Electronic Supplementary Material (ESI)

Enhancing Upconversion Luminescence Properties of Er^{3+}-Yb^{3+} Doped Yttrium Molybdate through Mg^{2+} Incorporation: Effect of Laser Excitation Power on Temperature Sensing and Heat Generation

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Table S1: Comparison of maximum UC QY measured for different materials at their corresponding saturation regime of power density.

Sample	Power density (W/cm^2)	Total QY (%)	References
$SrLa_2(MoO_4)_4$: Er/Yb	45	2.99	1
La_2O_2S: Er/Yb	13	5.83	2
$NaYF_4$: Er/Yb	20	3.0	3
SrF_2: Er/Yb	388	0.0057	4
$YMoO_4$: Er/Yb/Mg	35	2.48	present work

Table S2: Calculated temperature and the corresponding FIR values at various pump power densities for $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+} phosphor.

Power density (W/cm^2)	$YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+}		
	FIR value	Temperature (K) (7 W/cm^2)	Temperature (K) (66 W/cm^2)
7	1.472	285	304
19	1.910	321	362
30	2.226	346	407
40	2.424	363	434
55	2.520	371	452
66	2.623	380	470

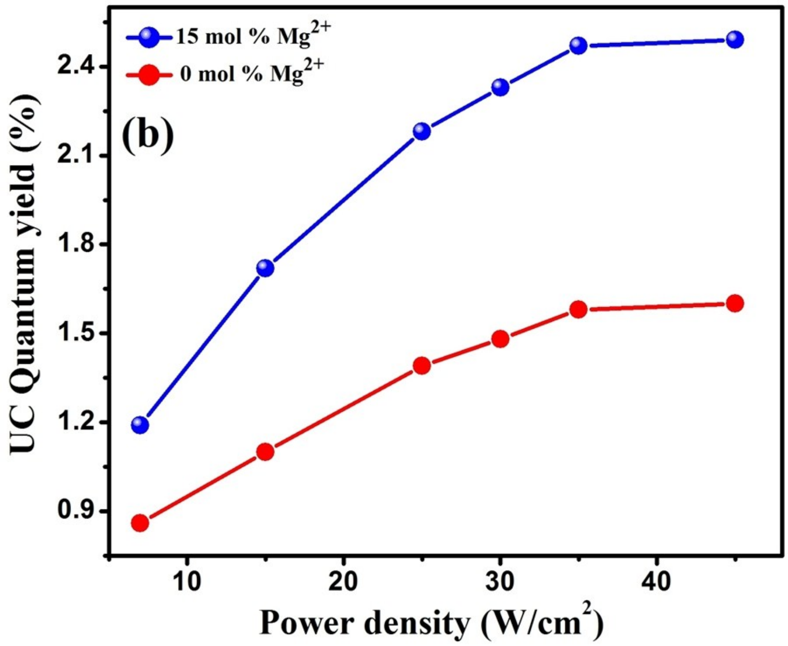

Fig. S1 Variation of emission quantum efficiency with excitation power densities for $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+} and $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+} phosphors. Maximum quantum efficiency is achieved around 35 W/cm^2. Beyond this excitation power, a saturation in the quantum yield is observed.

