Supporting information for

Er^{3+} doped Ba_2MgWO_6 double perovskite: a phosphor for low-temperature thermometry

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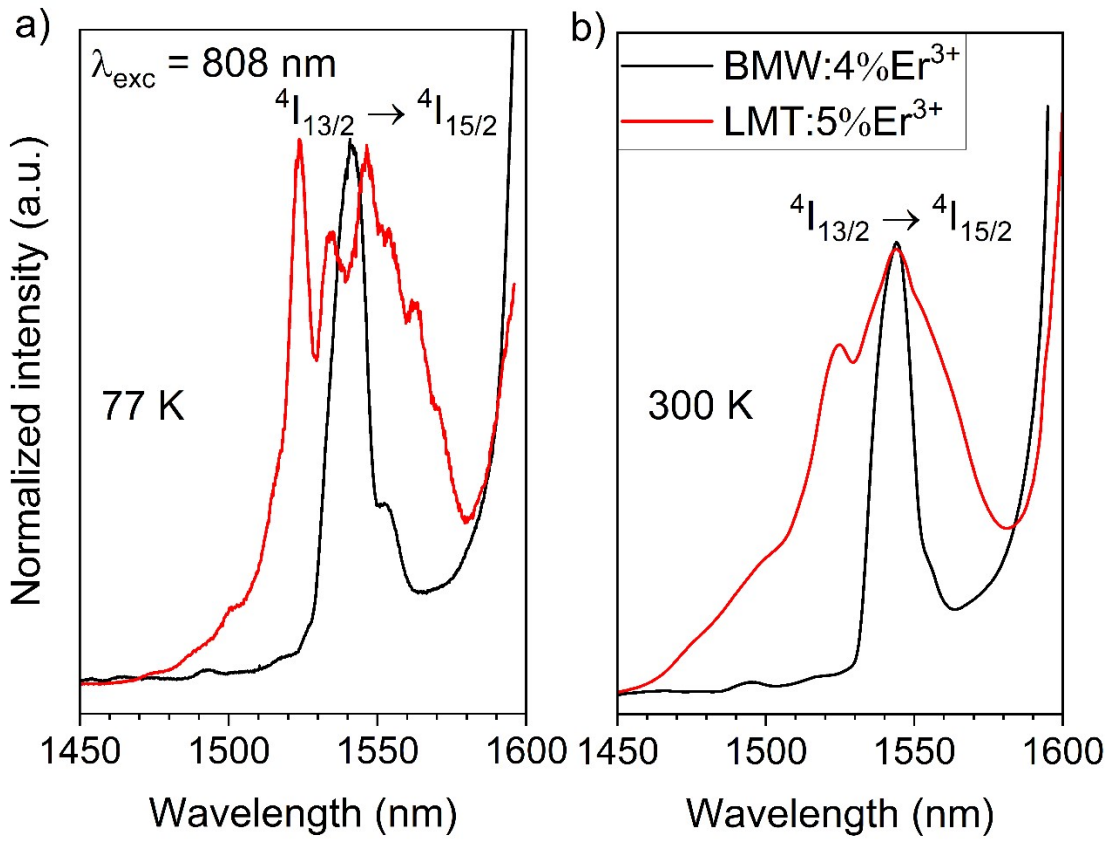

Fig. S1. Emission spectra of BMW:4%Er^{3+} and LMT:5%Er^{3+} excited by 808 nm at 77 K, 300 K. The second harmonic of the 808 nm laser diode, despite the RG850 filter used, is visible for the wavelengths longer than 1580 nm.

