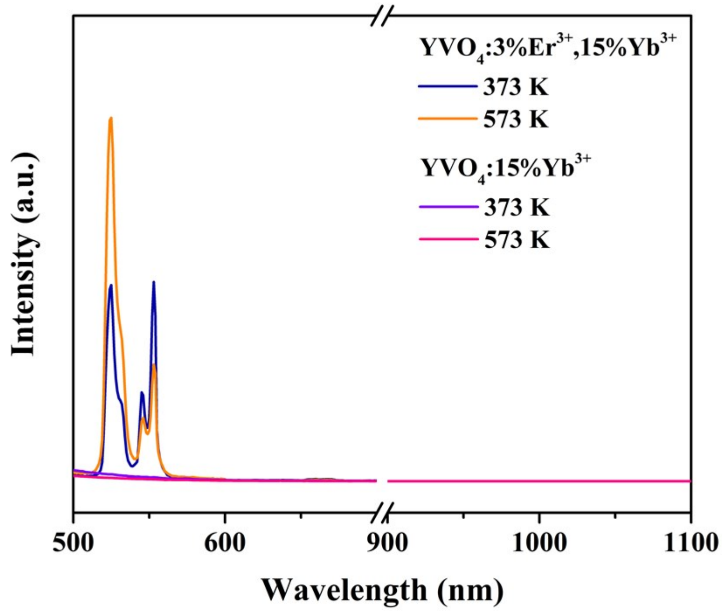

Fig. S3. Emission spectra of YVO_4: 3%Er^{3+}, 15%Yb^{3+} and YVO_4: 15%Yb^{3+} nanoparticles under the 320 nm excitation.

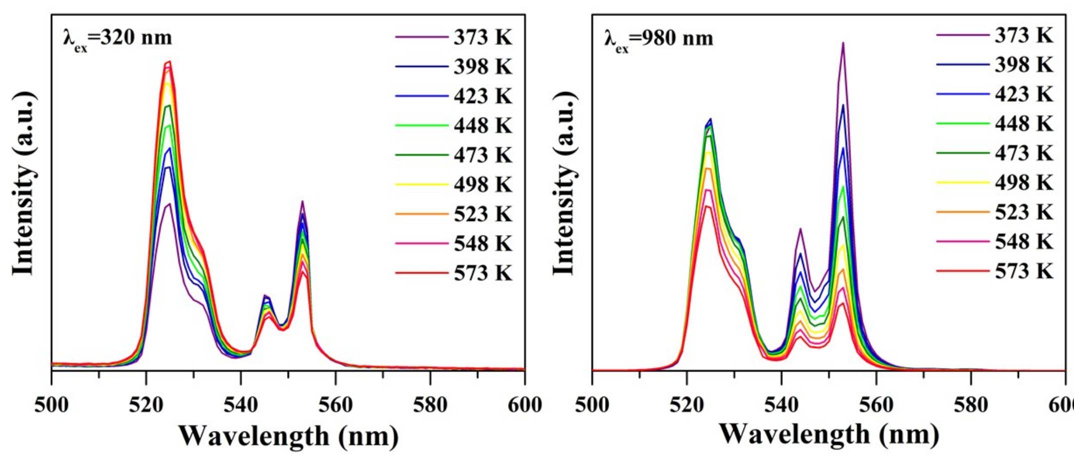

Fig. S4. Temperature evolution emission spectra under the excitation of 320 or 980 nm in the 373–573 K range of YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles.

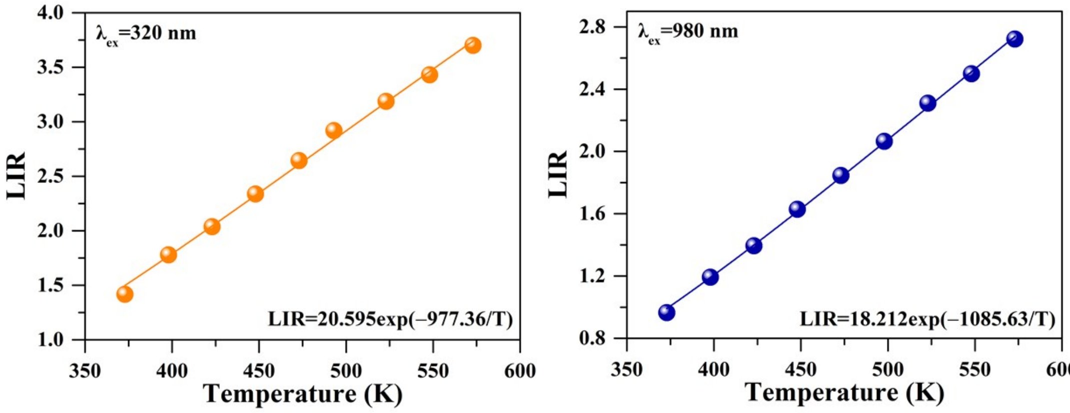

Fig. S5. Calibration curves based on thermally coupled thermometry of YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles under the excitation of 320 or 980 nm.

