Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Lanthanide doped lead-free double perovskite La_2MgTiO_6 as ultra-bright multicolour LEDs and novel self-calibration partition optical thermometer

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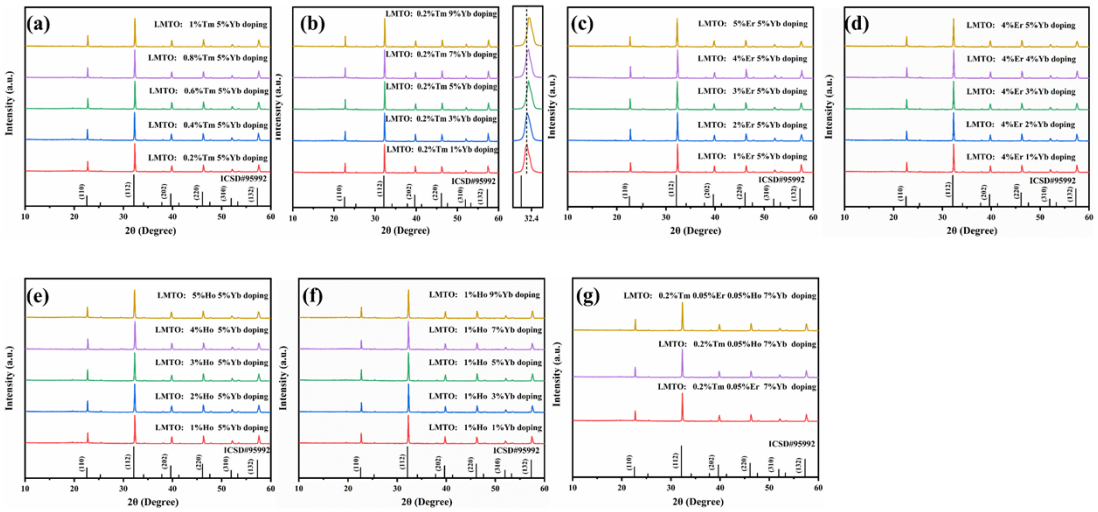

Fig. S1 XRD patterns of (a-b) Tm-Yb; (c-d) Er-Yb; (e-f) Ho-Yb; (g) Ho/Er/Tm-Yb doped LMTO phosphors.

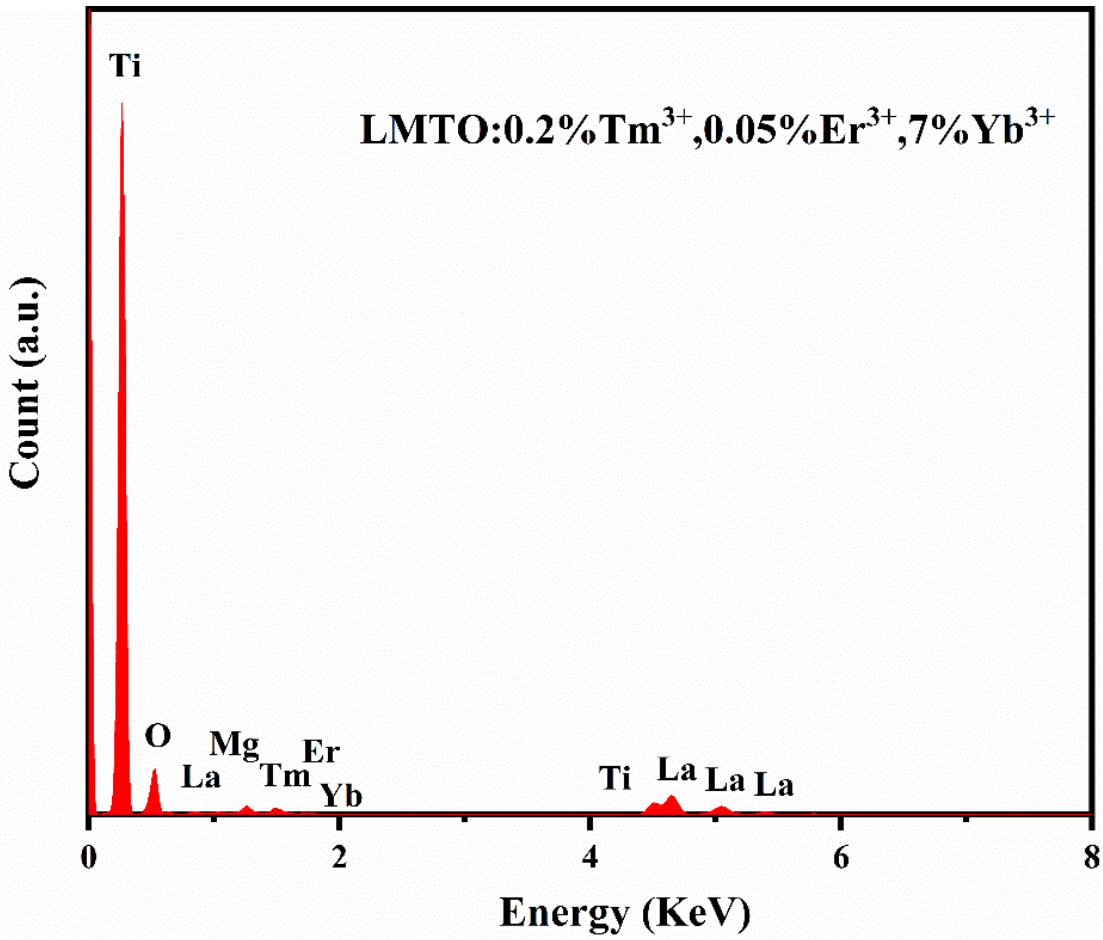

Fig. S2 EDS spectrum of LMTO: 0.2%Tm^{3+}, 0.05%Er^{3+}, 7%Yb^{3+} phosphor.