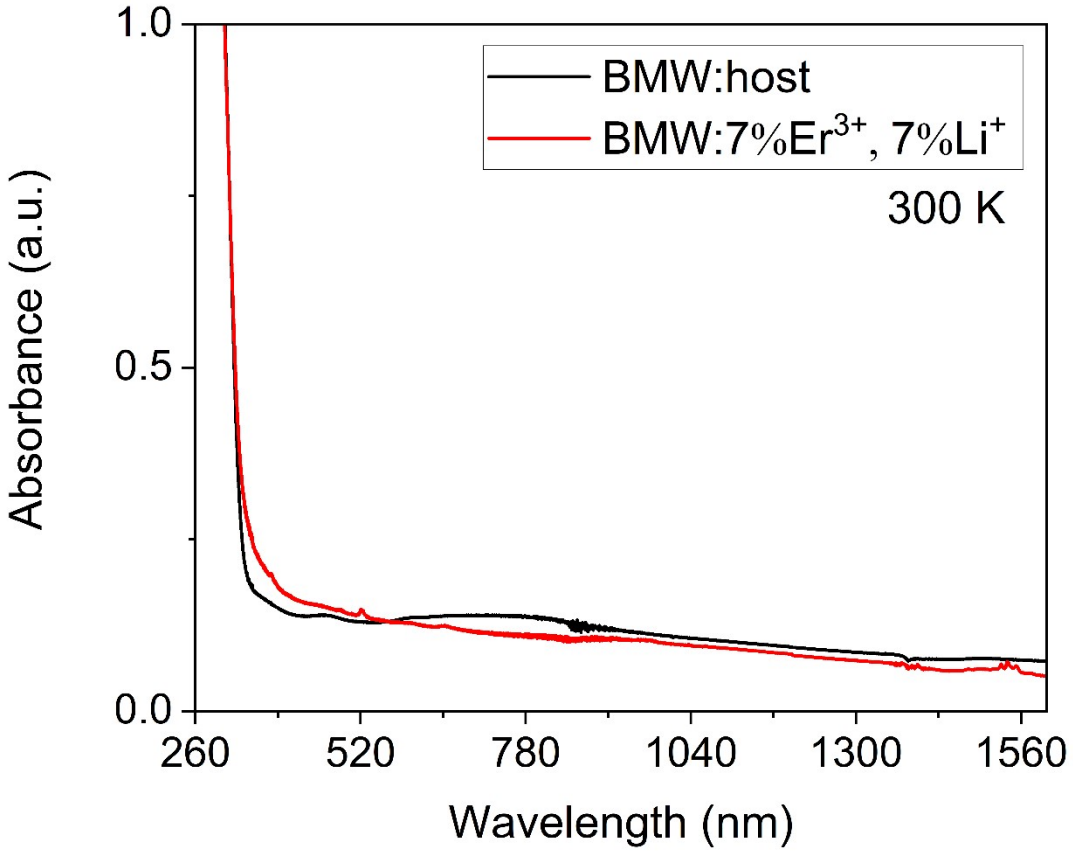

Fig. S2. 300 K absorption spectra of BMW host and BMW: 7%Er^{3+}, 7%Li^{+}

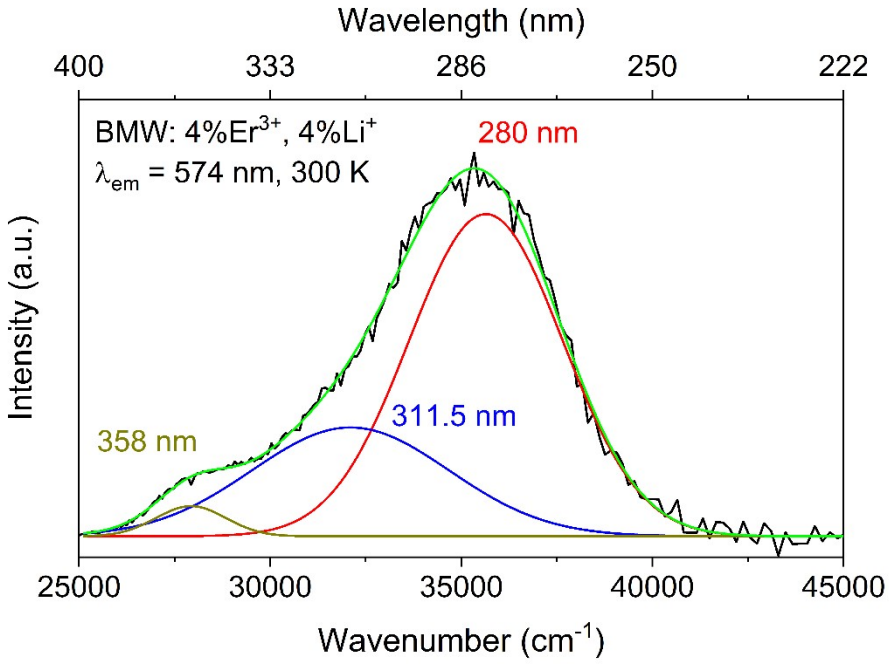

Fig. S3. Excitation spectrum of BMW: 4%Er^{3+}, 4%Li^{+} at 300 K

Table S1. Energy levels of Er^{3+} ions in Ba_2MgWO_6 double perovskites obtained from the 300 K emission spectra and the absorption spectrum*

Level	Number of levels		Energies (cm^{-1})	ΔE (cm^{-1})
	Experiment	Theory		
$^4I_{15/2}$	5	8	0, 77, 176, 199, 297	297
