Electronic Supplementary Information **(**ESI†**)**

A universal strategy to enhance the absolute sensitivity for temperature detection in bright Er^{3+}/Yb^{3+} doped double perovskite Gd_2ZnTiO_6 phosphors

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Table S1 Refinement parameters of the GZT host.

Cell parameters	GZT host
Space group	$P2_1/n$
Symmetry	monoclinic
a (Å)	5.3625(1)
b (Å)	5.6561(5)
c (Å)	7.6807(5)
β (º)	90.3601
V (Å^3)	232.962
W_{Rp} (%)	7.71
Rp (%)	5.70
χ^2	1.359

Table S2 Detail data of S_A and S_R in the conventional way and proposed method in the Er^{3+}/Yb^{3+} co-doped GZT phosphor.

S(10^{-4}/K)	Ratios	313K	333K	353K	373K	393K	413K	433K	453K	473K
	H/S	42.2	41.9	43.3	44.3	45.3	46.3	46.8	47.2	47.5
S_A	H/F	24.5	24.2	23.6	23.2	22.7	22.4	21.8	21.3	20.6
	S/F	-29.1	-24.4	-20.5	-17.6	-15.2	-13.3	-11.6	-10.3	-9.1
	H/S	95.2	84.1	74.9	67.0	60.4	54.7	49.7	45.4	41.7
S_R	H/F	62.7	55.4	49.3	44.1	39.7	36.0	32.7	29.9	27.4
	S/F	-31.5	-27.8	-24.7	-22.2	-20.0	-18.1	-16.4	-15.0	-13.8
	S/H	218.8	164.0	125.5	98.6	78.1	62.7	51.3	42.5	35.5
S'_A	F/H	157.4	124.6	101.0	82.5	68.4	56.7	48.4	41.4	35.9
	F/S	34.4	32.1	30.2	28.2	26.5	24.8	23.5	22.2	21.2
	S/H	92.5	81.7	72.7	65.1	58.7	53.1	48.3	44.2	40.5
S'_R	F/H	61.6	54.4	48.4	43.4	39.1	35.4	32.2	29.4	27.0
	F/S	31.8	28.1	25.0	22.4	20.2	18.3	16.6	15.2	13.9

Note: Simplification of ratios: $^2H_{11/2}/^4S_{3/2}$ (H/S), $^2H_{11/2}/^4F_{9/2}$ (H/F) and $^4S_{3/2}/^4F_{9/2}$ (S/F) (the conventional way); $^4S_{3/2}/^2H_{11/2}$ (S/H), $^4F_{9/2}/^2H_{11/2}$ (F/H) and $^4F_{9/2}/^4S_{3/2}$ (F/S) (the proposed method).

Table S3 Detail data of S_A and S_R in the conventional way and proposed method in the Er^{3+}/Yb^{3+} co-doped $NaYF_4$ phosphor.

S(10^{-4}/K)	Ratios	313K	333K	353K	373K	393K	413K	433K	453K	473K
	H/S	25.2	27.0	28.5	29.4	30.4	31.2	31.2	31.8	32.3
S_A	H/F	17.2	18.3	18.7	19.2	19.1	19.3	19.1	18.7	18.6
	S/F	12.9	11.3	9.8	8.7	7.5	6.7	6.1	5.3	4.8
	H/S	100.3	89.0	79.2	70.9	63.9	57.8	52.6	48.1	44.1
S_R	H/F	82.8	73.5	65.4	58.5	52.7	47.8	43.4	39.7	36.4
	S/F	15.6	13.8	12.3	11.0	9.9	9.0	8.2	7.5	6.9
	S/H	398.7	293.3	219.6	170.9	134.3	107.0	88.7	72.7	60.2
S'_A	F/H	413.9	306.2	237.4	185.0	150.6	122.6	102.4	87.2	73.9
	F/S	-19.6	-17.5	-16.1	-14.4	-13.5	-12.5	-11.4	-10.9	-10.2
	S/H	100.3	88.9	79.1	70.9	63.9	57.8	52.6	48.1	44.1
S'_R	F/H	85.8	76.1	67.7	60.7	54.7	49.5	45.0	41.1	37.7
	F/S	16.2	14.3	12.8	11.4	10.3	9.3	8.5	7.7	7.1

Note: Simplification of ratios: $^2H_{11/2}/^4S_{3/2}$ (H/S), $^2H_{11/2}/^4F_{9/2}$ (H/F) and $^4S_{3/2}/^4F_{9/2}$ (S/F) (the conventional way); $^4S_{3/2}/^2H_{11/2}$ (S/H), $^4F_{9/2}/^2H_{11/2}$ (F/H) and $^4F_{9/2}/^4S_{3/2}$ (F/S) (the proposed method).