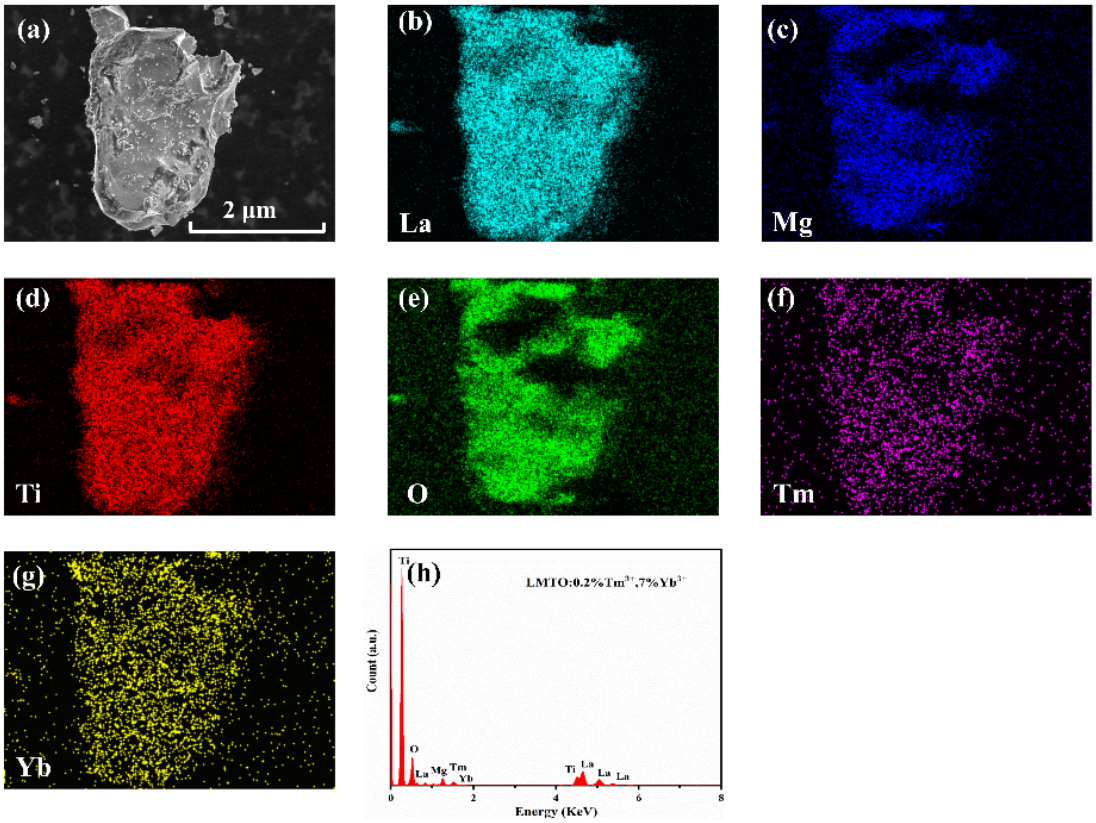

Fig. S3 (a) FE-SEM image and (b-g) elemental mapping images of the LMTO: 0.2%Tm^{3+}, 7%Yb^{3+} phosphor. (h) EDS spectrum of LMTO: 0.2%Tm^{3+}, 7%Yb^{3+} phosphor.

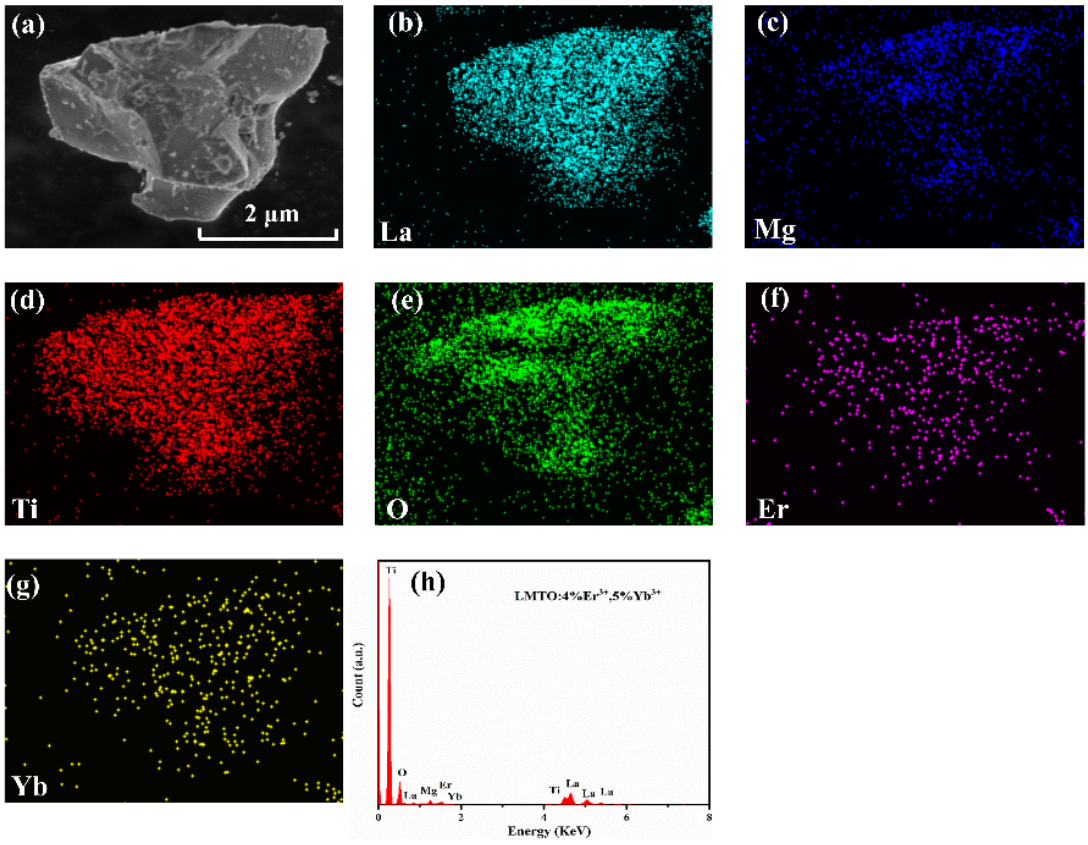

Fig. S4 (a) FE-SEM image and (b-g) elemental mapping images of the LMTO: 4%Er^{3+}, 5%Yb^{3+} phosphor. (h) EDS spectrum of LMTO: 4%Er^{3+}, 5%Yb^{3+} phosphor.

