Supporting Information

From the up-converting multimodal luminescent thermometer to ratiometric visual power density meter based on Er^{3+},Yb^{3+} emission

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Table S1. Amount of the precursor used in the synthesis of $Na_3Sc_2(PO_4)_3$:Er^{3+},5%Yb^{3+} phosphors.

Phosphor	Na_2CO_3 (g)	$NH_4H_2PO_4$ (g)	Sc_2O_3 (g)	Er_2O_3 (g)	Yb_2O_3 (g)
$Na_3Sc_2(PO_4)_3$:0.5%Er^{3+},5%Yb^{3+}	0.1737	0.3770	0.1424	0.00209	0.02152
$Na_3Sc_2(PO_4)_3$:0.5%Er^{3+},10%Yb^{3+}	0.1689	0.3667	0.1312	0.00203	0.04188
$Na_3Sc_2(PO_4)_3$:0.5%Er^{3+},15%Yb^{3+}	0.1645	0.3570	0.1206	0.00198	0.06115
$Na_3Sc_2(PO_4)_3$:0.5%Er^{3+},30%Yb^{3+}	0.1524	0.3307	0.0919	0.00183	0.11329

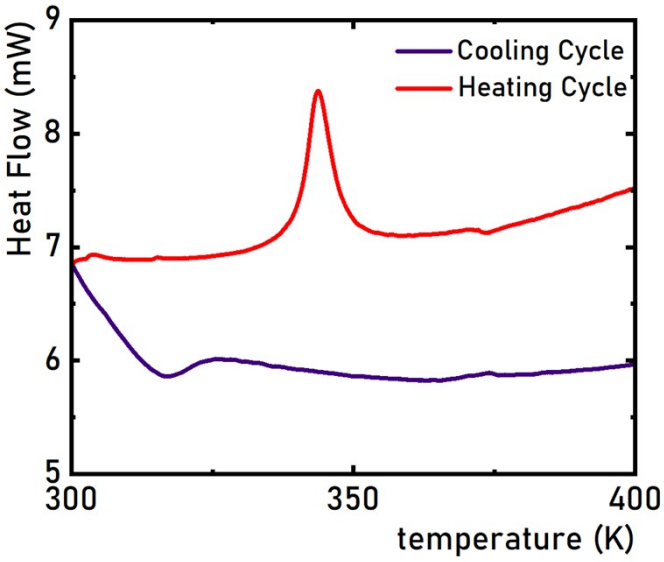

Figure S1. The DSC curves during heating and cooling for $Na_3Sc_2(PO_4)_3$:Er^{3+},5%Yb^{3+}

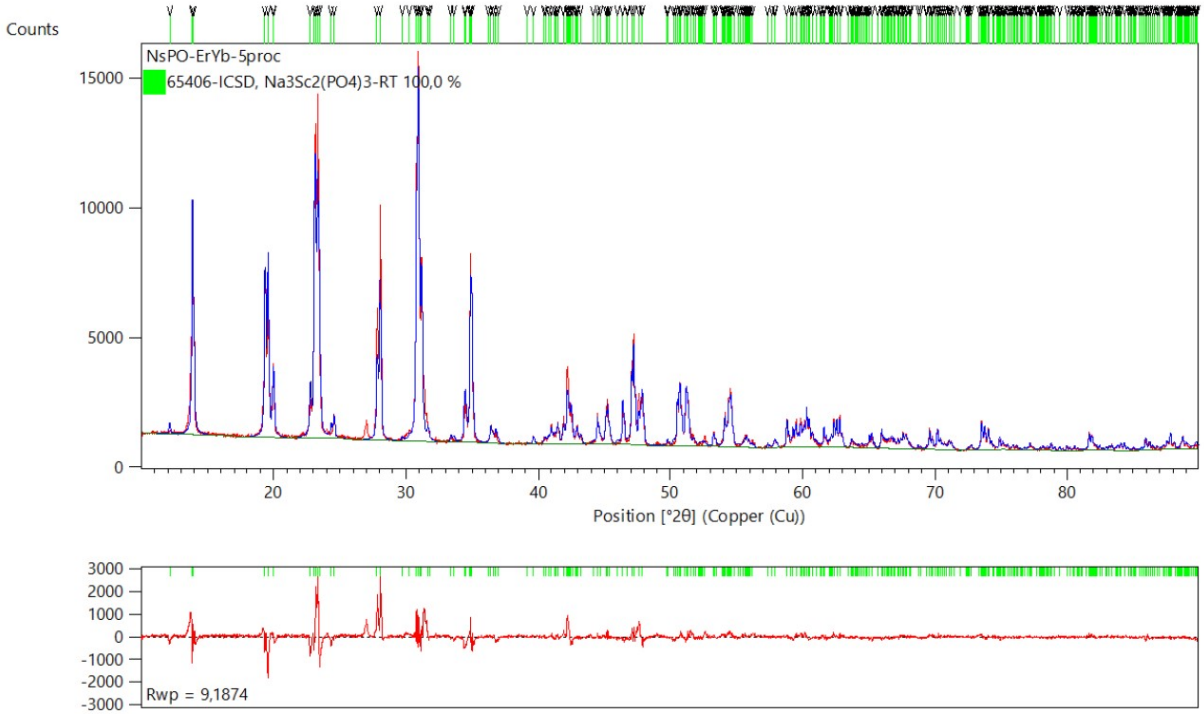

Figure S2. Results of Rietveld refinement of the room temperature XRD pattern of $Na_3Sc_2(PO_4)_3:Er^{3+}$,5%Yb^{3+}.