Table S4 The S_A in Er^{3+}/Yb^{3+} co-doped diverse phosphors.

Phosphors	S_A (10^{-4} K^{-1})	$I_1>I_2$	$I_1 \sim I_2$	$I_1<I_2$	Ref.
$NaYF_4$:Er/Yb	41.9 (α)			√	[1]
	46.6 (β)			√	
$Yb_3Al_5O_{12}$:Er/Yb	48		√		[2]
$LiNbO_3$:Er/Yb	75	√			[3]
$YNbO_4$:Er/Yb	72	√			[4]
β-$NaLuF_4$: Yb/Er/Ca	19			√	[5]
$NaErF_4$@ $NaYF_4$@$NaGdF_4$	41			√	[6]
$NaLaMgWO_6$: Er/Yb	229	√			[7]
$Ba_2In_2O_5$: Er/Yb	65	√			[8]
Lu_2TeO_6: Er/Yb	103	√			[9]
$Ba_3Y_4O_9$: Er/Yb	24.8			√	[10]
$Gd_6O_5F_8$: Er/Yb	57			√	[11]
Yb_2WO_6+ $Yb_2W_3O_{12}$ (mixture) : Er/Yb	1050	√			[12]
GZT: Er/Yb	218.8	√			This work
NaYF4: Er/Yb	398.7			☑	

Note: ☑ represents $I_1 < I_2$, but calculation on its S_A by FIR = I_2/I_1.

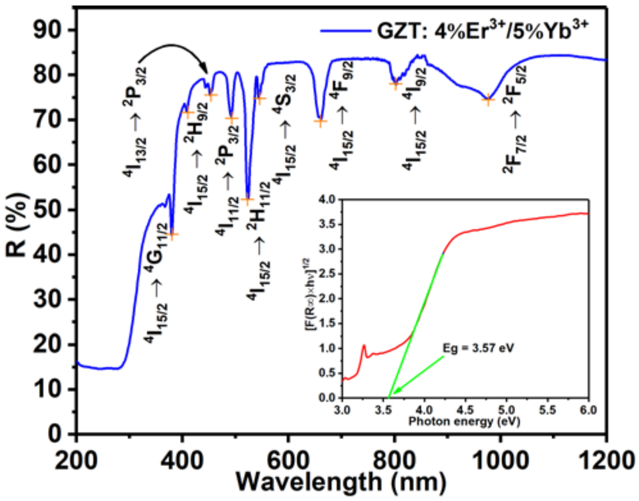

Fig. S1 Diffuse reflection spectrum of the GZT:4%Er^{3+}/5%Yb^{3+} sample; the insert: the plots of $[F(R_{\infty})hv]^{1/2}$ vursus the photon energy.