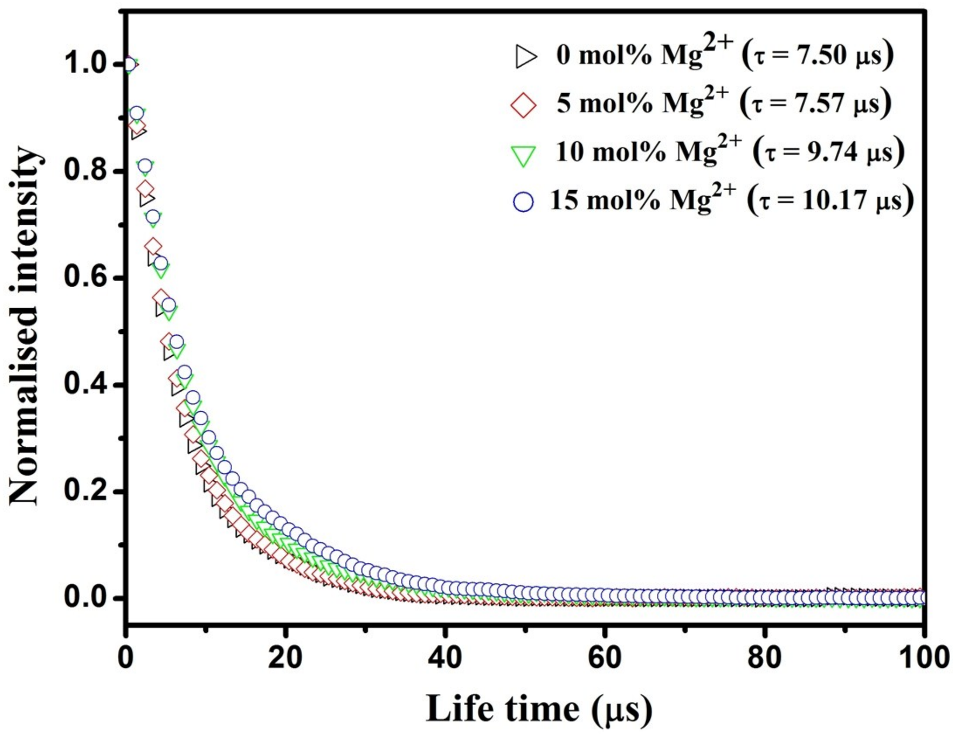

Fig. S2 Lifetime curves for $^4S_{3/2} \rightarrow ^4I_{15/2}$ transition of Er^{3+} for $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+} phosphor co-doped with different concentrations of Mg^{2+} ions (0, 5, 10, and 15 mol%) under 980 nm light excitation.

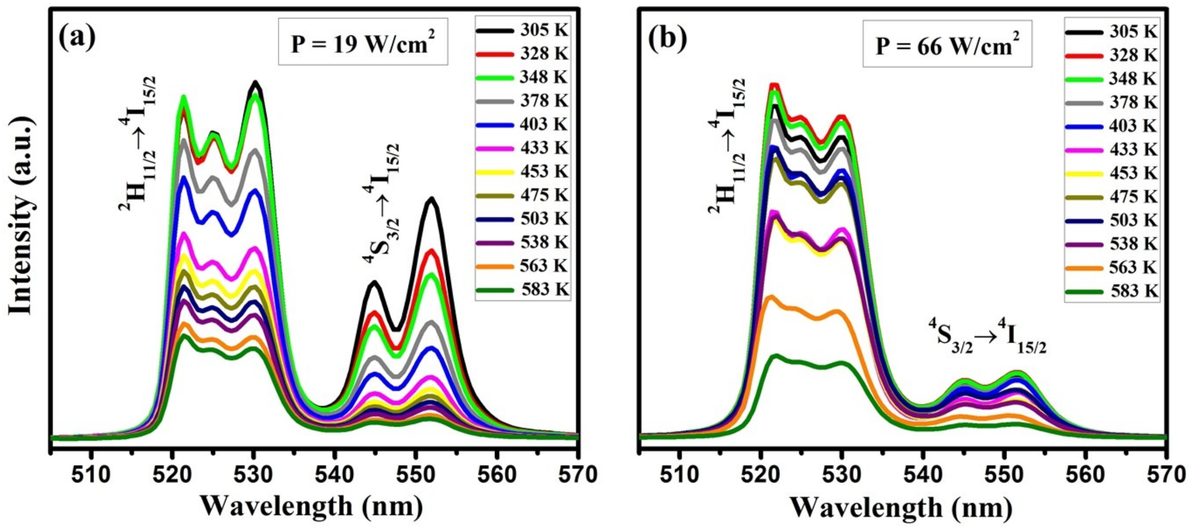

Fig. S3 Temperature dependent UC emission spectra for 530 nm ($^2H_{11/2}\rightarrow{}^4I_{15/2}$) and 552 nm ($^4S_{3/2}\rightarrow{}^4I_{15/2}$) bands of $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+} phosphor excited by 980 nm excitation (a) at 19 W/cm^2 excitation power density; (b) at 66 W/cm^2 excitation power density.