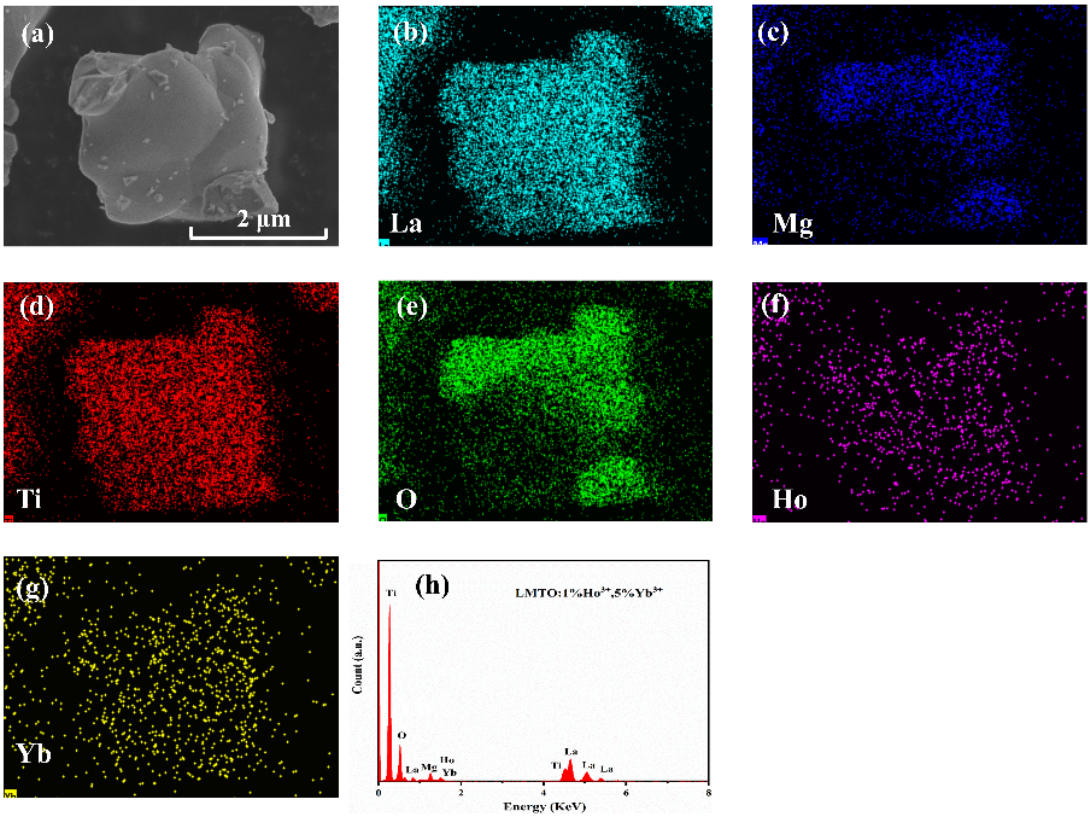

Fig. S5 (a) FE-SEM image and (b-g) elemental mapping images of the LMTO: 1%Ho^{3+}, 5%Yb^{3+} phosphor. (h) EDS spectrum of LMTO: 1%Ho^{3+}, 5%Yb^{3+} phosphor.

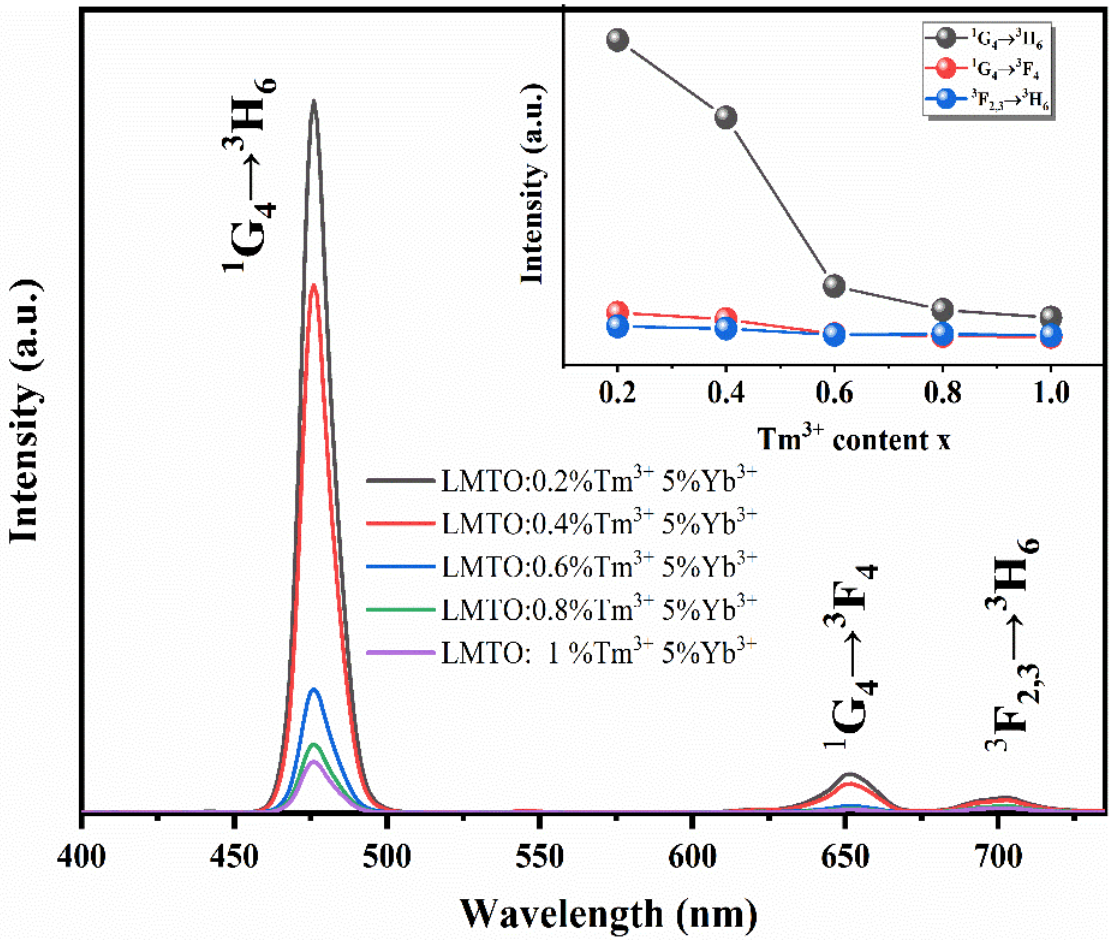

Fig. S6 UC emission spectra of LMTO: x%Tm^{3+}, 5Yb^{3+} phosphors. Inset: Emission intensity as a function of the Yb^{3+} contents. λ_{ex}= 980 nm.