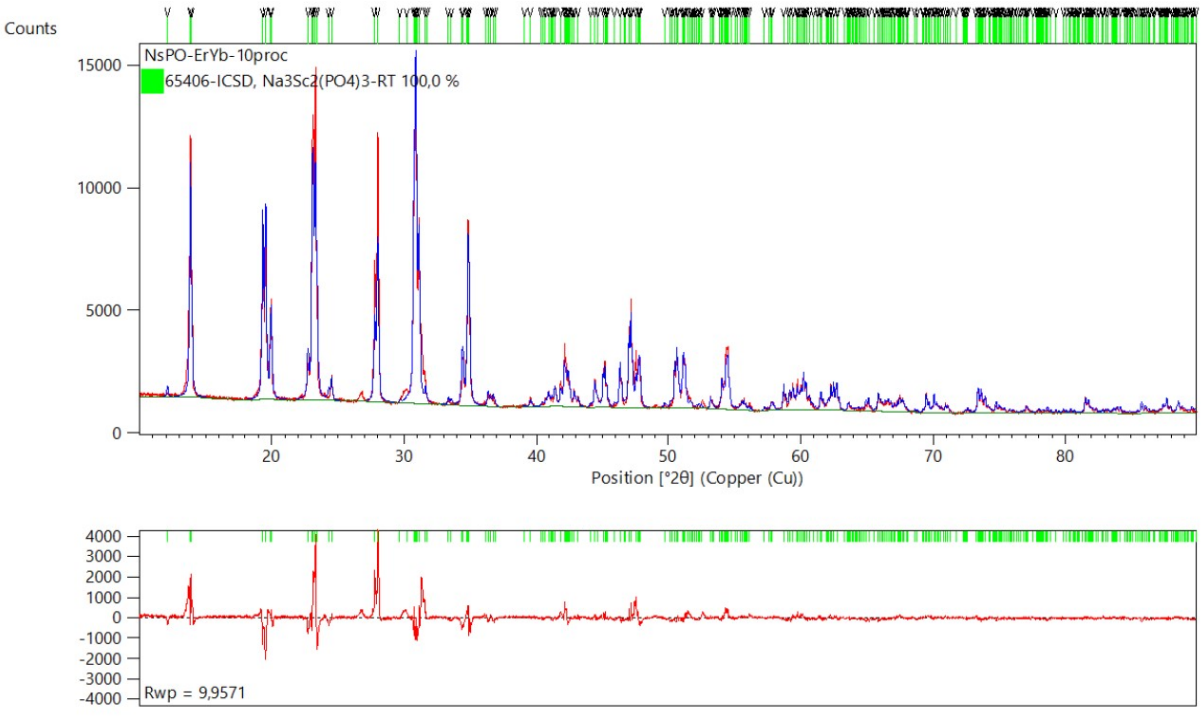

Figure S3. Results of Rietveld refinement of the room temperature XRD pattern of $Na_3Sc_2(PO_4)_3:Er^{3+}$,10%Yb^{3+}.