$^4I_{13/2}$	5	7	6443, 6494, 6545, 6528, 6584*	141
$^4I_{11/2}$	3	6	10107, 10220, 10373	266
$^4I_{9/2}$	1	5	12162	-
$^4F_{9/2}$	3	5	15006, 15108, 15193, 15333*	327
$^4S_{3/2}$	1	2	18312	-
$^2H_{11/2}$	3	6	19073, 19183, 19231*	158
$^4F_{7/2}$	3	4	20408*, 20471*, 20483	75
$^4F_{5/2}$	1	3	21877	-
$^2H_{9/2}$	1	5	24301	-
$^4G_{11/2}$	1	6	26316*	-
$^4G_{9/2}$	1	5	27071*	-

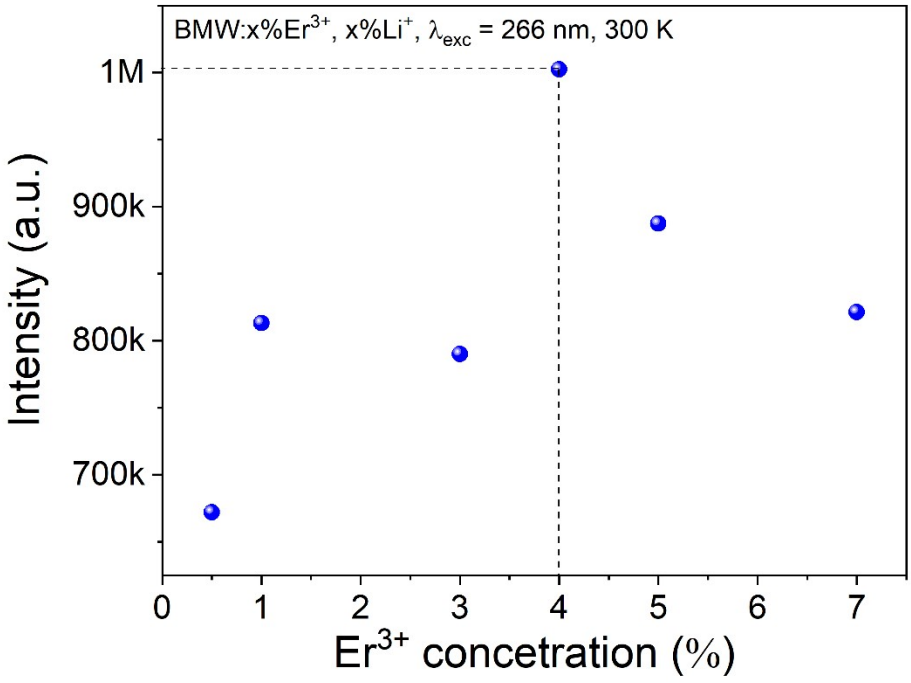

Fig. S4. Integrated emission intensity of all samples as a function of Er^{3+} concentration at 300 K

