Supporting information for

A highly sensitive ratiometric optical thermometer based on Sr_2MgWO_6 double perovskite doped with Dy^{3+} exploiting thermally coupled and uncoupled levels

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Crystallographic Data (Powder)

Source: The measurements were conducted using the X'Pert PRO powder diffractometer (PANalitycal, The Netherlands) equipped with a linear PIXcel detector and using CuKα radiation (λ = 1.54056 Å) in the 2θ range of 10° to 90°.

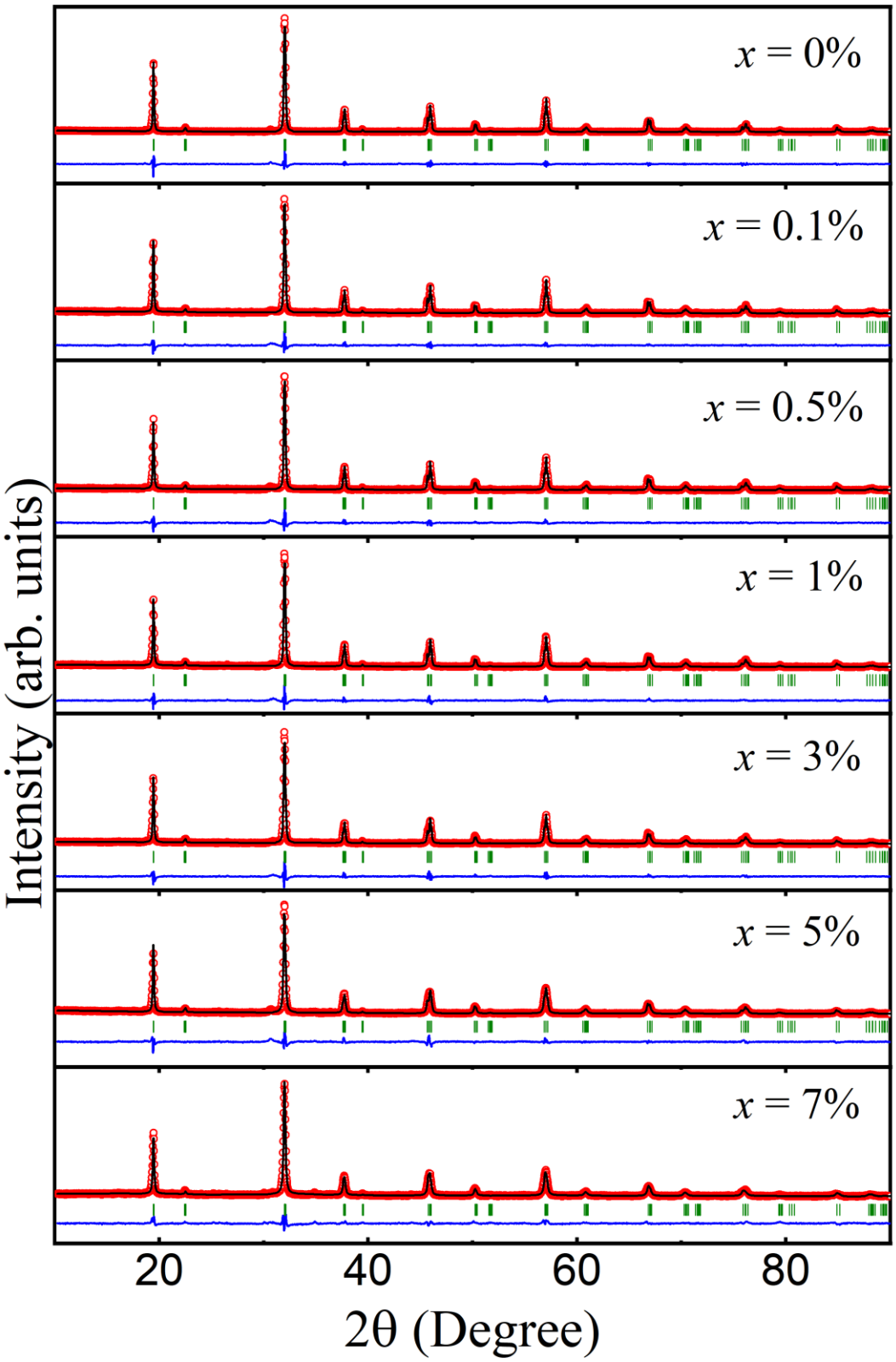

Figure S1. Xray diffraction patterns of the compound $Sr_2Mg_{1-2x}WO_6:xDy^{3+}$, xLi^+ (x = 0%, 0.1%, 0.5%, 1%, 3%, 5%, 7%). The red circles, black lines, blue lines, and the olive bars represents the experimental data, simulated data, the difference between the experimental

and simulated data, and the Bragg positions allowed by the space group symmetry, respectively.