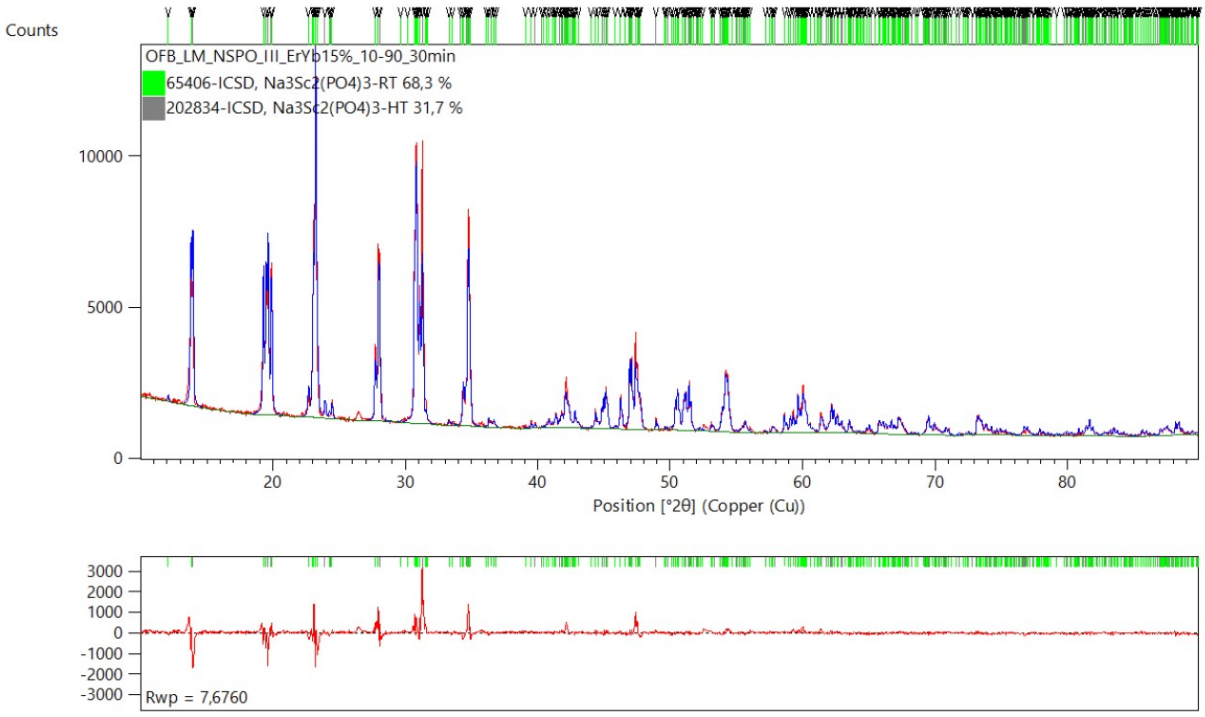

Figure S4. Results of Rietveld refinement of the room temperature XRD pattern of $Na_3Sc_2(PO_4)_3$:Er^{3+},15%Yb^{3+}.

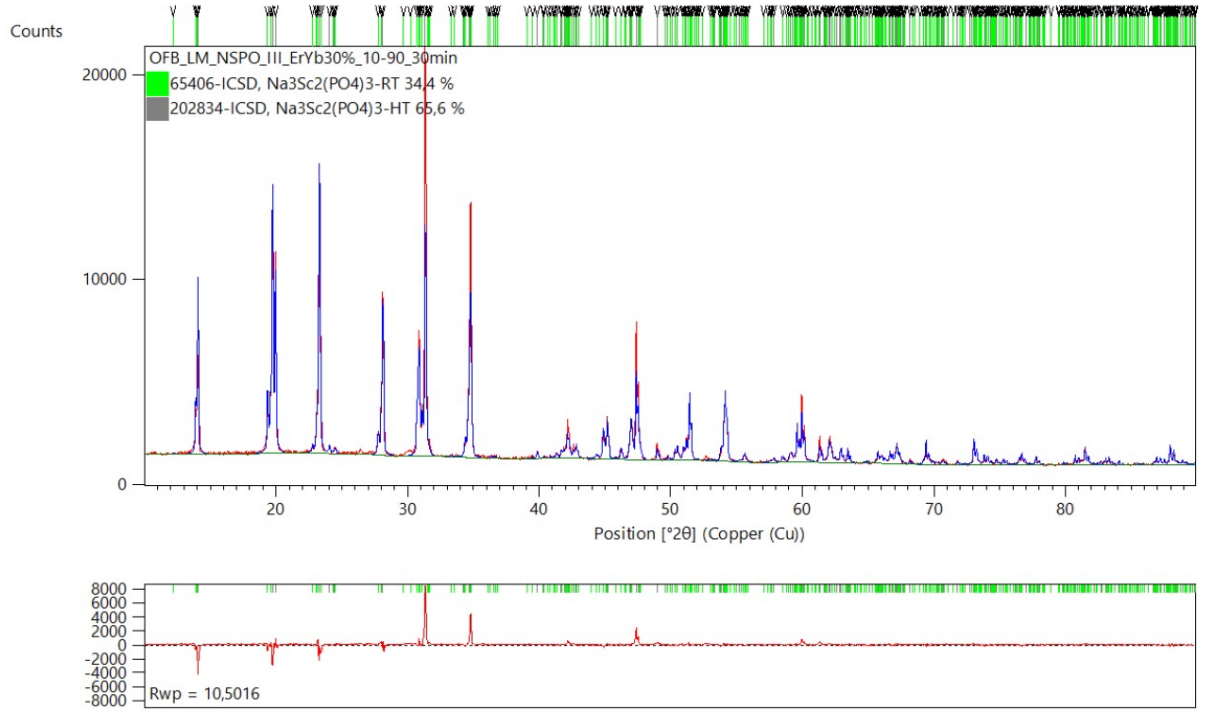

Figure S5. Results of Rietveld refinement of the room temperature XRD pattern of $Na_3Sc_2(PO_4)_3$:Er^{3+},30%Yb^{3+}.

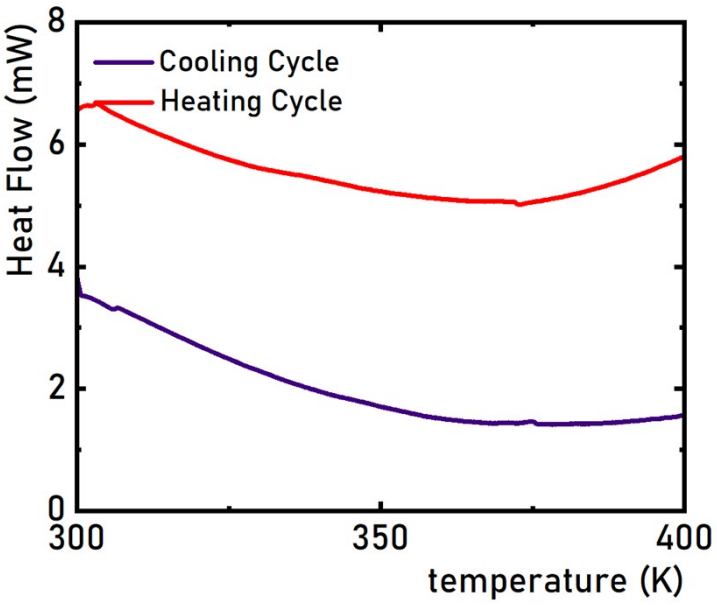

Figure S6. The DSC curves during heating and cooling for $Na_3Sc_2(PO_4)_3:Er^{3+},30\%Yb^{3+}$