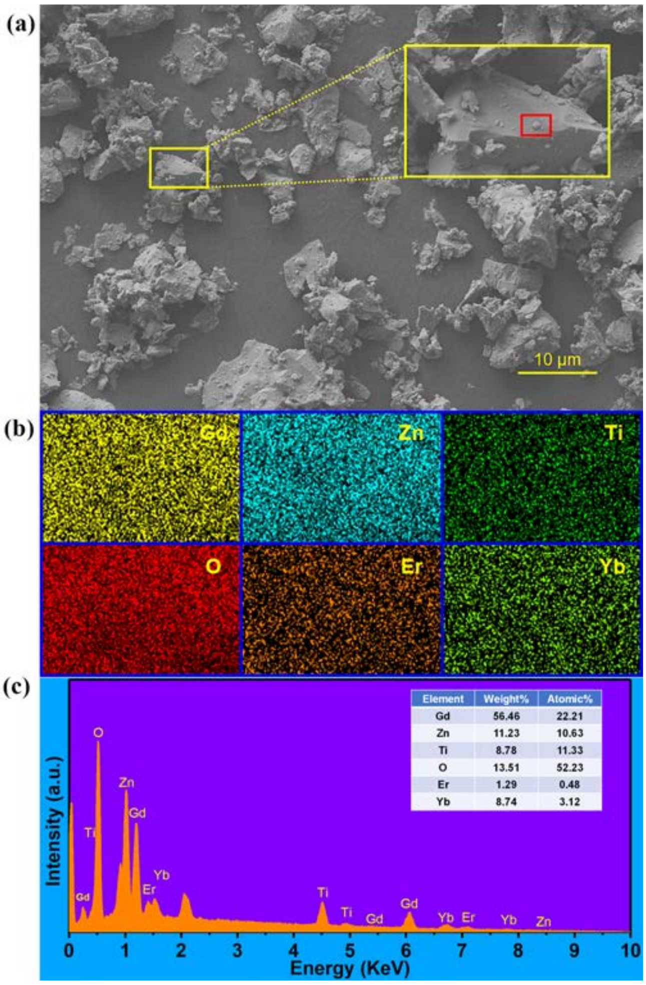

Fig. S2 (a) The morphology of GZT:4%Er^{3+}/5%Yb^{3+} sample; (b) elemental mapping images of Gd, Zn, Ti, O, Er and Yb; (c) the EDS result of GZT:4%Er^{3+}/5%Yb^{3+} sample.

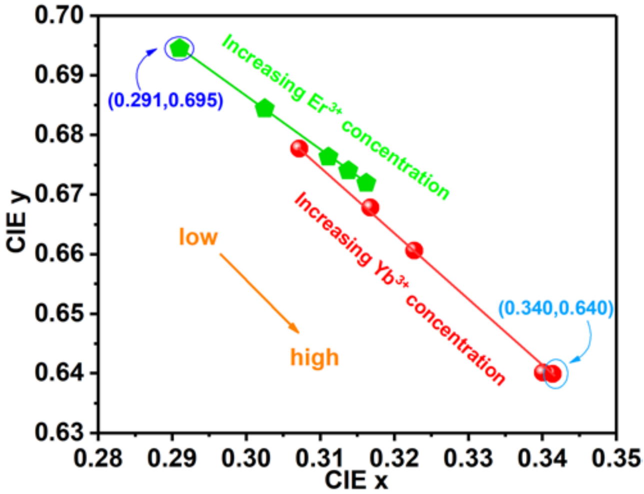

Fig.S3 The CIE chromaticity coordinate of Er^{3+}/Yb^{3+} doped GZT samples as a function the Er^{3+} or Yb^{3+} concentration.

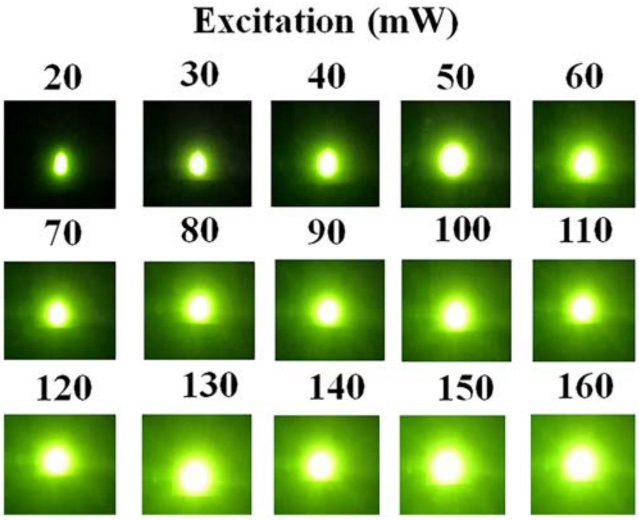

Fig. S4 Real pictures of the GZT:4%Er^{3+}/5%Yb^{3+} sample under different excitation power recorded by a Honor V10.

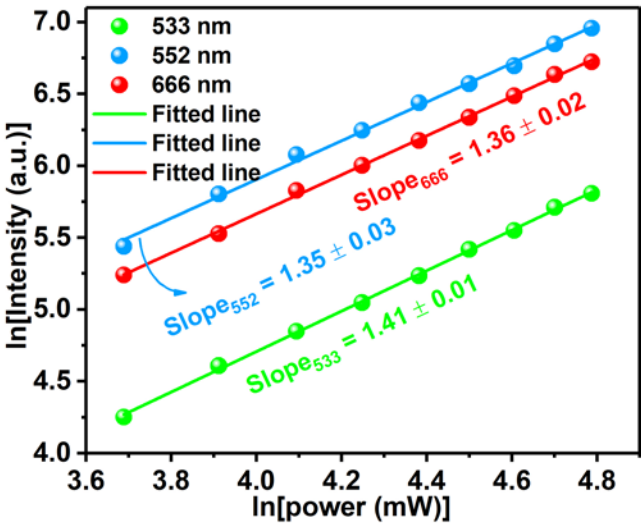

Fig.S5 The plots of ln[Intensity (a.u.)] versus ln[power (mW)] in GZT:4%Er^{3+}/5%Yb^{3+} sample.