Table S1. (a) Crystallographic parameters from ICSD card no. 152574 of Sr_2MgWO_6, (b) The refined lattice parameters, unit cell volumes, and uncertainties of the undoped and $Sr_2Mg_{1-2x}WO_6$:xDy^{3+}, xLi^+

a)

Chemical formula	***Sr_2MgWO_6***
Formula weight *(g/mol)*	*479.4*
Temperature	*298 K*
Pressure	*Atmospheric*
Crystal system	*tetragonal*
Space-group	*I 4/m (#87)*
Z	*2*
a (Å)	*5.5876(1)*
c (Å)	*7.9490(3)*
α = β= γ (º)	*90*
V (Å³)	*248.18(1)*

b)

	$Sr_2Mg_{1-2x}WO_6$: xDy^{3+}, xLi^+						
x	0%	0.1%	0.5%	1%	3%	5%	7%
a= b (Å)	5.582(3)	5.582(0)	5.582(3)	5.5822(3)	5.5828(0)	5.5832(8)	5.5853(5)
c (Å)	7.935(4)	7.935(8)	7.935(4)	7.9376(7)	7.9390(6)	7.9416(3)	7.9251(7)
α= β= γ (º)	*90*	*90*	*90*	*90*	*90*	*90*	*90*
V ($Å^3$)	*247.2(5)*	247.2(3)	247.2(8)	247.3(4)	247.4(4)	247.5(6)	247.2(3)
χ2	*34.46*	7.8	8.58	8.59	9.84	8.5	7.01
R_p (%)	*6.39*	2.16	2.27	2.27	2.36	2.25	2.29
R_{wp} (%)	*11.2*	3.29	3.47	3.49	3.76	3.51	3.19

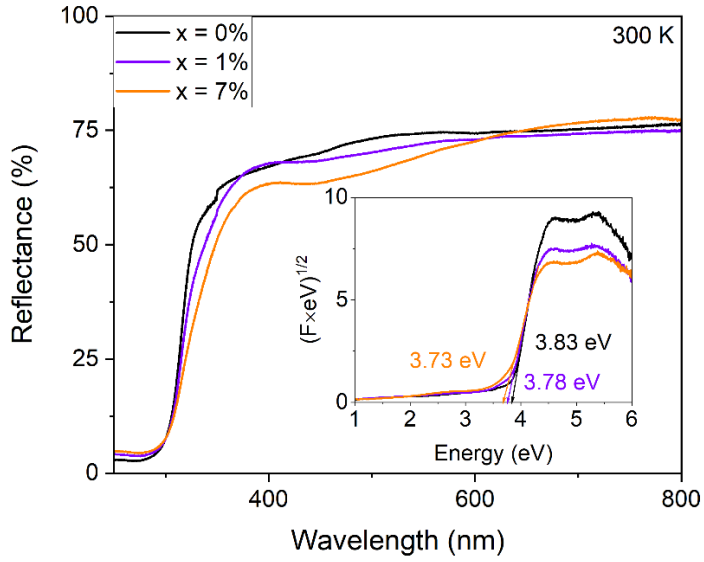

Figure S2. Diffuse reflectance spectra of $Sr_2Mg_{1-2x}WO_6:xDy^{3+}$, xLi^+ (x = 0%, 1%, 7%) samples. Inset: Energy bandgaps estimated by using the Kubelka-Munk function

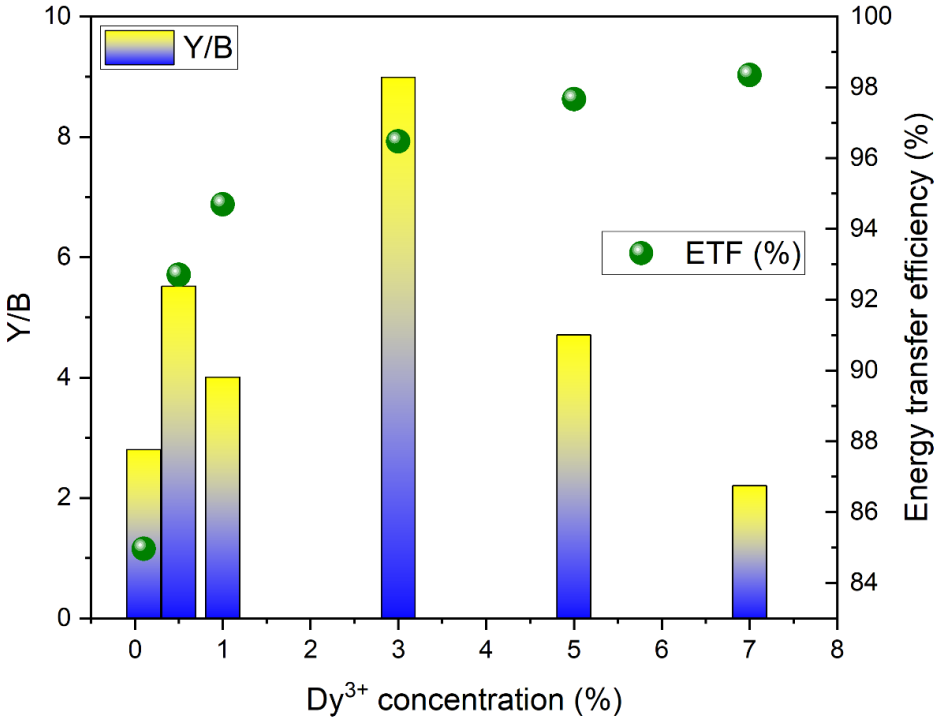

Figure S3. The Y/B ratio (yellow-blue columns, left axis) and the energy transfer efficiency (dark green dots, right axis) as a function of Dy^{3+} concentration