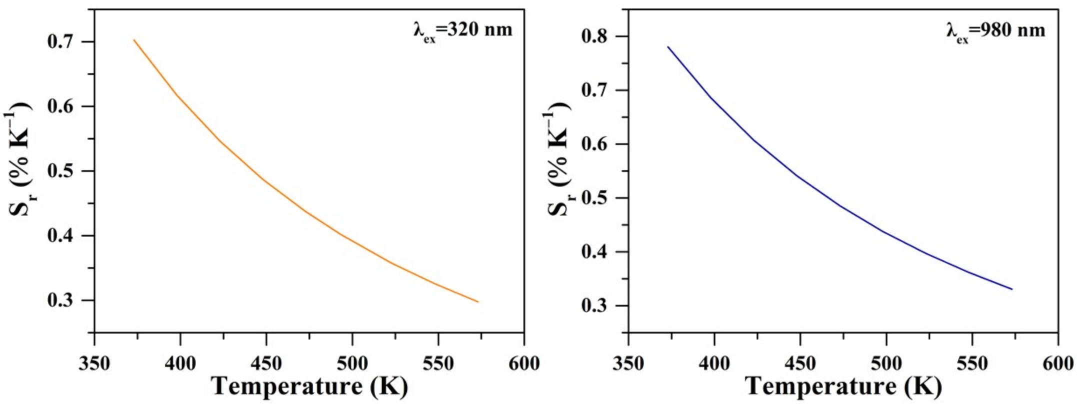

Fig. S6. S_r based on thermally coupled thermometry of YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles under the excitation of 320 or 980 nm.

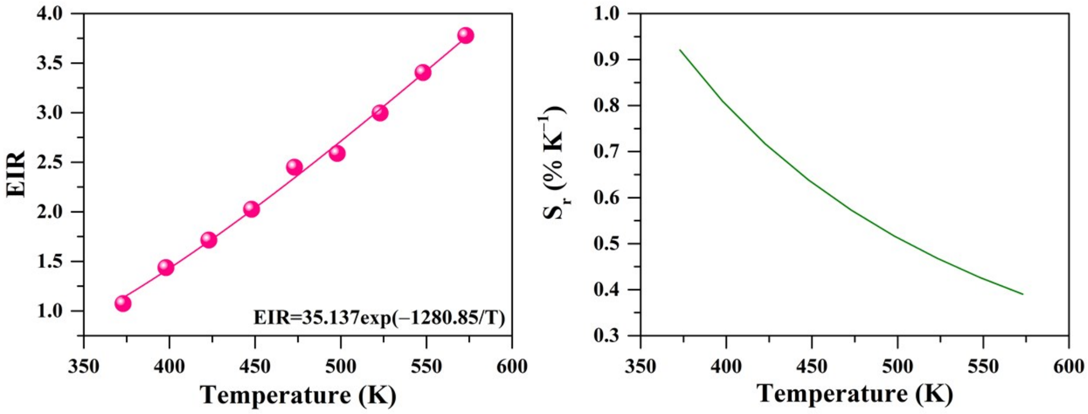

Fig. S7. Calibration curve and S_r based on *EIR* of entire 320 nm peak for YVO_4: 3%Er^{3+}, 15%Yb^{3+} nanoparticles.

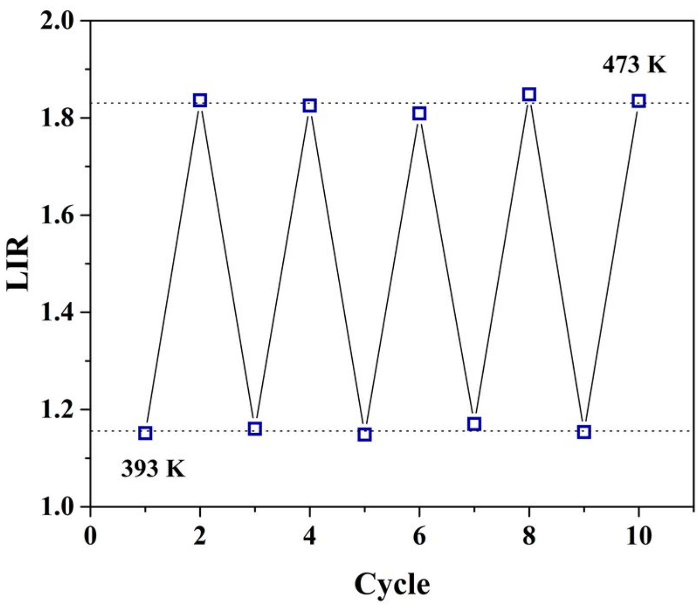

Fig. S8. Temperature cycling between 393 and 473 K based on thermally coupled thermometry of Er^{3+} under the excitation of 980 nm.