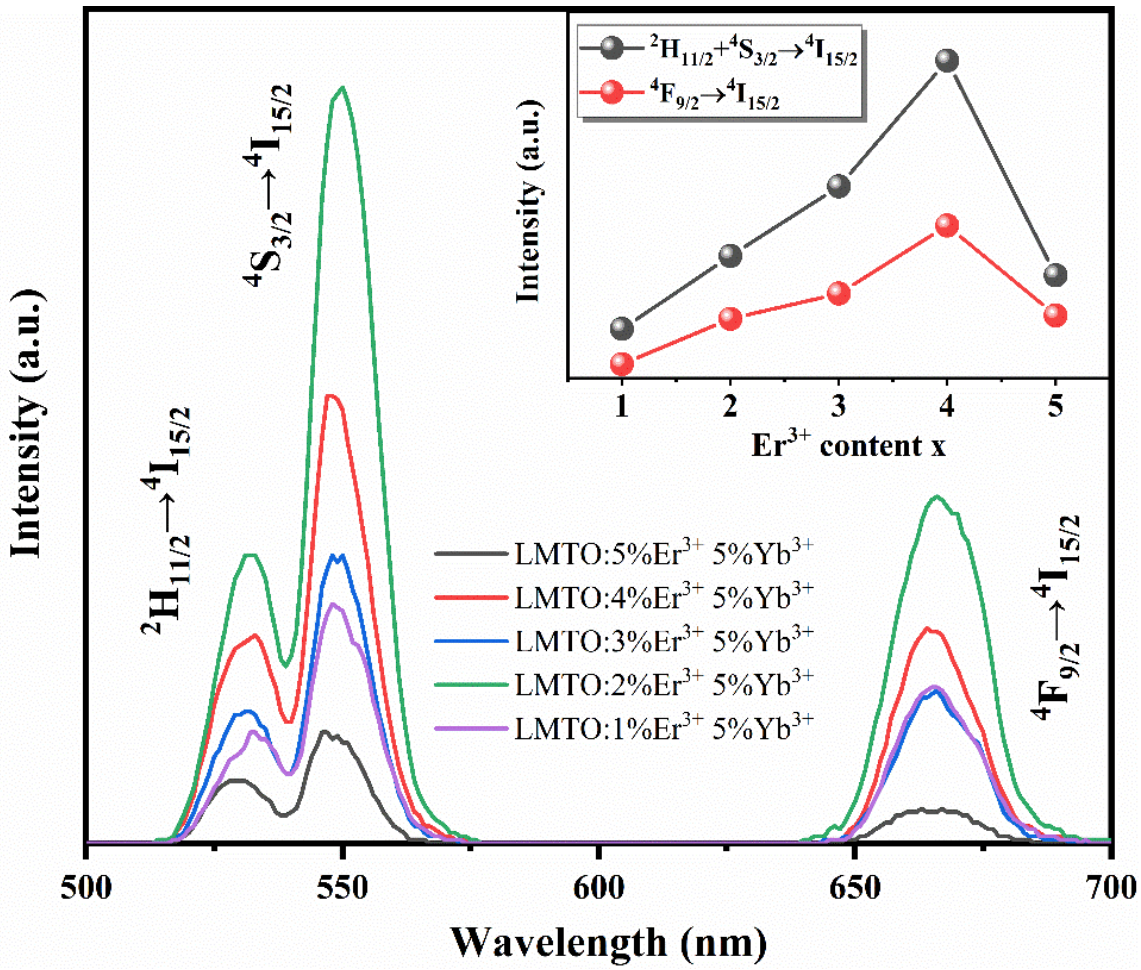

Fig. S7 UC emission spectra of LMTO: x%Er^{3+}, 5Yb^{3+} phosphors. Inset: Emission intensity as a function of the Yb^{3+} contents. λ_{ex}= 980 nm.

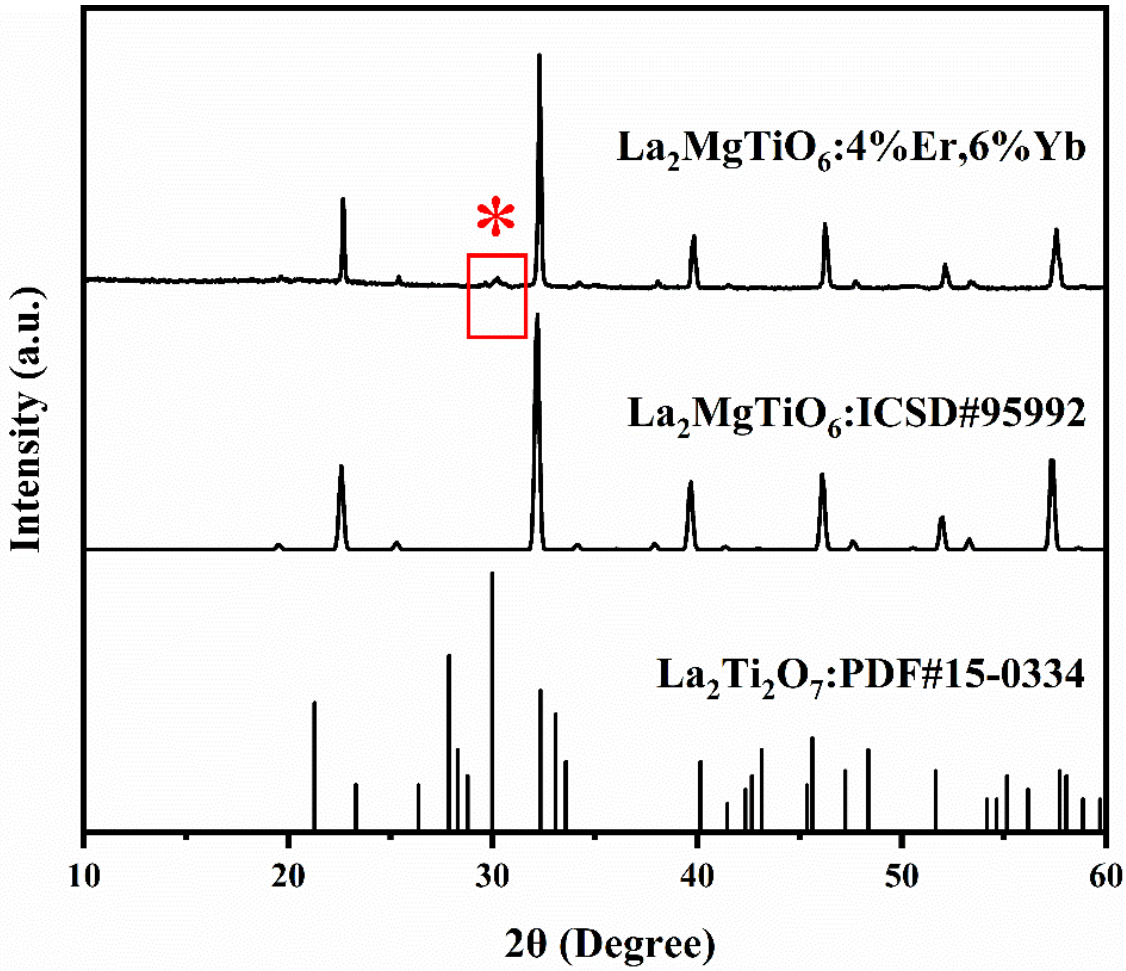

Fig. S8 XRD pattern of LMTO:4%Er^{3+}, 6%Yb^{3+} phosphor.