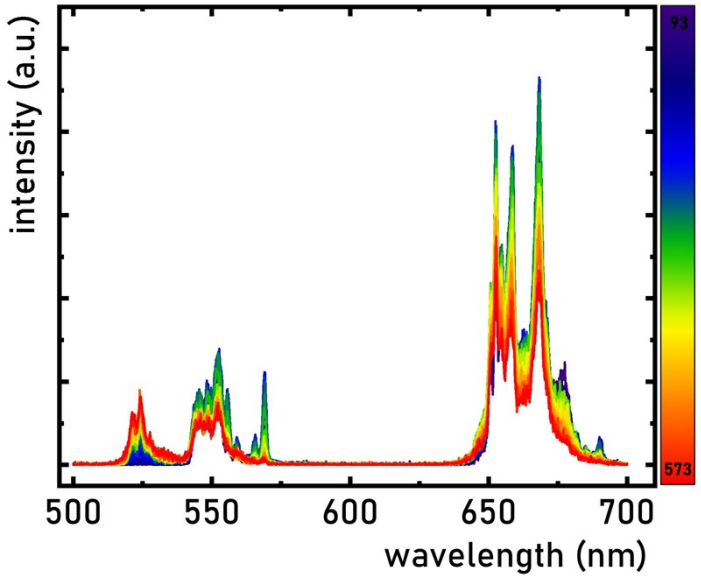

Figure S7. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+},5\%Yb^{3+}$ measured as a function of temperature.

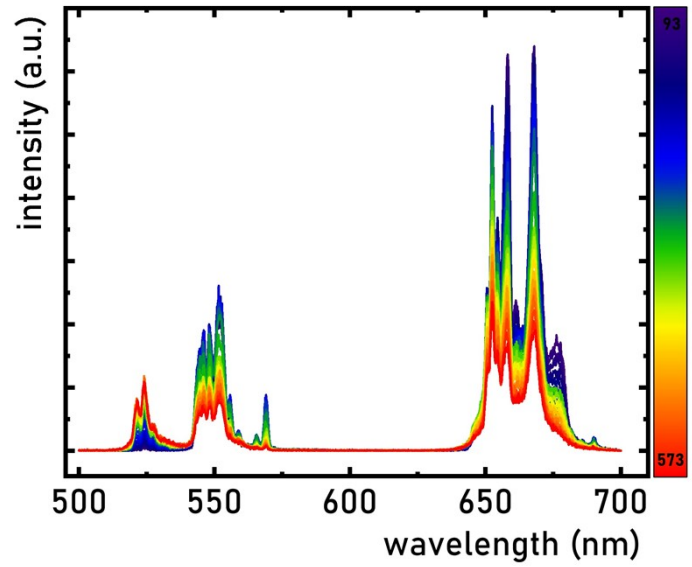

Figure S8. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+}$,10%Yb^{3+} measured as a function of temperature.

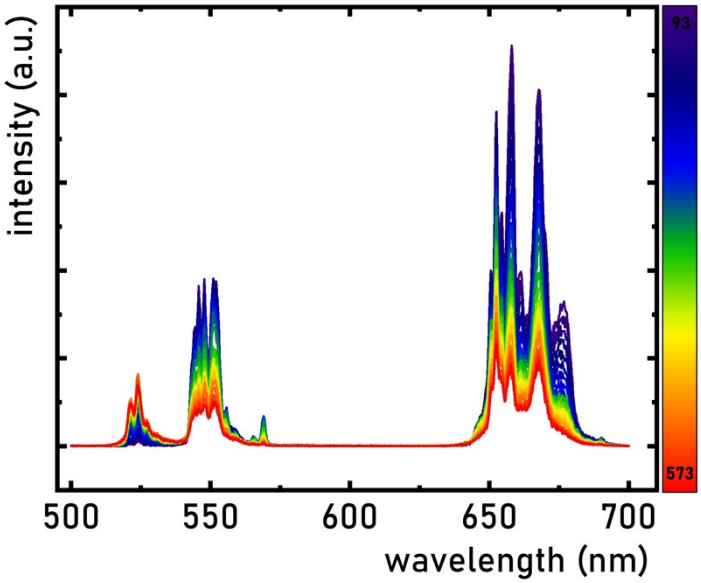

Figure S9. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+}$,15%Yb^{3+} measured as a function of temperature.