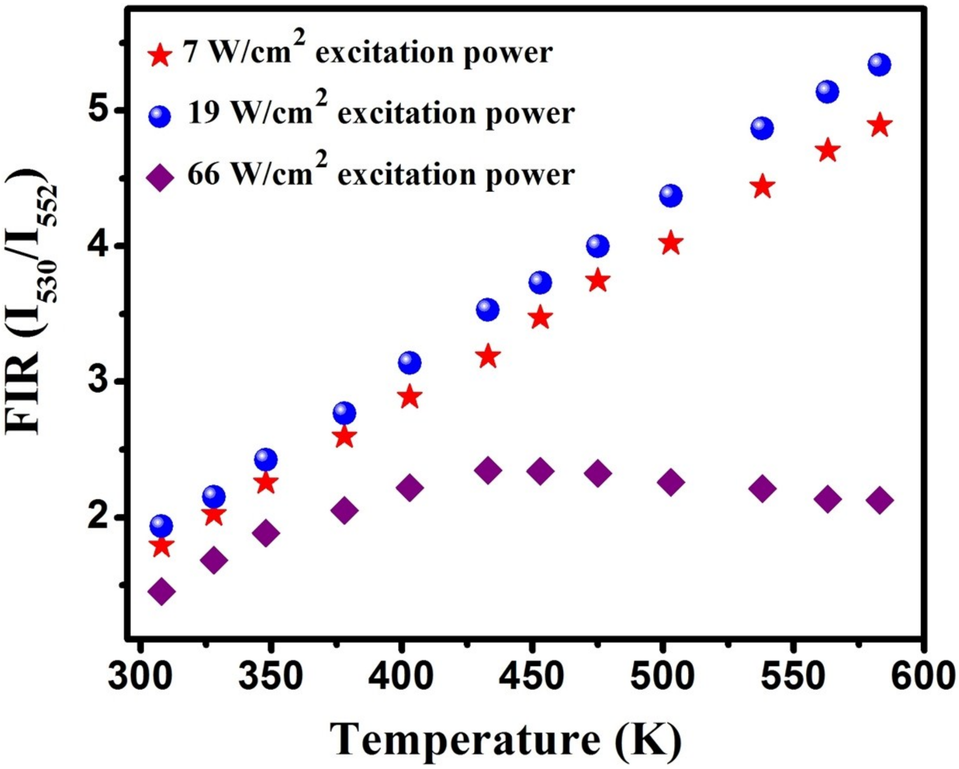

Fig. S4 Variation of FIR (I_{530}/I_{552}) as a function of absolute temperature for $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+} phosphor at three different excitation power density (7, 19 and 66 W/cm^2).

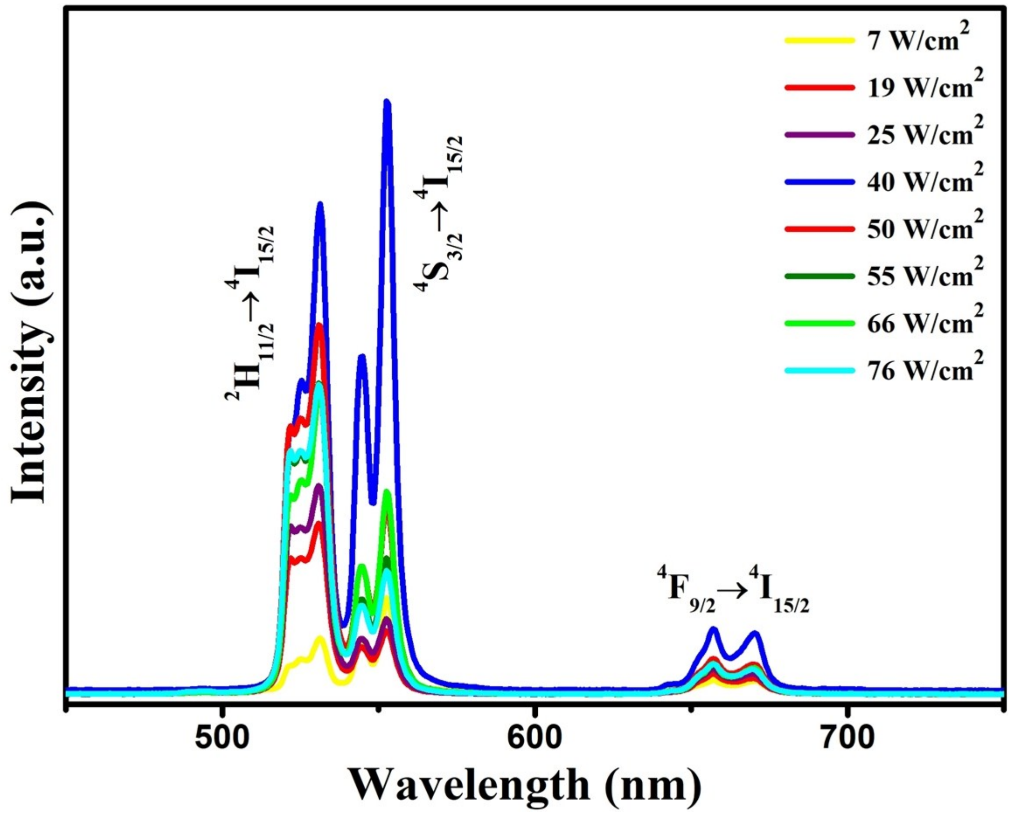

Fig. S5 Variation of UC emission intensity at different excitation power densities for $YMoO_4$: 0.3 mol% Er^{3+}- 3 mol% Yb^{3+}- 15 mol% Mg^{2+} phosphor.

References

1. S. Sinha, K. Kumar, Opt. Mater., 2018, 75, 770.
2. M. Pokhrel, A. K. Gangadharan, D. K.Sardar, Materials Letters, 2013, 99, 86.
3. J. C. Boyer, F. C. J. M. van Veggel, Nanoscale, 2010, 2, 1417.
4. S. Balabhadra, M.L. Debasu, C.D.S. Brites, R.A.S. Ferreira, L.D. Carlos, J. Lumin. 189 2017, 189, 64.