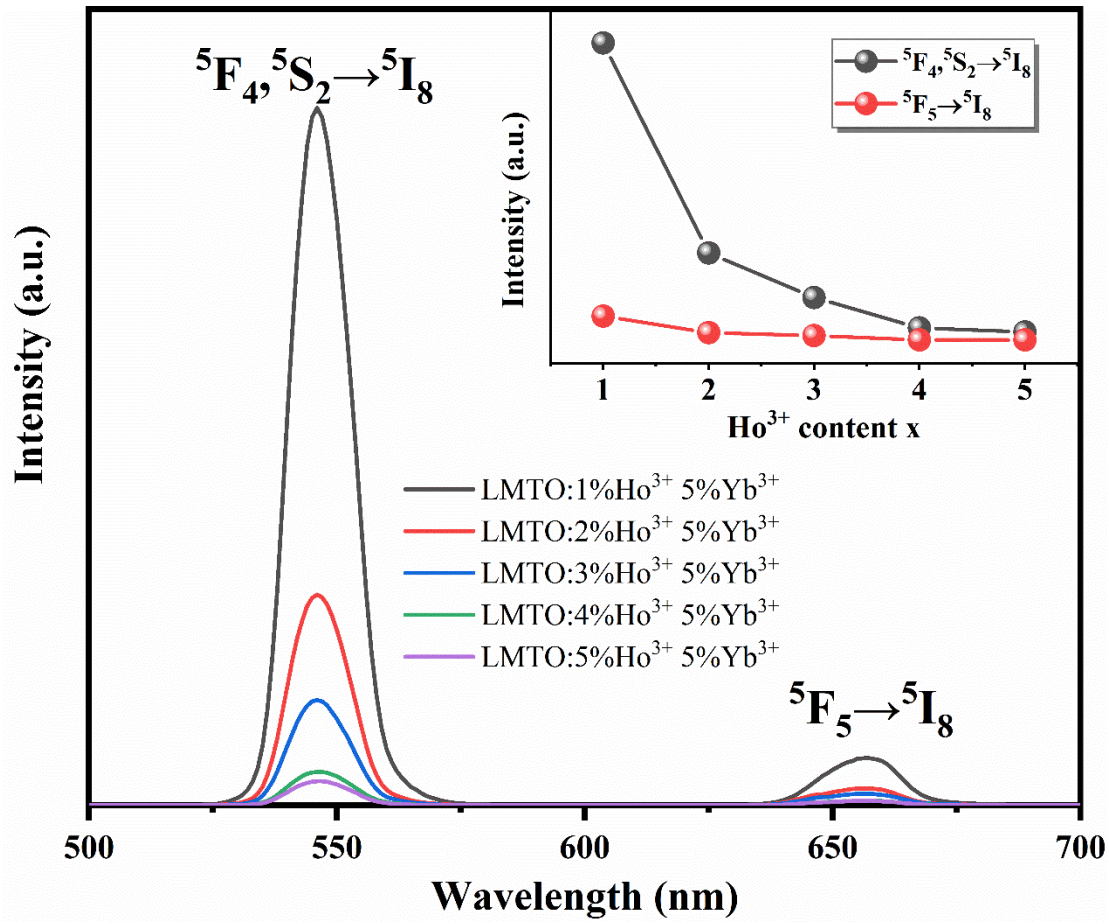

Fig. S9 UC emission spectra of LMTO: x%Ho^{3+}, 5%Yb^{3+} phosphors. Inset: Emission intensity as a function of the Yb^{3+} contents. λ_{ex}= 980 nm.

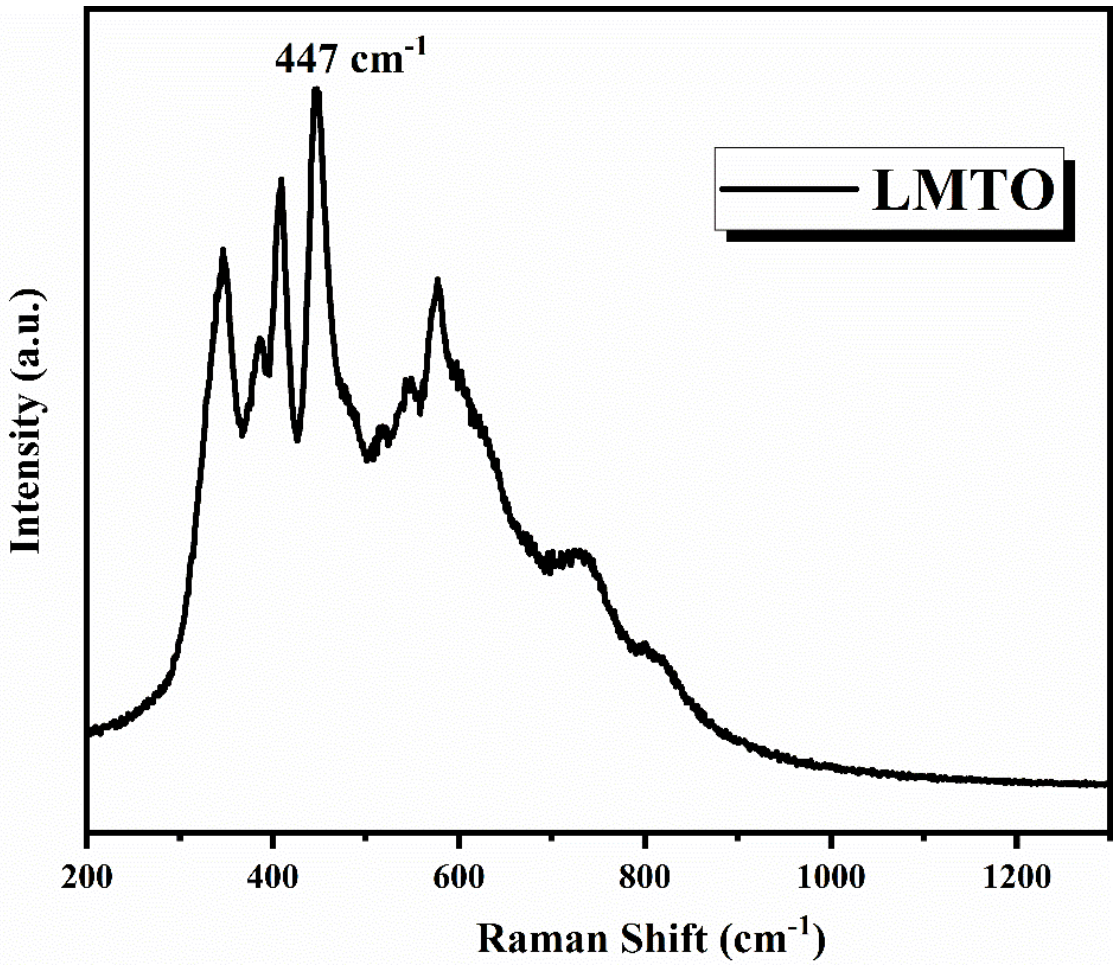

Fig. S10 Raman spectrum of the LMTO host.