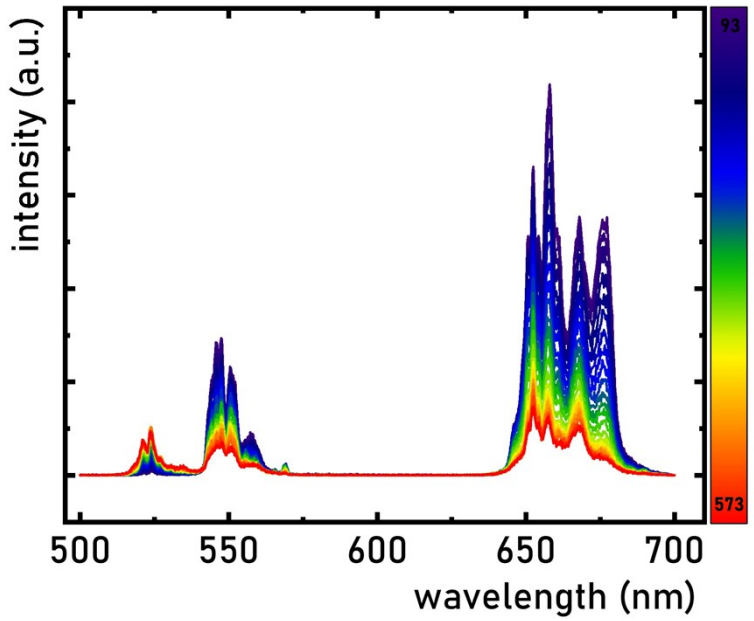

Figure S10. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} measured as a function of temperature.

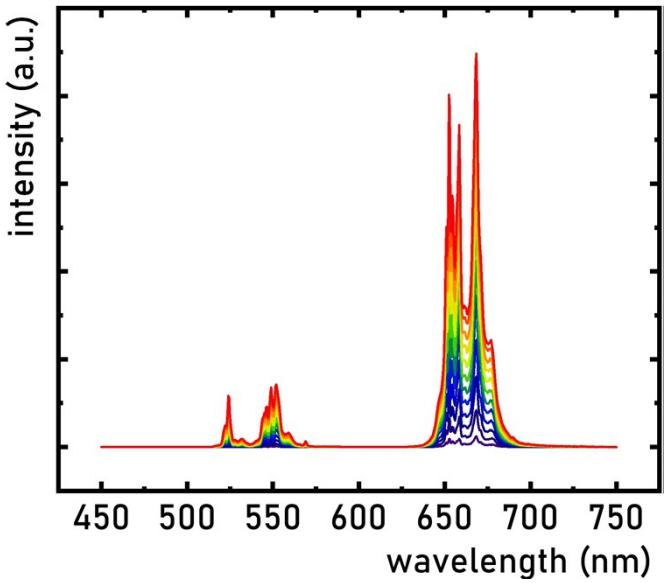

Figure S11. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+}$,5%Yb^{3+} measured as a function of excitation density from 2.1 W cm^{-2} (navy curve) to 114 W cm^{-2} (red curve).

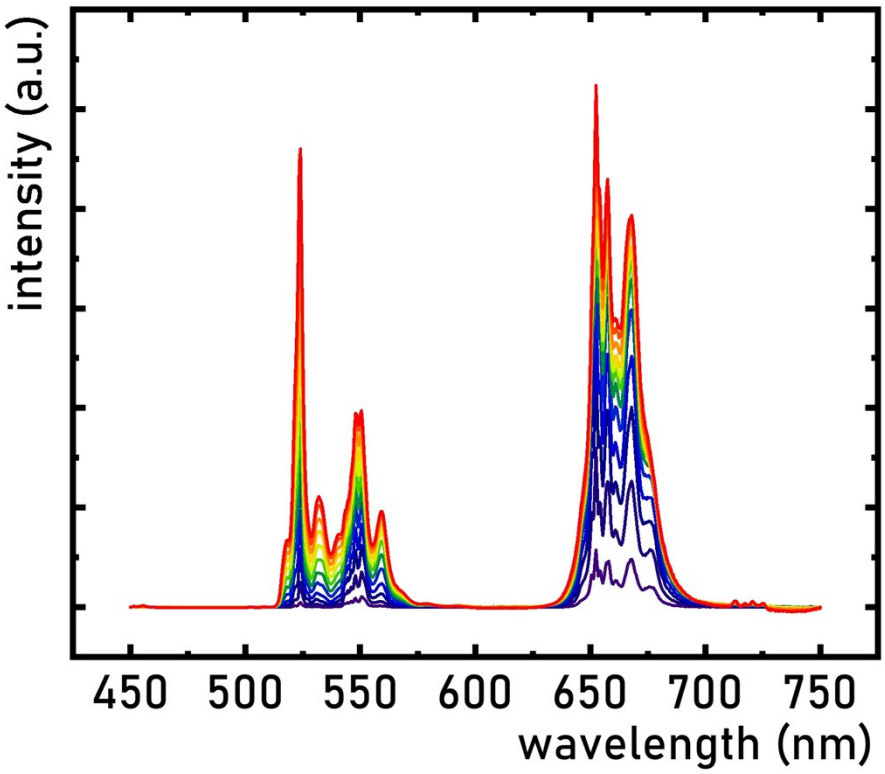

Figure S12. Up-conversion emission spectra of $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} measured as a function of excitation density from 2.1 W cm^{-2} (navy curve) to 114 W cm^{-2} (red curve).