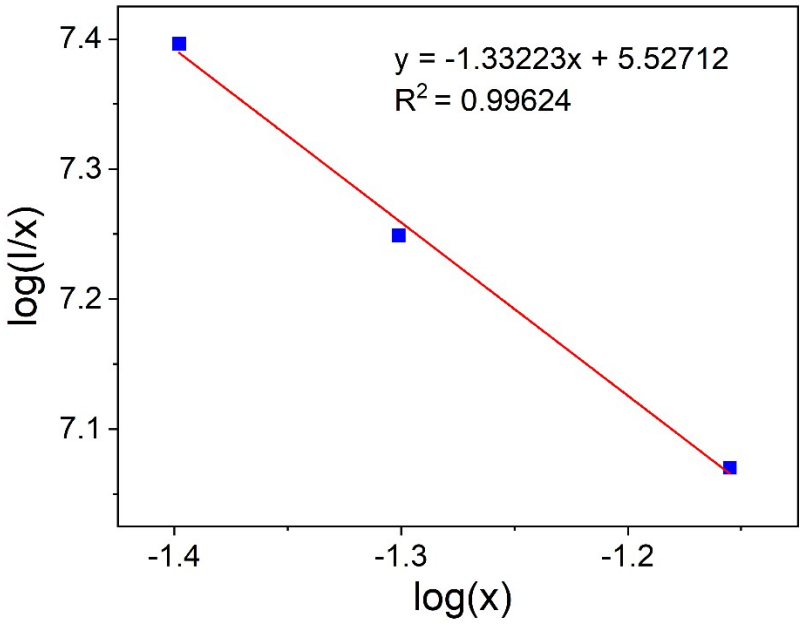

Fig. S5. Relation between log(x) and log(I/x) of samples BMW: xEr^{3+}, xLi^{+}, (x = 4%, 5%, 7%)

Table S2. Decay time of BMW: xEr^{3+}, xLi^{+} double perovskites (x = 0.1%, 0.5%, 1%, 3%, 4%, 5%, 7%) excited at 266 nm, monitored at 574 nm, at 300 K

Er^{3+} (%)	T_{avg} (μs)
0.1	58.33
0.5	57.36
1	56.33
3	54.69
4	50.15
5	49.06
7	48.79