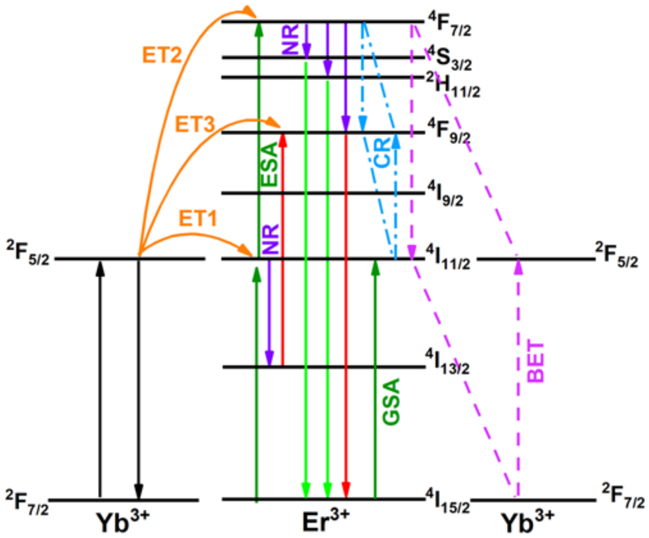

Fig. S6 The proposed UC mechanism in Er^{3+}/Yb^{3+} doped GZT system.

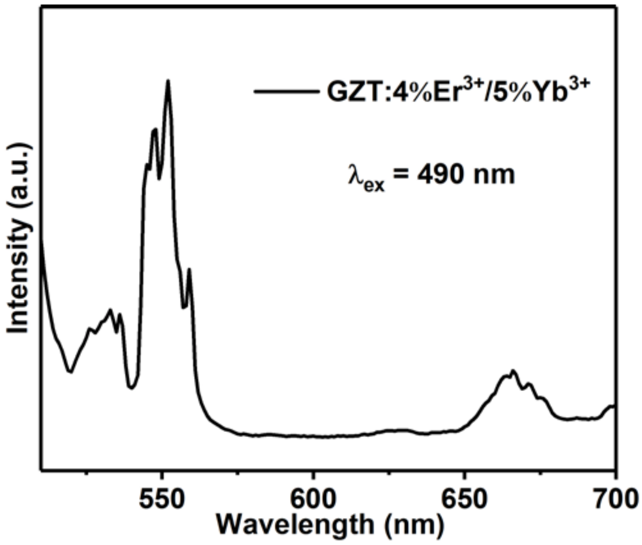

Fig. S7 The down-shifting spectrum of GZT:4%Er^{3+}/5%Yb^{3+} sample upon 490 nm excitation.