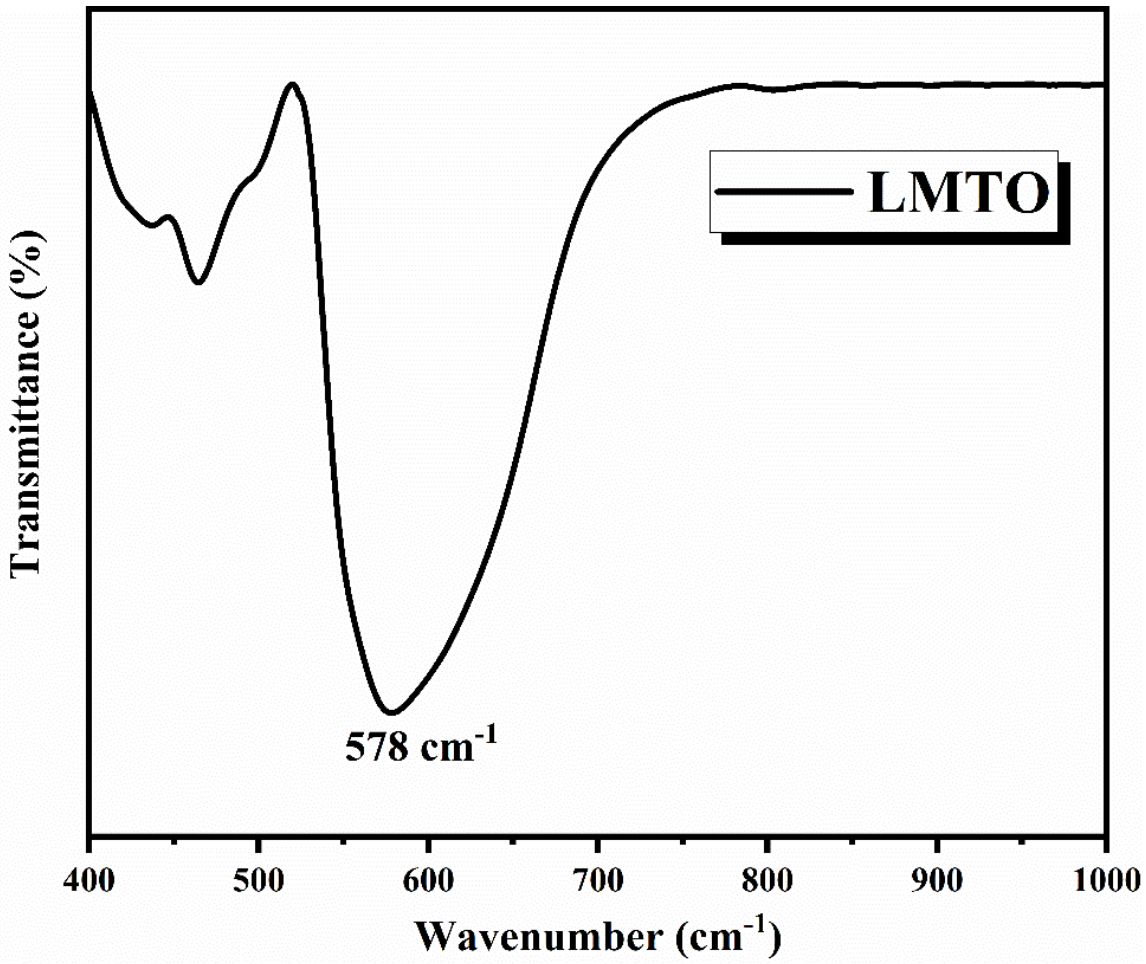

Fig. S11 FT-IR spectrum of the LMTO host.

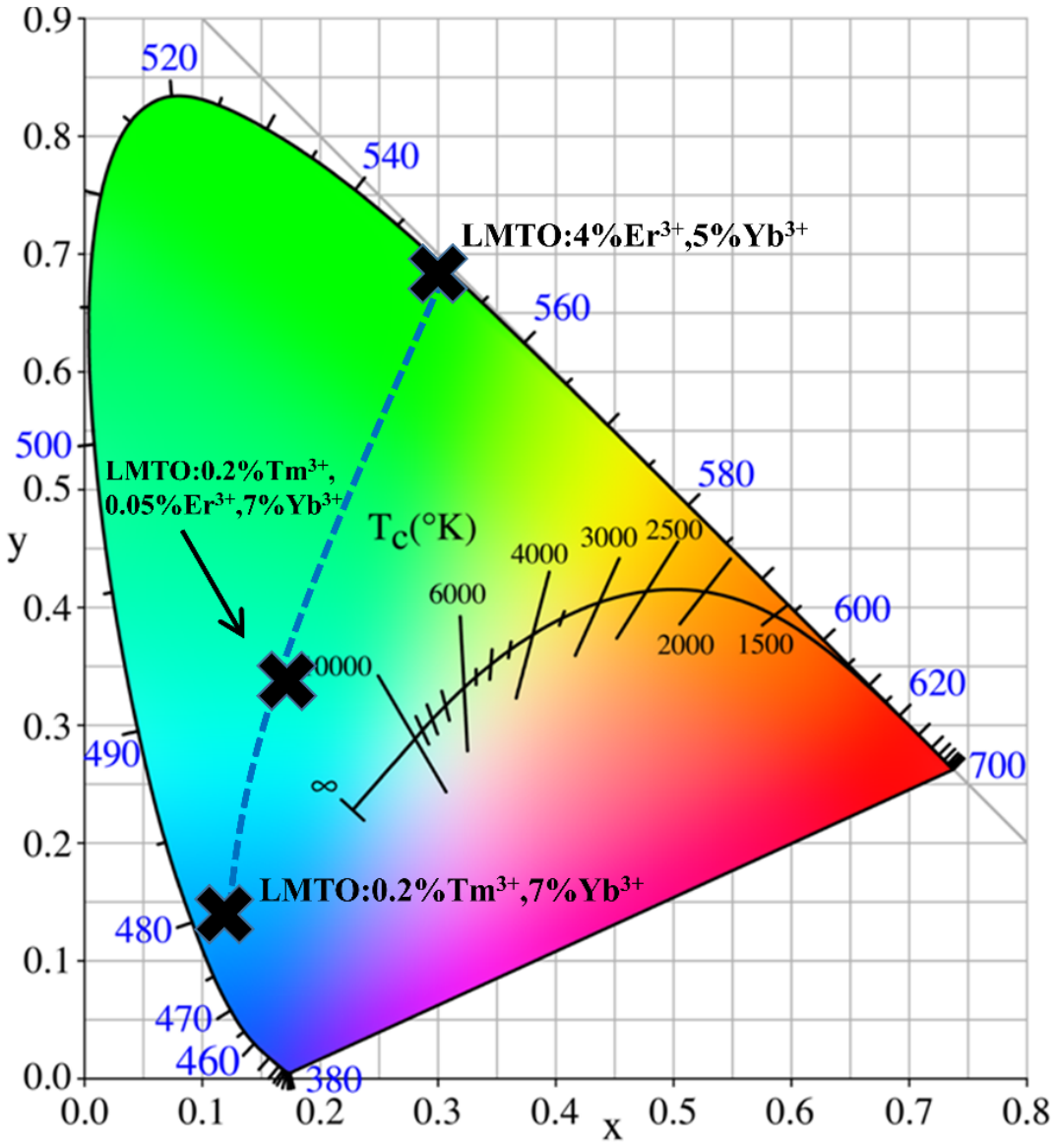

Fig. S12 CIE chromatic coordinates of LMTO:0.2%Tm^{3+}, 7%Yb^{3+}, LMTO:4%Er^{3+}, 5%Yb^{3+} and LMTO:0.2%Tm^{3+}, 0.05Er^{3+}, 7%Yb^{3+} phosphors.