Table S2. The chromaticity coordinates (x,y) of $Sr_2Mg_{1-2x}WO_6:xDy^{3+}$, xLi^+ (x = 0%, 0.1%, 0.5%, 1%, 3%, 5%, 7%) upon 266 nm excitation at room temperature

Sample	CIE (x, y)
SMW host	(0.211, 0.269)
SMW:0.1%Dy^{3+}	(0.382, 0.387)
SMW:0.5%Dy^{3+}	(0.456, 0.453)
SMW:1%Dy^{3+}	(0.445, 0.449)
SMW:3%Dy^{3+}	(0.480, 0.471)
SMW:5%Dy^{3+}	(0.463, 0.462)
SMW:7%Dy^{3+}	(0.426, 0.444)

Table S3. Quantum yield of all synthesized samples (λ_{exc} = 270 nm)

Sample	QY %
SMW host	10.5%
SMW:0.1%Dy^{3+}	12.9%
SMW:0.5%Dy^{3+}	18.3%
SMW:1%Dy^{3+}	15%
SMW:3%Dy^{3+}	30.7%
SMW:5%Dy^{3+}	13.8%
SMW:7%Dy^{3+}	9.7%

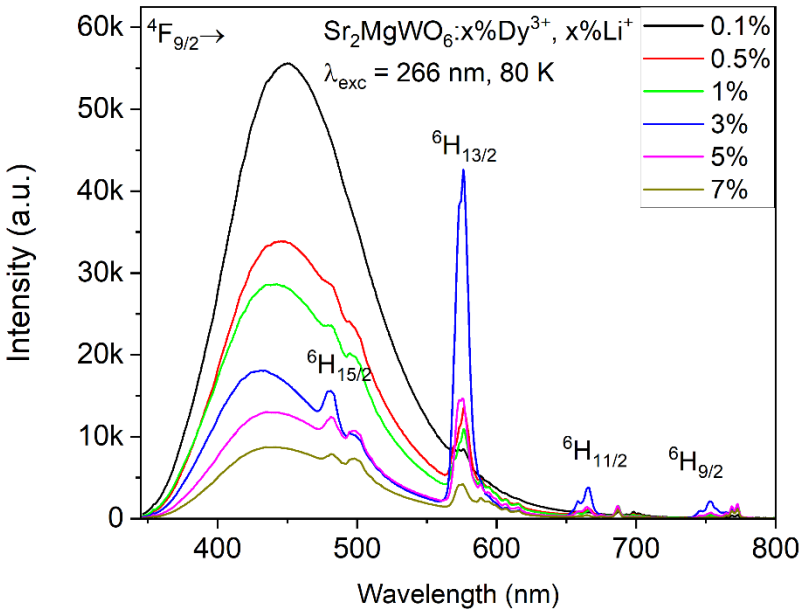

Figure S4. 80 K emission spectra of $Sr_2Mg_{1-2x}WO_6$:xDy^{3+}, xLi^+ (x = 0.1%, 0.5%, 1%, 3%, 5%, 7%) excited at λ_{exc} = 266 nm