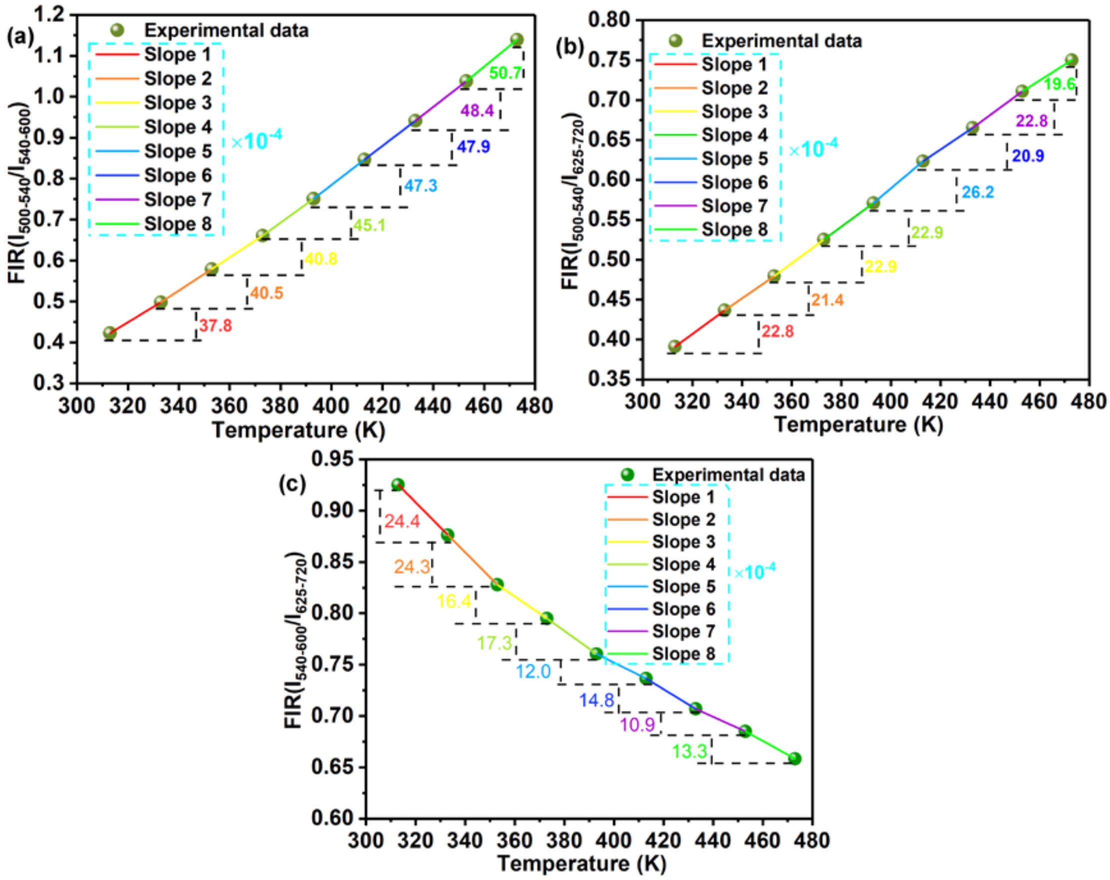

Fig. S8 The slopes of FIRs versus the temperature for (a) $^2H_{11/2}/^4S_{3/2}$, (b) $^2H_{11/2}/^4F_{9/2}$ and (c) $^4S_{3/2}/^4F_{9/2}$ couples.

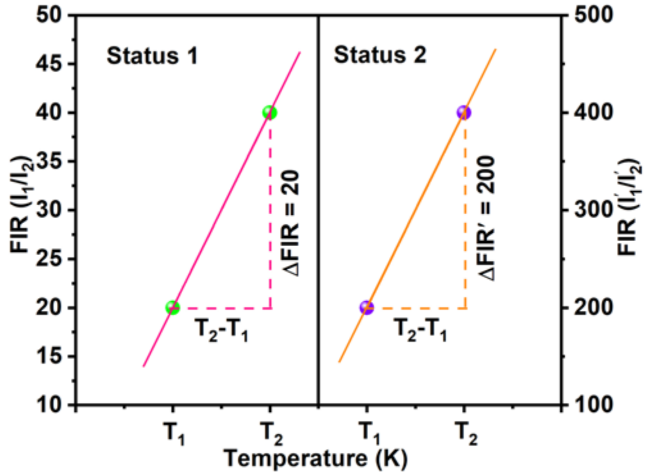

Fig. S9 variation of FIR value as a function of the absolute temperature.