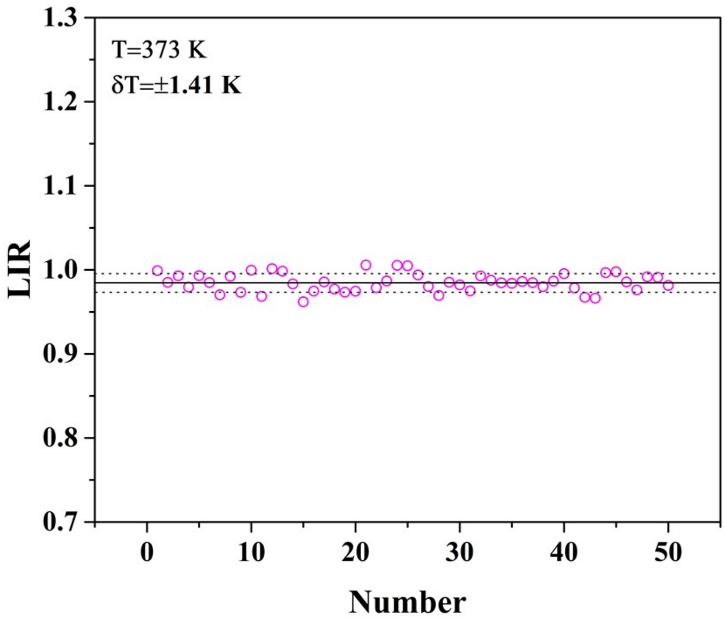

Fig. S9. Temperature uncertainty δT (50 measurements at 373 K) based on thermally coupled thermometry under the excitation of 980 nm.

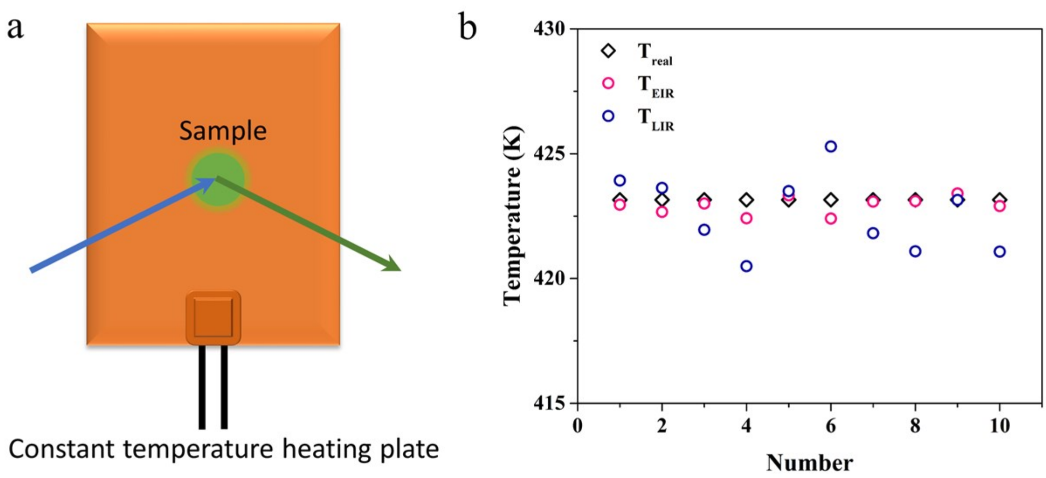

Fig. S10. (a) Scheme of temperature detection using a constant temperature heating plate. The sample is coated on the plate. (b) Temperature measurements based on the proposed *EIR* thermometry and typical *LIR* thermometry based on TCLs.

Table S1. Fitting parameters of the calibration curve based on the proposed *EIR* thermometry.

Parameter	Value	r^2
a	−0.6804±0.1099	
b	0.0598±0.0169	0.9992
c	143.9456±9.1418	

Table S2. Comparison of the thermometric performance of proposed *EIR* thermometry and typical *LIR* thermometry based on TCLs of Er^{3+}.

Thermometry	Maximum S_r (%)	R (%)	δT (K)
EIR	4.7 (373 K)	98.2 (393−473 K)	0.15 (373 K)
LIR	0.8 (373 K)	98.8 (393−473 K)	1.41 (373 K)