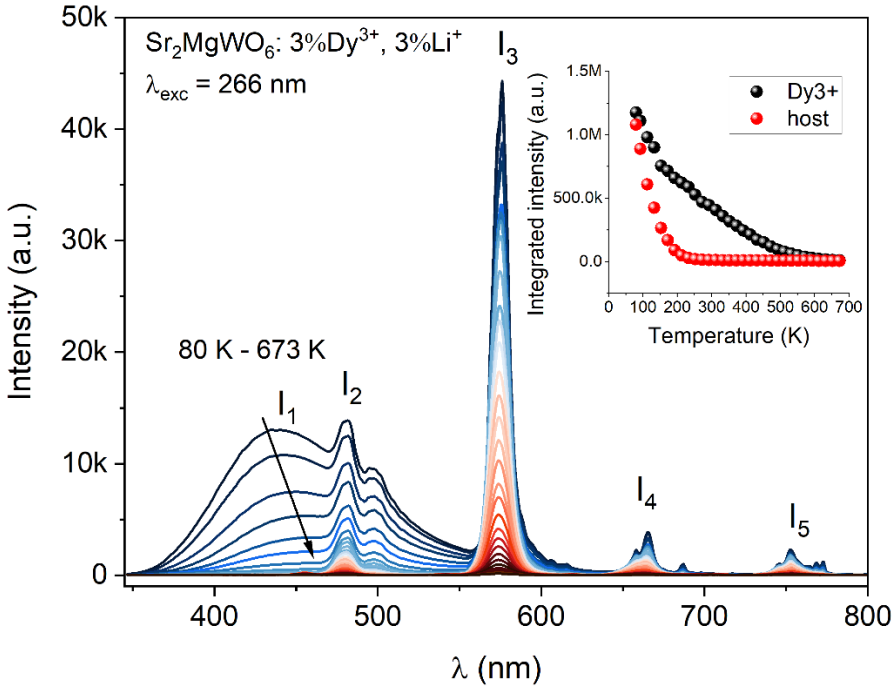

Figure S5. Temperature-dependent emission spectra of $Sr_2Mg_{1-2x}WO_6$:xDy^{3+}, xLi^+ (x = 3%) excited at 266 nm, from 80 – 673 K. Inset: Integrated emission intensities of the host and Dy^{3+} as a function of temperature.

Table S4. a) Fitting parameters of the decay profiles for SMW:xDy^{3+}, xLi^{+} (x = 0.1%, 0.5%, 1%, 3%, 5%, 7%)

x	A_1	t_1	A_2	t_2	A_3	t_3	R-Square
0.1%	0.28171	4.97E-05	0.62502	2.03E-04	0.07596	3.74E-04	0.99989
0.5%	0.29716	2.38E-05	0.56419	1.60E-04	0.31878	2.95E-04	0.99998
1%	0.22882	6.83E-05	0.68039	2.11E-04	0.07681	4.38E-04	0.99989
3%	0.07972	2.10E-05	0.54315	1.51E-04	0.40011	2.79E-04	0.99997
5%	0.19046	5.03E-05	0.58492	1.62E-04	0.21426	2.85E-04	0.99994
7%	0.26818	3.47E-05	0.46636	1.23E-04	0.24433	2.65E-04	0.9998

Table S4. b) The mean lifetimes of $Sr_2Mg_{1-2x}WO_6$:xDy^{3+}, xLi^{+} (x = 0.1%, 0.5%, 1%, 3%, 5%, 7%) monitored at 574 nm, excited at 266 nm wavelength at room temperature

x	τ_mean (μs)
0.1%	222
0.5%	227
1%	240
3%	248
5%	225
7%	203

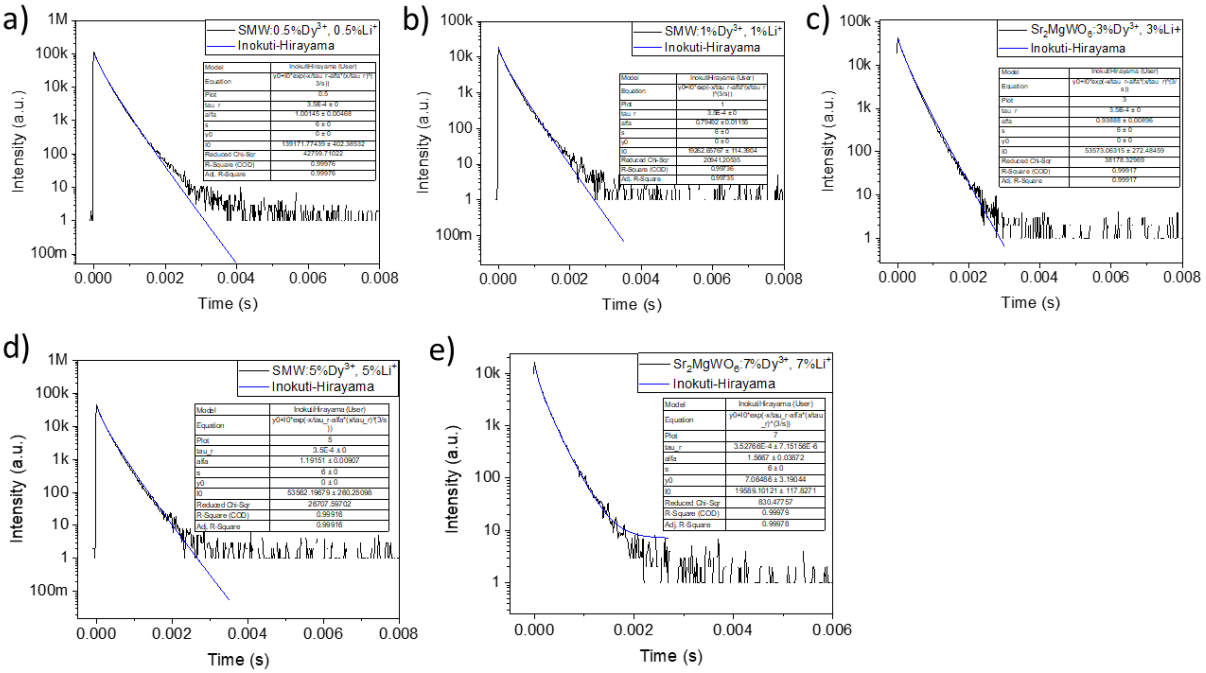

Figure S6. Decay profiles and fitting curves (blue solid line) of $Sr_2Mg_{1-2x}WO_6$:x%Dy^{3+}, x%Li^+ (x = 0.5, 1, 3, 5, 7%). Inset: Fitting parameters of Inokuti-Hirayama function