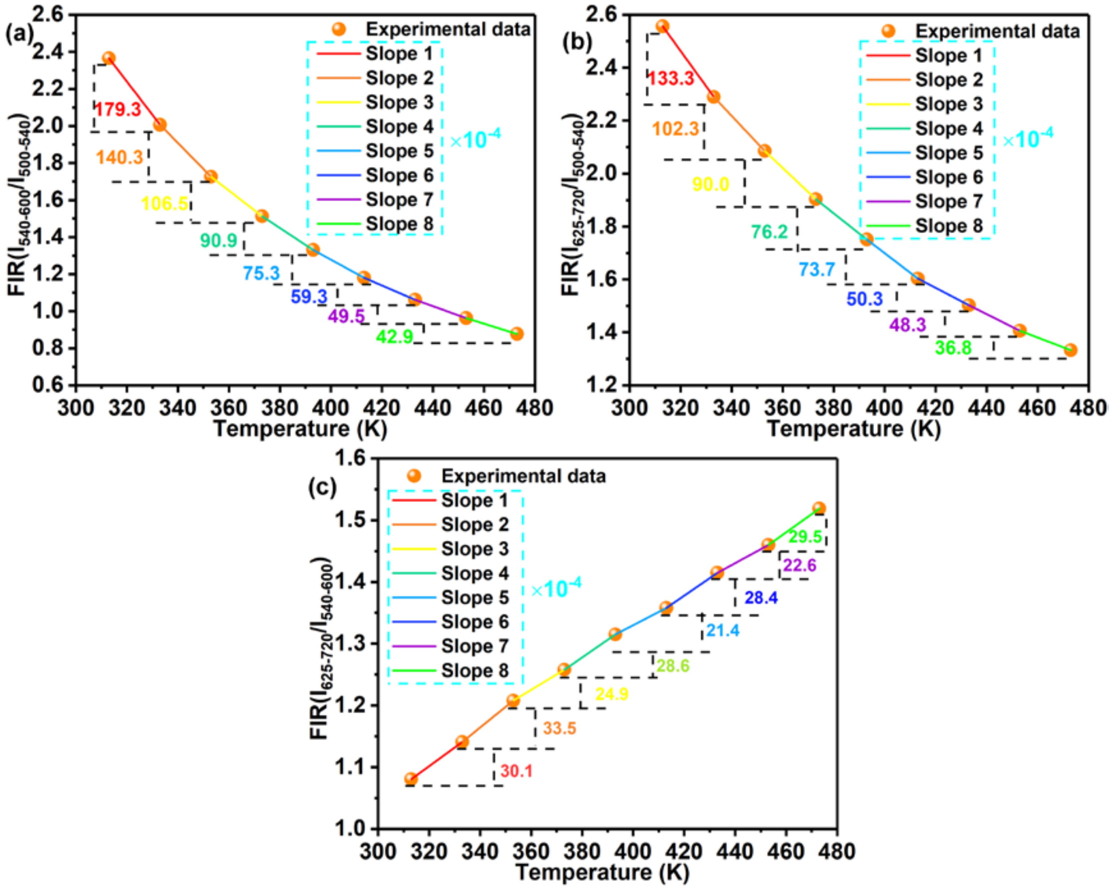

Fig. S10 The slopes of FIRs versus the temperature for (a) $^4S_{3/2}/^2H_{11/2}$, (b) $^4F_{9/2}/^2H_{11/2}$ and (c) $^4F_{9/2}/^4S_{3/2}$ couples.

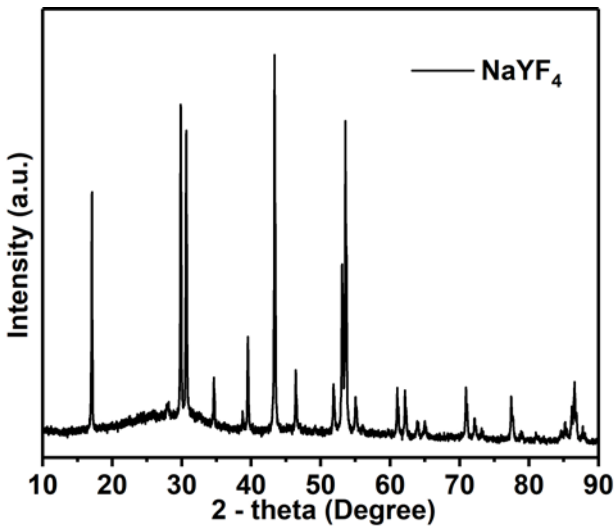

Fig. 11 The XRD pattern of the $NaYF_4$ sample.

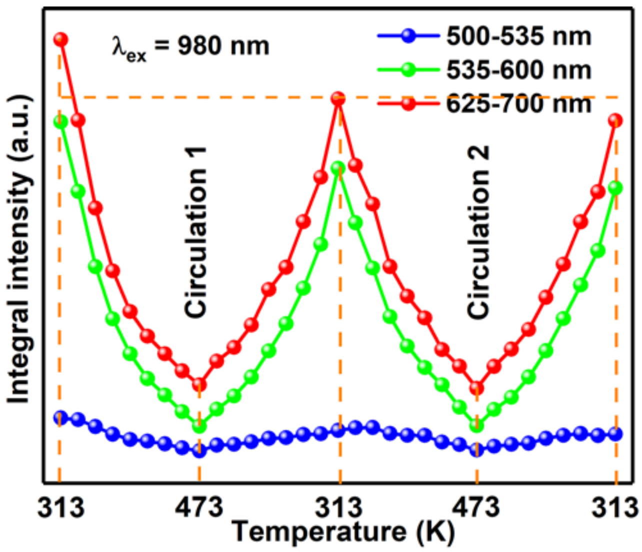

Fig. S12 The plots of integral intensity of emissions versus the temperature in the $NaYF_4$ sample.