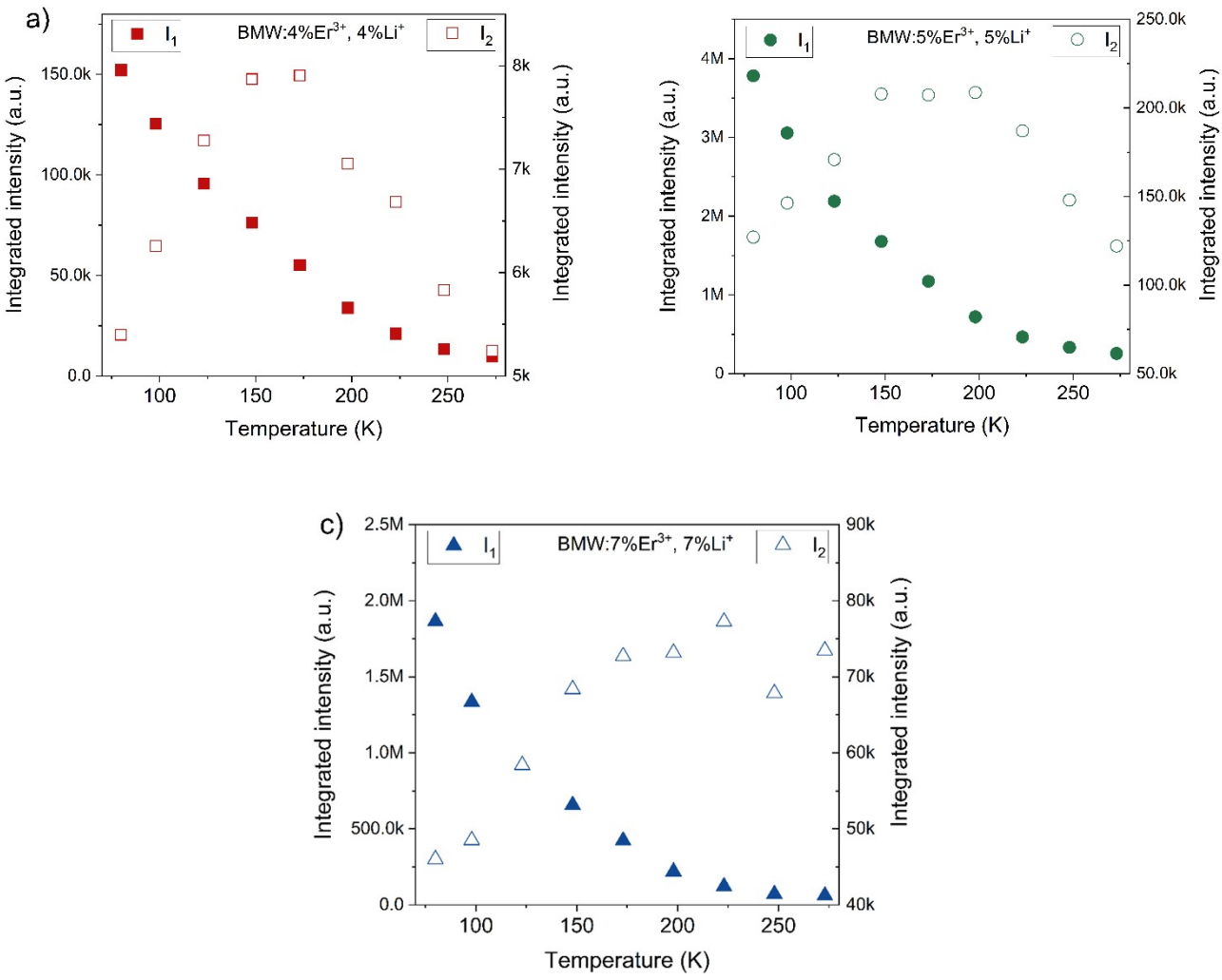

Fig. S6. Integrated emission intensity of the BMW host (I_1) and the $^4I_{11/2} \rightarrow {}^4I_{15/2}$ (I_2) transition as a function of temperature for BMW:4%Er^{3+},4%Li^+ (red squares), BMW:5%Er^{3+},5%Li^+ (green circles) and BMW:7%Er^{3+},7%Li^+ (blue triangles).

Table S3. Details of the fitted curves for BMW:4%Er^{3+},4%Li^+ (red squares), BMW:5%Er^{3+},5%Li^+ (green circles) and BMW:7%Er^{3+},7%Li^+ (blue triangles)

$$y = A + C \times \exp\left(\frac{-\Delta E}{k_B \times T}\right)$$

	A	C	ΔE	R^2
BMW:4%Er^{3+},4%Li^+	0.04505	7.1810	0.06312	0.99661
BMW:5%Er^{3+},5%Li^+	0.01514	2.50964	0.03833	0.92804
BMW:7%Er^{3+},7%Li^+	0.02436	32.68331	0.07736	0.99492