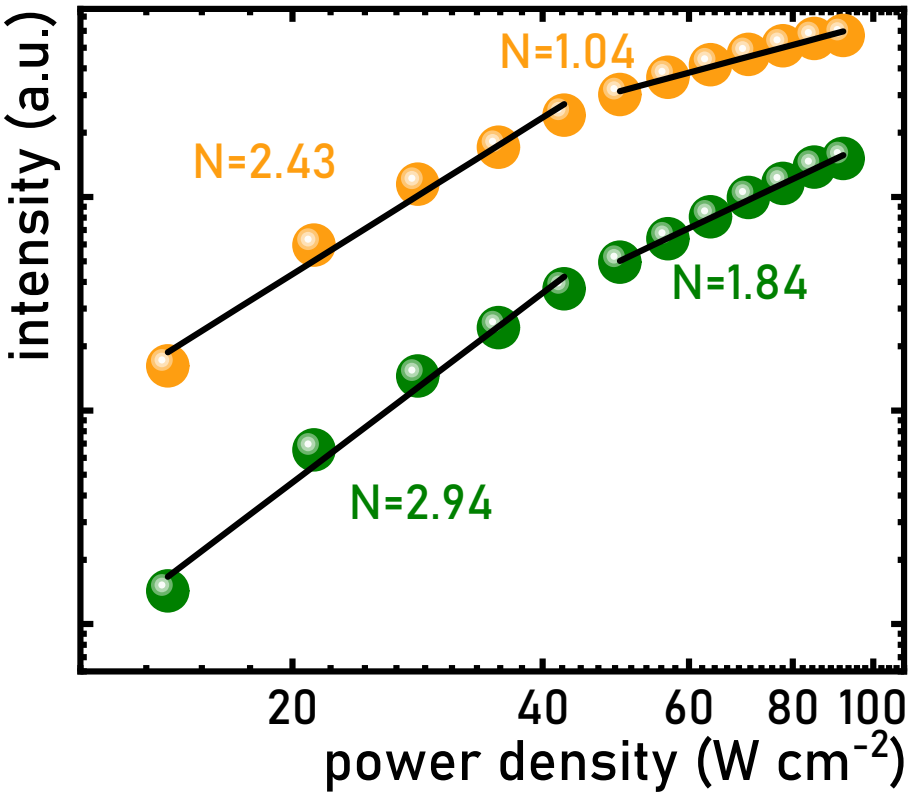

Figure S13. The log-log plots of the total emission intensity in the green spectral region corresponding to the $^4S_{3/2}\rightarrow{}^4I_{15/2}$, $^2H_{9/2}\rightarrow{}^4I_{13/2}$ and $^2H_{11/2}\rightarrow{}^4I_{15/2}$ as a function of excitation density for $Na_3Sc_2(PO_4)_3:Er^{3+}$, 5%Yb^{3+} (green points) and $Na_3Sc_2(PO_4)_3:Er^{3+}$, 30%Yb^{3+} (orange points).

Absolute sensitivity can be calculated as follows:

$$S_A = \frac{\Delta LIR}{\Delta T} \qquad \text{(S1)}$$

where ΔLIR is a change of LIR corresponding to change in temperature by ΔT.

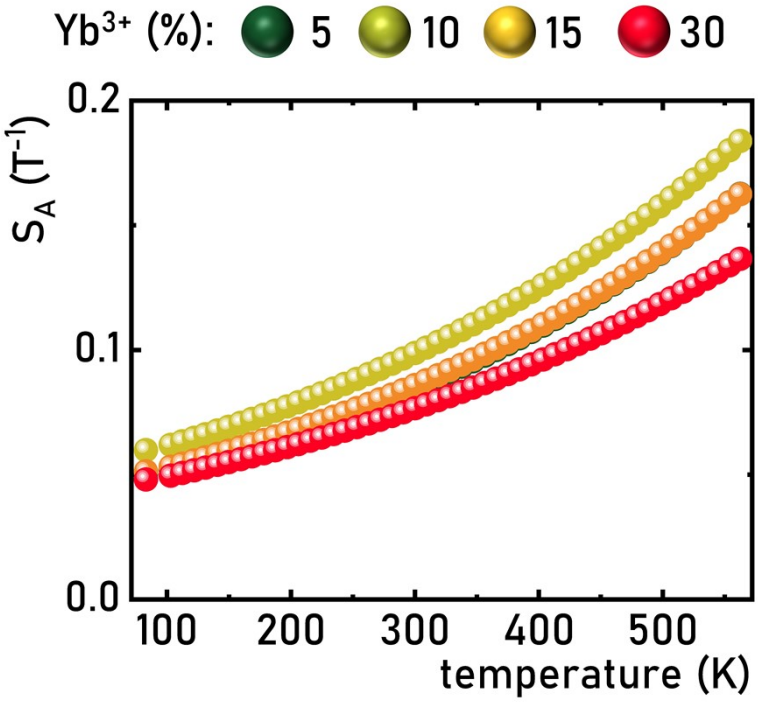

Figure S14. Thermal dependence of S_A corresponding to LIR_1 for $Na_3Sc_2(PO_4)_3$:Er^{3+}, Yb^{3+}.