Table S1. The color purity of LMTO: 1%Ho^{3+},5%Yb^{3+}, LMTO: 4%Er^{3+},5%Yb^{3+} and LMTO: 0.2%Tm^{3+},7%Yb^{3+} phosphors.

Compound	(x, y)	(x_i, y_i)	(x_d, y_d)	Color purity (%)
LMTO: 1%Ho^{3+},5%Yb^{3+}	(0.276,0.713)	(0.3101,0.3162)	(0.264,0.725)	91.8%
LMTO: 4%Er^{3+},5%Yb^{3+}	(0.314,0.675)		(0.288,0.700)	93.4%
LMTO:0.2%Tm^{3+},7%Yb^{3+}	(0.118,0.139)		(0.095,0.131)	92.2%

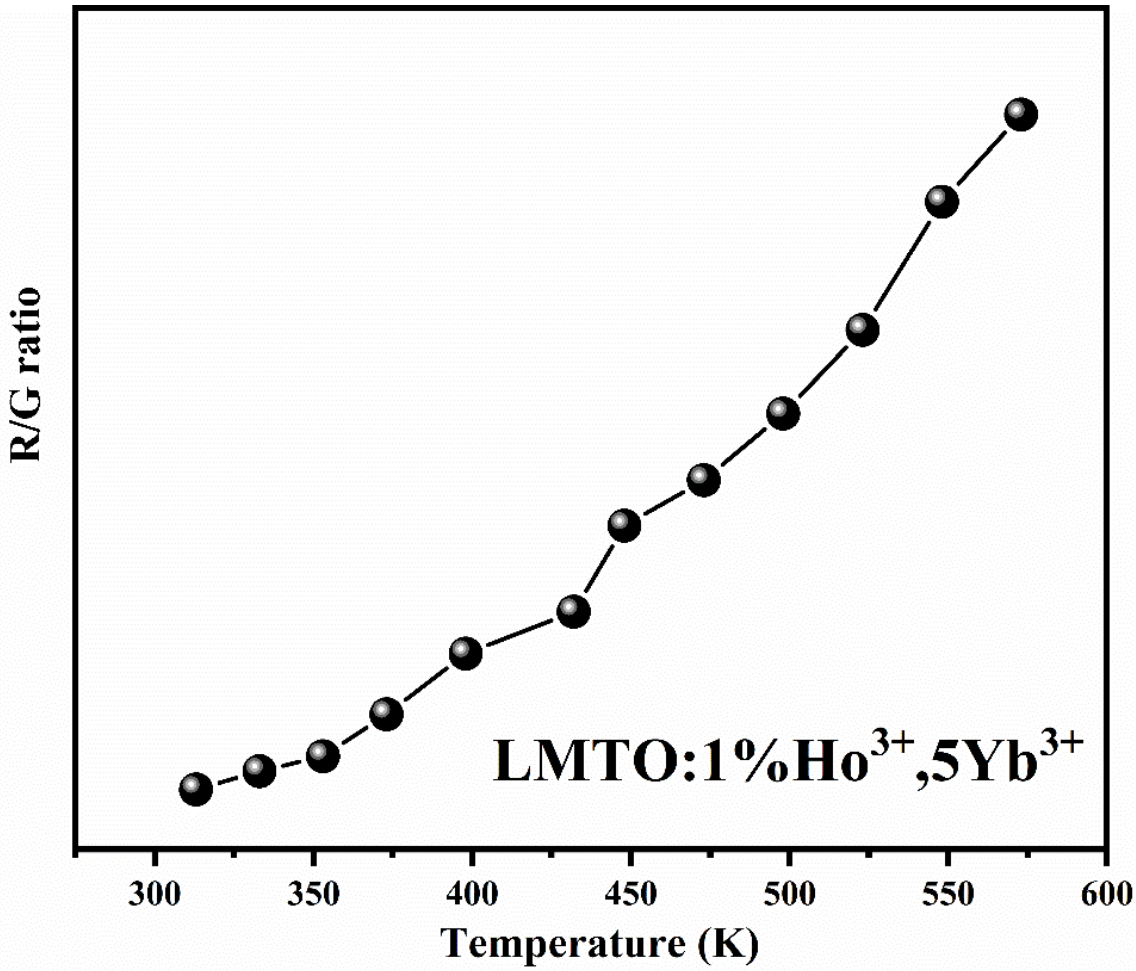

Fig. S13 The curve of red-green ratio varying with temperature.