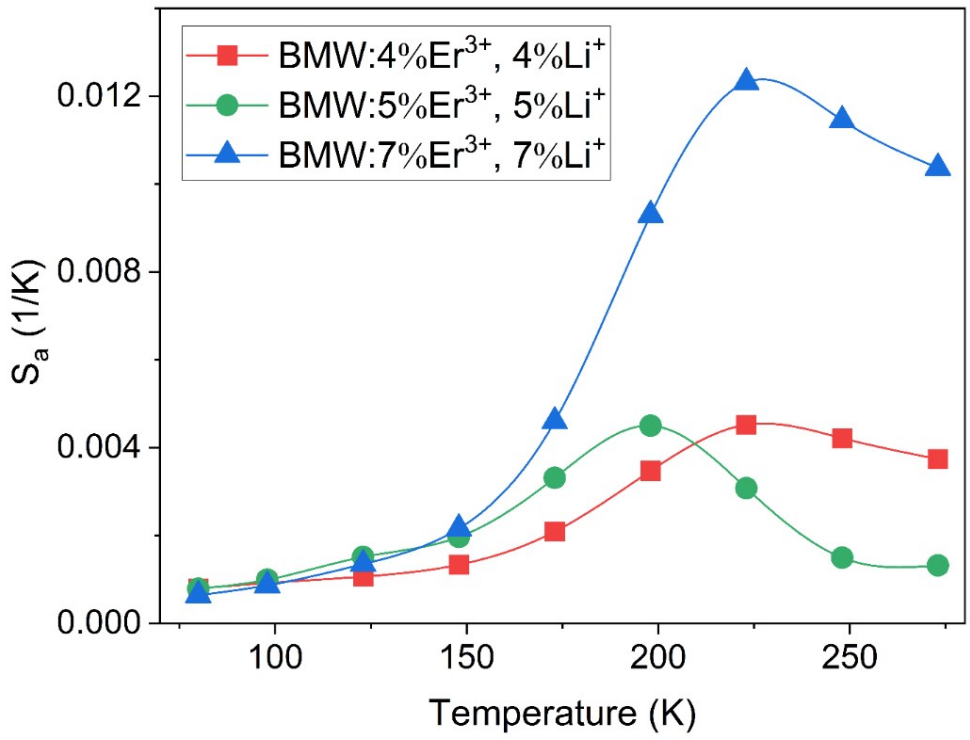

Fig. S7. Absolute sensitivity versus temperature, S_a (K^{-1}) for BMW:4%Er^{3+},4%Li^{+} (red squares), BMW:5%Er^{3+},5%Li^{+} (green circles) and BMW:7%Er^{3+},7%Li^{+} (blue triangles)

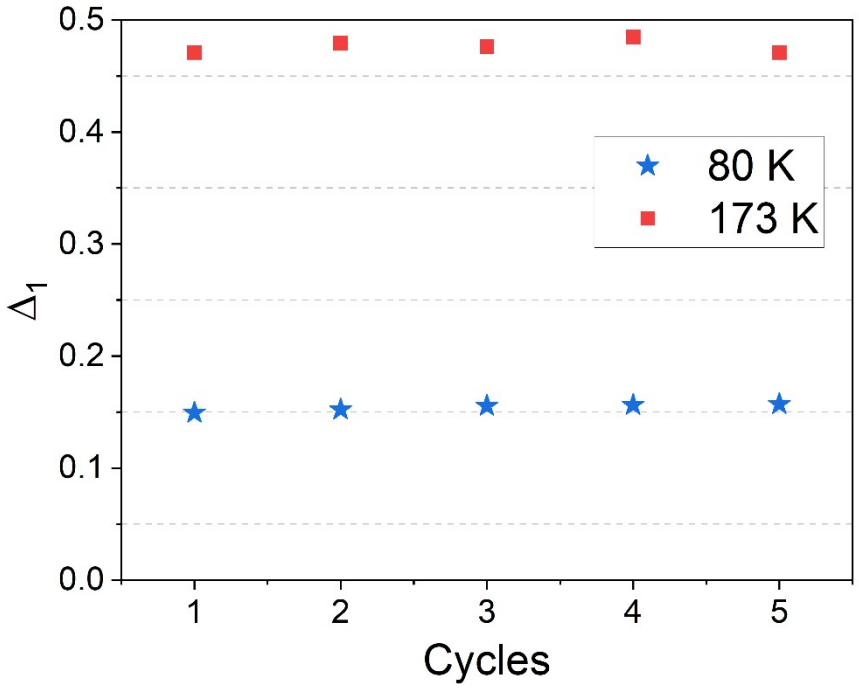

Fig. S8. The intensity ratio between $^4S_{3/2} \rightarrow {}^4I_{15/2}$ (530-600 nm) and the host (350-530 nm) during several cycles of heating-cycling between 80 K and 173 K.

Repeatability R (%) is calculated via the following formula.

$$R = \left[1 - \frac{max(|\Delta_m - \Delta_i|}{\Delta_m}\right] \times 100\%$$

where Δ_m is the mean value of thermometric parameter (Δ) at each temperature and Δ_i is the value of each specific measurement.

The estimated average repeatability is 98.3 %.