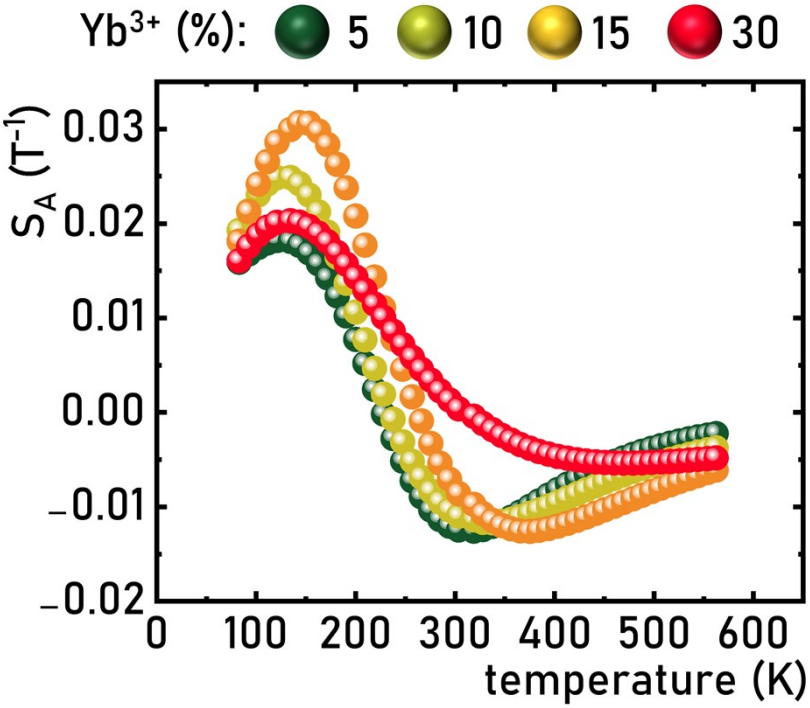

Figure S15. Thermal dependence of S_A corresponding to LIR_2 for $Na_3Sc_2(PO_4)_3$:Er^{3+}, Yb^{3+}.

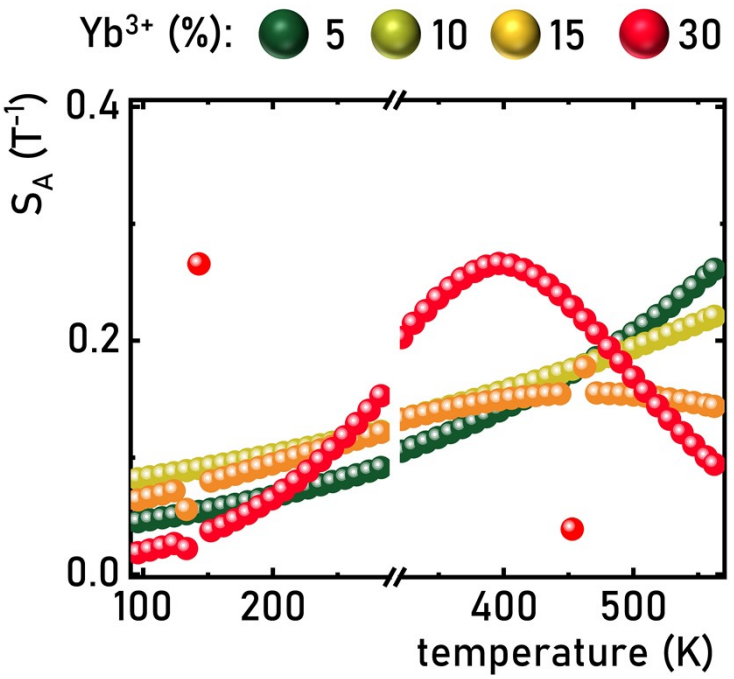

Figure S16. Thermal dependence of S_A corresponding to LIR_3 for $Na_3Sc_2(PO_4)_3:Er^{3+}$, Yb^{3+}.

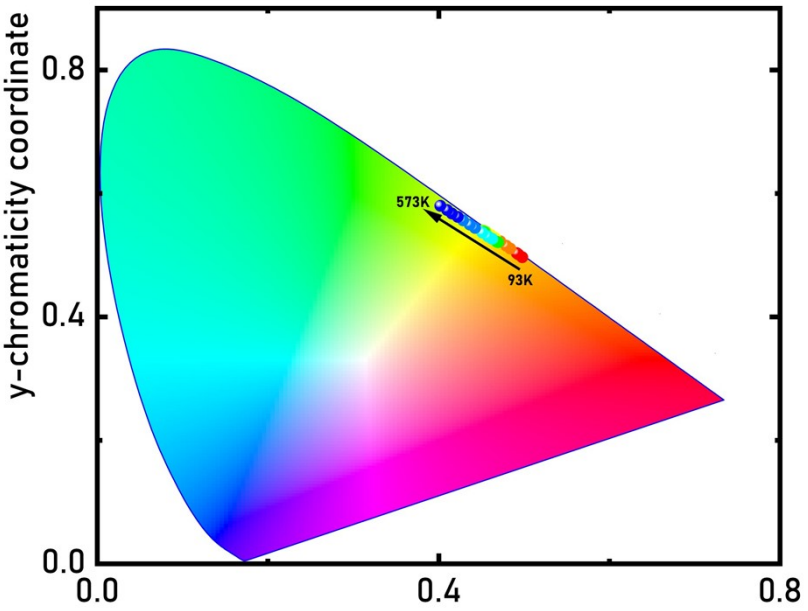

Figure S17. CIE 1931 chromatic coordinates calculated for $Na_3Sc_2(PO_4)_3:Er^{3+}$,5%Yb^{3+} as a function of temperature.