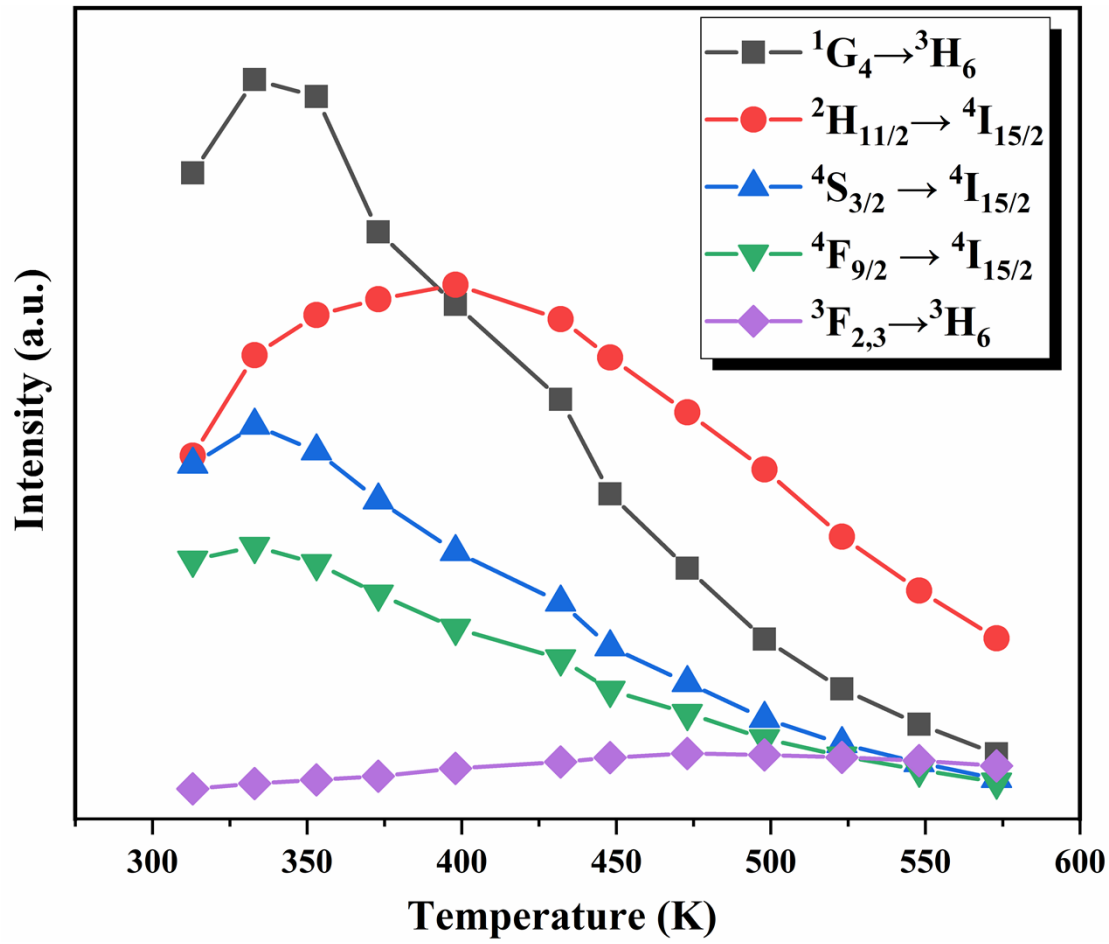

Fig. S14 The PL emission intensity of La_2MgTiO_6: 0.2%Tm^{3+}, 0.05%Er^{3+}, 7%Yb^{3+} phosphor versus various temperatures.

Table S2. Sensing sensitivities of Ln^{3+}-activated luminescent thermometers.

Compounds	Transitions	Range (K)	S_a (% K^{-1})	S_r (% K^{-1})	Refs
$Na_2YMg_2(VO_4)_3$: Er^{3+}/Yb^{3+}	$^2H_{11/2}$,$^4S_{3/2}\rightarrow{}^4I_{15/2}$	303-573	0.77	1.104	1
$Ba_2SrLu_4O_9$:Er^{3+}/Yb^{3+}	$^2H_{11/2}$,$^4S_{3/2}\rightarrow{}^4I_{15/2}$	303-573	0.46	0.99	2
$Na_3Gd\ (VO_4)_2$: Er^{3+}/Yb^{3+}	$^2H_{11/2}$,$^4S_{3/2}\rightarrow{}^4I_{15/2}$	291-578	0.48	0.83	3
$La_2Ti_2O_7$: Ho^{3+}/Yb^{3+}	$^5F_5/^5F_4$,$^5S_2\rightarrow{}^5I_8$	293-473	0.32	1.41	4
TeO_2-ZnO-BaO: Ho^{3+}/Yb^{3+}	$^5F_5/^5F_4$,$^5S_2\rightarrow{}^5I_8$	303-503	0.49	0.41	5
$NaLuF_4$: Ho^{3+}/Yb^{3+}	$^5F_1$,$^5G_6/^5F_{2,3}$,$^3K_8\rightarrow{}^5I_8$	390-780	0.14	0.83	6
YOF: Tm^{3+}/Yb^{3+}	$^3H_{4(2)}$, $^3H_{4(2)}\rightarrow{}^3H_6$	190-300	0.27	0.1207	7
Sr_2GdF_7: Tm^{3+}/Yb^{3+}	$^3F_3\rightarrow{}^3H_6/^1G_4\rightarrow{}^3F_4$	293-563	3.9	1.97	8
Bi_2SiO_5:Tm^{3+}, Yb^{3+}@SiO_2	$^1G_4\rightarrow{}^3F_4/^3F_{2,3}\rightarrow{}^3H_6$	280-400	1.68	1.95	9
LMTO:0.2%Tm^{3+}, 7%Yb^{3+}	LIR 1 $_{Tm}$	313-573	4.94	1.92	This work
	LIR 2 $_{Tm}$		3.32	1.63	
LMTO:4%Er^{3+}, 5%Yb^{3+}	LIR 3 $_{Er}$		0.68	1.13	
LMTO:1%Ho^{3+}, 5%Yb^{3+}	LIR 4 $_{Ho}$		0.18	0.58	
LMTO:0.2%Tm^{3+}, 0.05%Er^{3+}, 7%Yb^{3+}	LIR 2 $_{Tm}$		0.81	1.36	
	LIR 3 $_{Er}$		1.47	1.09	
	LIR 5 $_{Er+Tm}$		1.06	1.21	

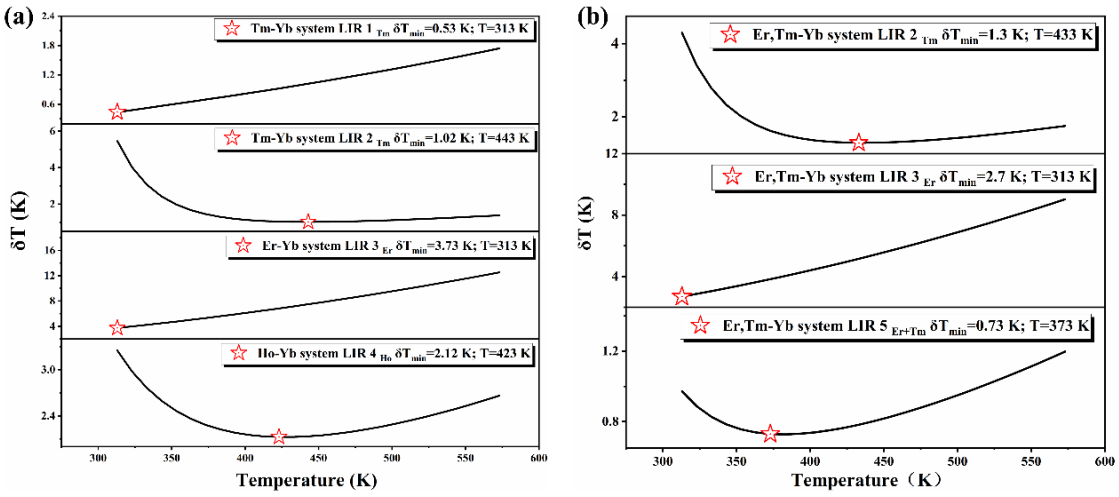

Fig. S15 Temperature uncertainty δT of Mode I-IV.

Table S3. The δT_{min} and Repeatability (R) values of four temperature measurement modes.

Compounds	LIR	δT_{min}	Repeatability (R)
LMTO:0.2%Tm^{3+}, 7%Yb^{3+}	LIR 1 $_{Tm}$	0.53	96.1%
	LIR 2 $_{Tm}$	1.02	91.4%
LMTO:4%Er^{3+}, 5%Yb^{3+}	LIR 3 $_{Er}$	3.73	98.5%
LMTO:1%Ho^{3+}, 5%Yb^{3+}	LIR 4 $_{Ho}$	2.12	92.1%
LMTO:0.2%Tm^{3+}, 0.05%Er^{3+}, 7%Yb^{3+}	LIR 2 $_{Tm}$	1.3	95.6%
	LIR 3 $_{Er}$	2.7	96.3%
	LIR 5 $_{Er+Tm}$	0.73	97%

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