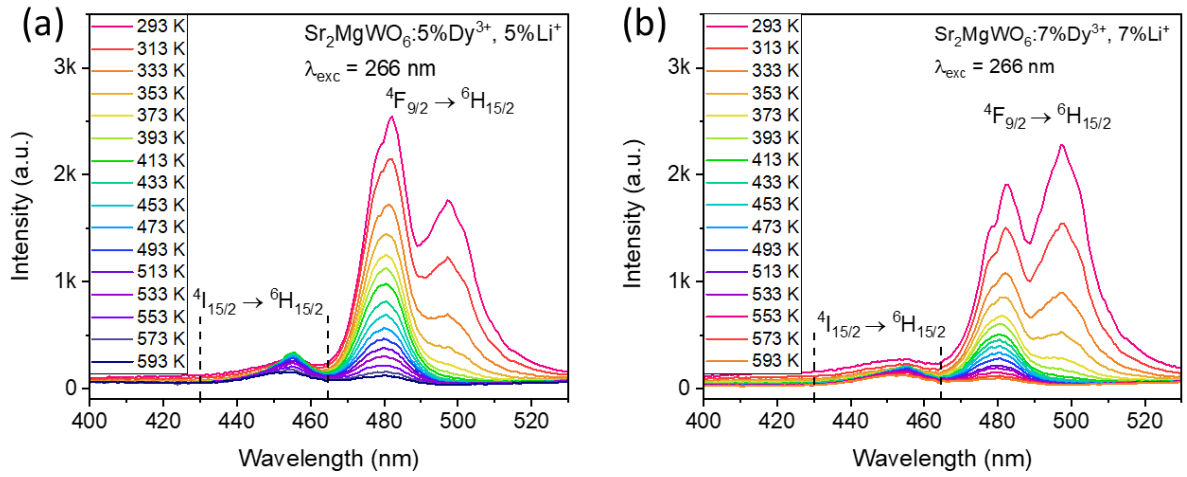

Figure S7. Temperature - dependent emission spectra (400 - 530 nm) of $Sr_2Mg_{1-2x}WO_6$:5%Dy^{3+}, 5%Li^+ (a) and $Sr_2Mg_{1-2x}WO_6$:7%Dy^{3+}, 7%Li^+ (b) in the range of 293 - 593 K excited at λ_{exc} = 266 nm

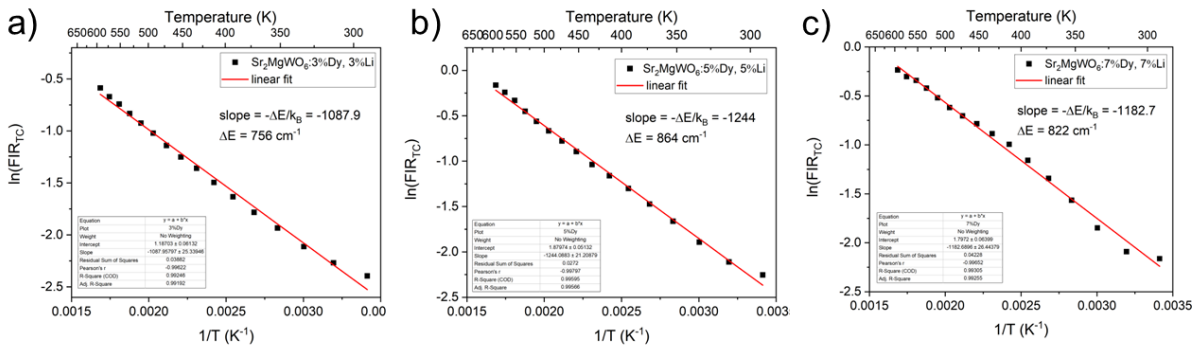

Figure S8. Plots of ln (FIR_{TC}) versus (1/T) for the sample Sr_2MgWO_6:x%Dy^{3+}, x%Li^+ (x = 3, 5, 7%) along with the linear fit (red solid line)