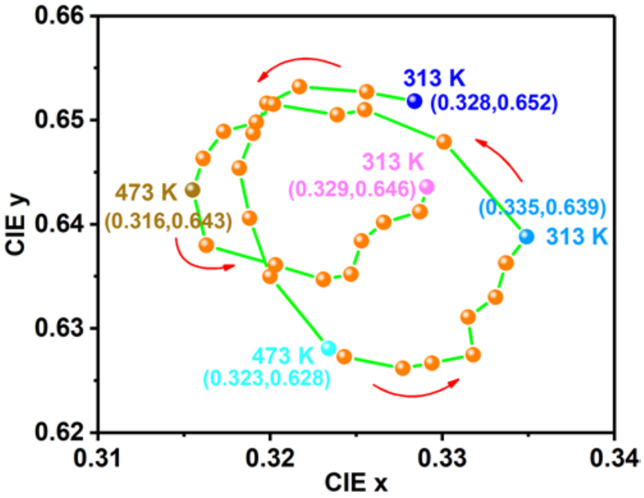

Fig. S13 CIE chromaticity corrdinate in the $NaYF_4$ sample.

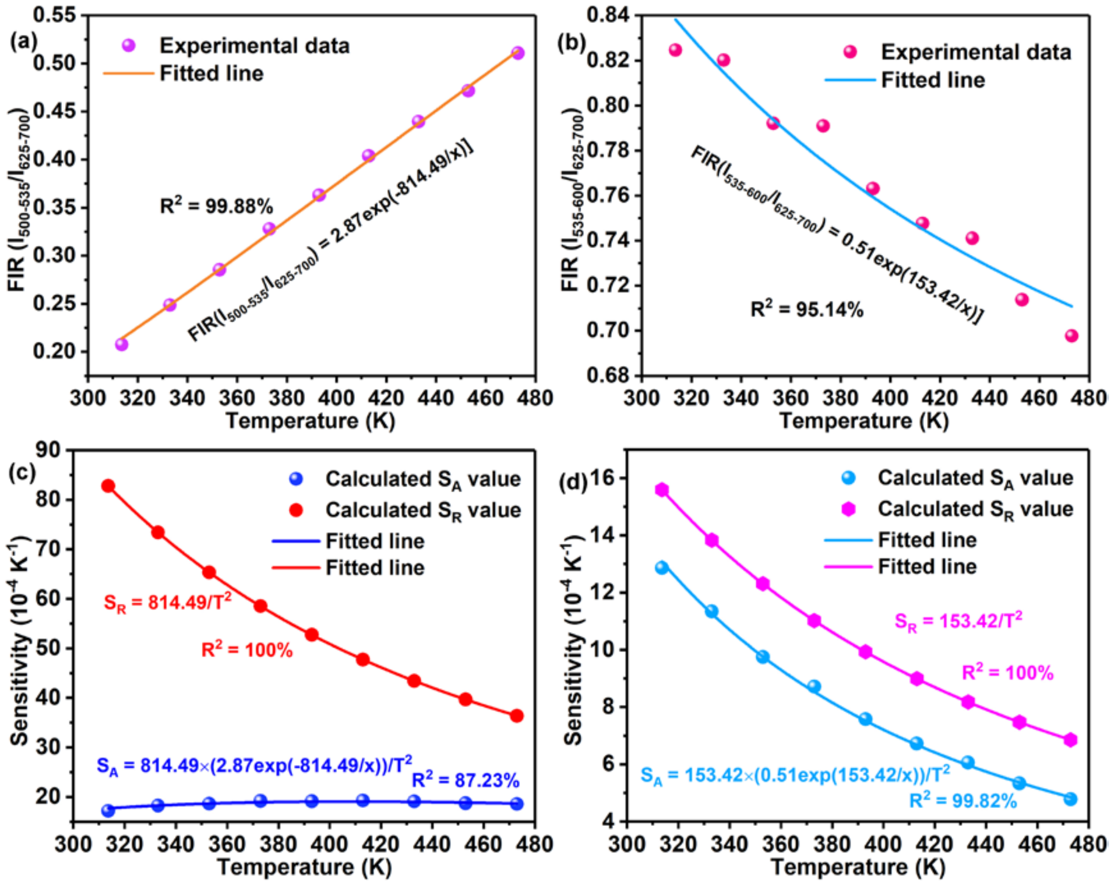

Fig. S14 The plots of FIR value of (a) $^2H_{11/2}/^4F_{9/2}$ and (b) $^4S_{3/2}/^4F_{9/2}$ couples versus the temperature; Calculated sensitivities of (c) $^2H_{11/2}/^4F_{9/2}$ and (d) $^4S_{3/2}/^4F_{9/2}$ couples at diverse temperature.