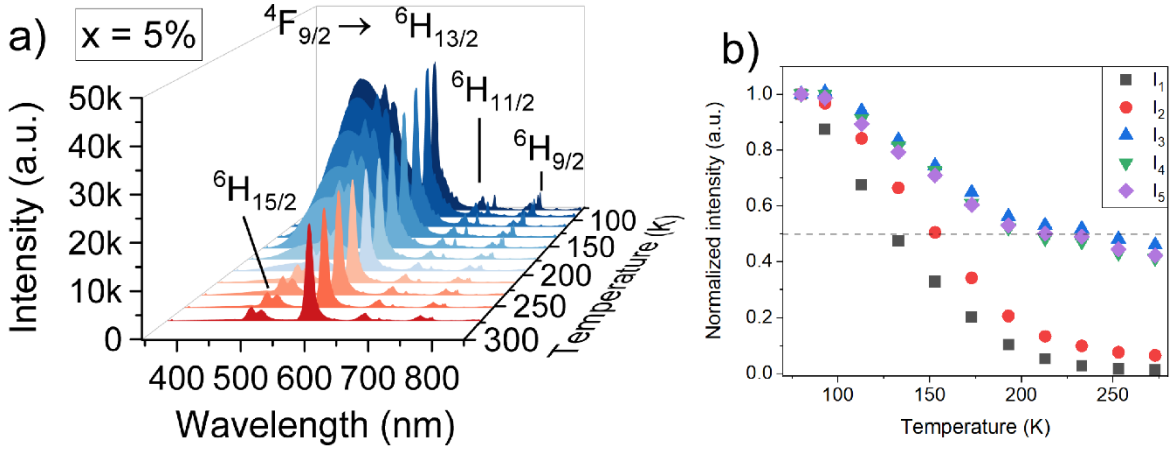

Figure S9. (a) Temperature - dependent emission spectra of $Sr_2Mg_{1-2x}WO_6$:xDy^{3+}, xLi^+ (x = 5%) (λ_{exc} = 266 nm) in the range of 80 - 293 K; (b) Normalized emission intensity of the host and Dy^{3+} transitions as a function of temperature

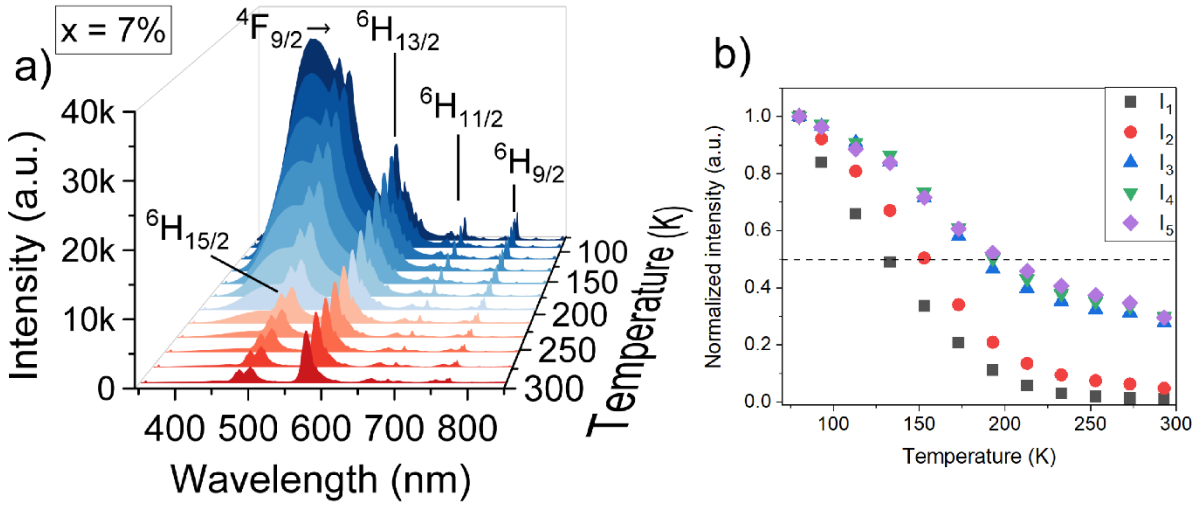

Figure S10. (a) Temperature - dependent emission spectra of $Sr_2Mg_{1-2x}WO_6:xDy^{3+}$, xLi^+ (x = 7%) (λ_{exc} = 266 nm) in the range of 80 - 293 K; (b) Normalized emission intensity of the host and Dy^{3+} transitions as a function of temperature

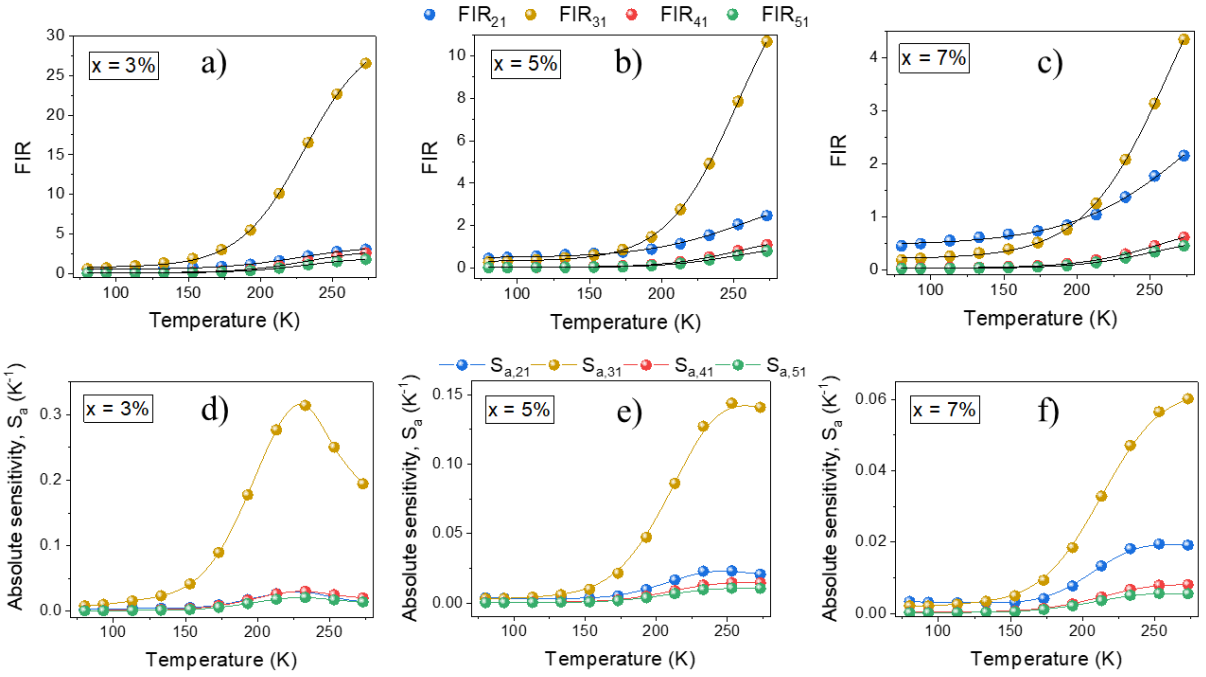

Figure S11. (a-c) FIRs of thermally uncoupled levels and its fitting curves (black lines); (d-f) Absolute sensitivities, S_a (K^{-1}) of SMW:xDy^{3+}, xLi^+ (x = 3%, 5%, 7%) in the range of 80 - 293 K

Table S5. Fitting parameters of the FIR_{NC} for SMW:xDy^{3+}, xLi^{+} (x = 3%, 5%, 7%) in the temperature range of 80 - 293 K

SMW:3%Dy^{3+}, 3%Li^{3+}

	FIR_{21}	FIR_{31}	FIR_{41}	FIR_{51}
A1	0.51486 ± 0.03558	0.77004 ± 0.0812	0.07474 ± 0.00764	0.04852 ± 0.00483
A2	3.55038 ± 0.18509	30.51565 ± 0.42833	3.0209 ± 0.0439	2.07766 ± 0.02756
x0	227.35284 ± 4.00379	230.29791 ± 0.84799	231.99559 ± 0.88169	231.85179 ± 0.80287
dx	26.87941 ± 2.64467	22.5339 ± 0.56685	23.16337 ± 0.56734	23.08887 ± 0.5185
Reduced Chi-Sqr	0.00315	0.02327	2.01E-04	8.06E-05
R-Square (COD)	0.99751	0.99982	0.99983	0.99986
Adj. R-Square	0.99645	0.99974	0.99976	0.9998

SMW:5%Dy^{3+}, 5%Li^{3+}

	FIR_{21}	FIR_{31}	FIR_{41}	FIR_{51}
A1	0.48644 ± 0.03478	0.3194 ± 0.02079	0.03598 ± 0.00234	0.0252 ± 0.00152
A2	3.87872 ± 0.67327	14.96534 ± 0.30243	1.54847 ± 0.03466	1.11473 ± 0.02055
x0	260.06161 ± 13.89687	251.75563 ± 1.11928	252.0888 ± 1.25205	250.34059 ± 1.03
dx	34.90115 ± 4.91271	24.0825 ± 0.48426	24.40833 ± 0.53561	24.04188 ± 0.4597
Reduced Chi-Sqr	0.00208	0.00163	2.02E-05	8.66E-06
R-Square (COD)	0.99687	0.99991	0.99989	0.99992
Adj. R-Square	0.99553	0.99987	0.99985	0.99988

SMW:7%Dy^{3+}, 7%Li^{3+}

	FIR_{21}	FIR_{31}	FIR_{41}	FIR_{51}
A1	0.46183 ± 0.03623	0.20486 ± 0.01493	0.02716 ± 0.00189	0.01918 ± 0.00114
A2	4.28217 ± 1.39181	7.17302 ± 0.36326	0.96569 ± 0.03987	0.64723 ± 0.01736
x0	282.26492 ± 27.49911	262.19918 ± 3.05333	259.22638 ± 2.49273	252.42052 ± 1.60937
dx	41.75954 ± 7.01354	28.66605 ± 1.02568	28.15358 ± 0.89162	26.58843 ± 0.66879
Reduced Chi-Sqr	0.00141	6.49E-04	1.06E-05	4.16E-06
R-Square (COD)	0.99687	0.99977	0.99981	0.99987
Adj. R-Square	0.99554	0.99967	0.99973	0.99981