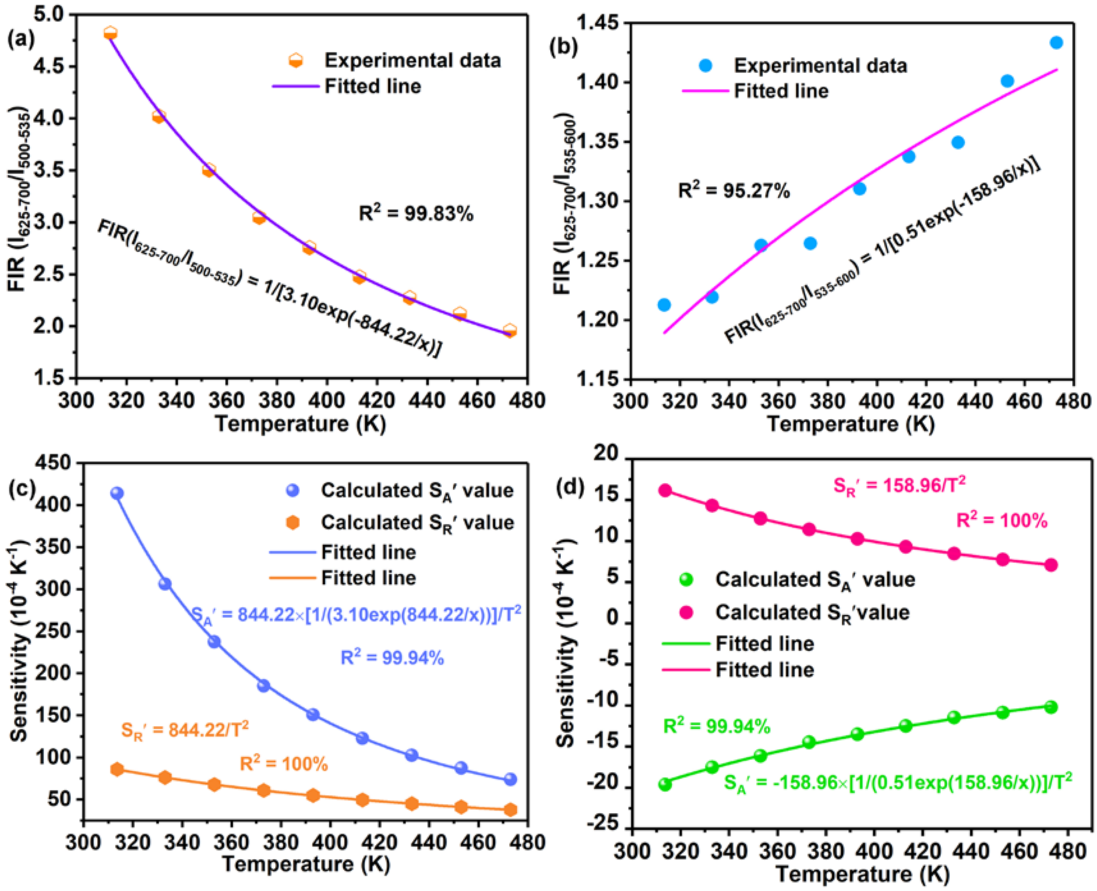

Fig. S15 The plots of FIR value of (a) $^4F_{9/2}/^2H_{11/2}$ and (b) $^4F_{9/2}/^4S_{3/2}$ couples versus the temperature; Calculated sensitivities of (c) $^4F_{9/2}/^2H_{11/2}$ and (d) $^4F_{9/2}/^4S_{3/2}$ couples at diverse temperature.

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