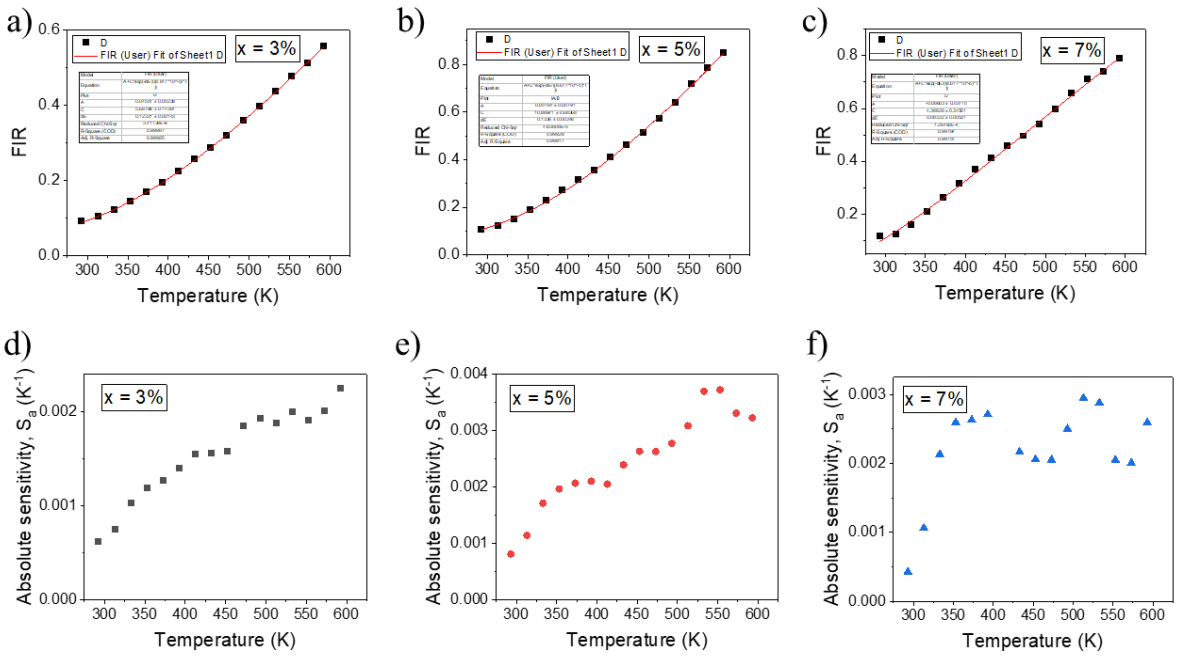

Figure S12. (a-c) FIRs of thermally coupled levels and its fitting curves (red lines); (d-f) Absolute sensitivities, S_a (K^{-1}) of SMW:xDy^{3+}, xLi^{+} (x = 3%, 5%, 7%), respectively in the range of 293 - 593 K

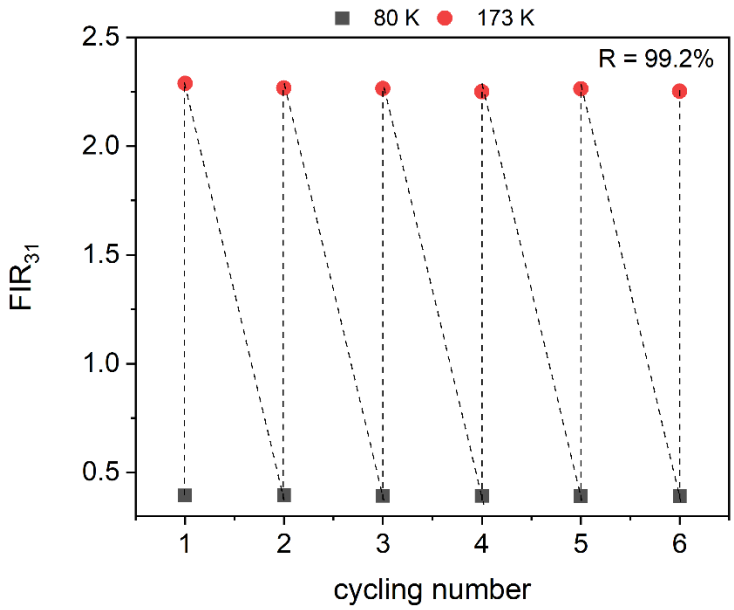

Figure S13. Repeatability of FIR_{31} at 80 K and 173 K during 6 consecutive heating/cooling cycles of Sr_2MgWO_6: 3%Dy^{3+}, 3%Li^{+}