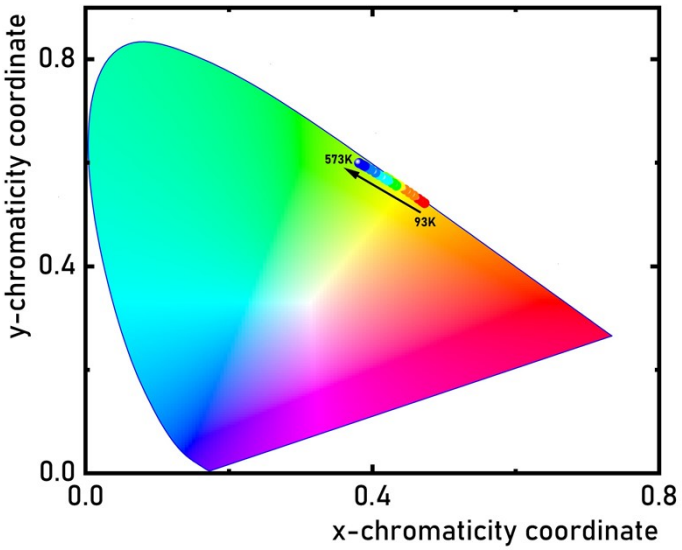

Figure S18. CIE 1931 chromatic coordinates calculated for $Na_3Sc_2(PO_4)_3:Er^{3+}$,10%Yb^{3+} as a function of temperature.

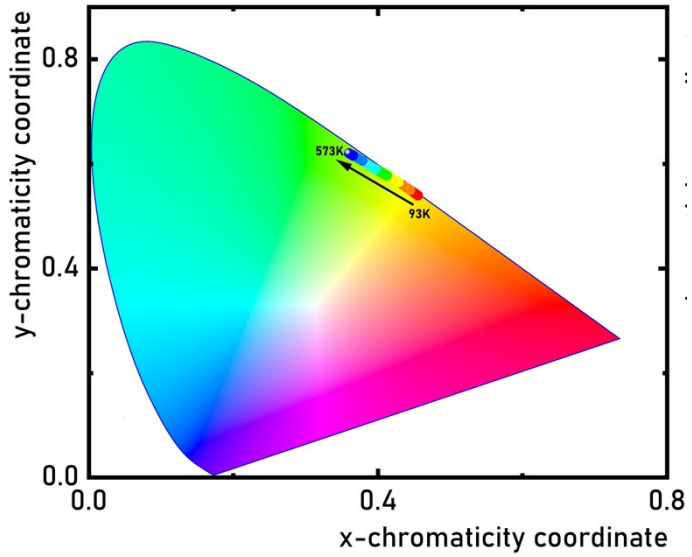

Figure S19. CIE 1931 chromatic coordinates calculated for $Na_3Sc_2(PO_4)_3:Er^{3+}$,15%Yb^{3+} as a function of temperature.

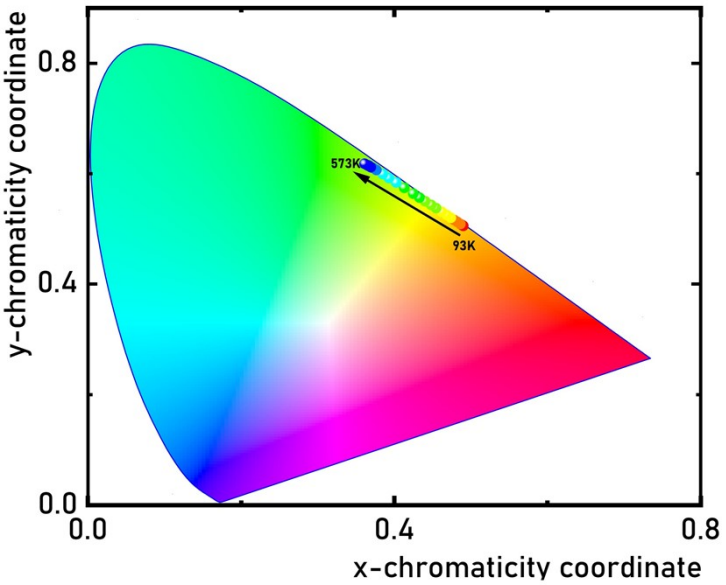

Figure S20. CIE 1931 chromatic coordinates calculated for $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} as a function of temperature.

The relative sensitivity of the analyzed phosphors to the excitation denisty based on the CIE1931 chromatic coordinates can be calculated as follows:

$$S_{R,x} = \frac{1}{x}\frac{\Delta x}{\Delta p}\cdot 100\% \qquad \text{(S2)}$$

$$S_{R,y} = \frac{1}{y}\frac{\Delta y}{\Delta p}\cdot 100\% \qquad \text{(S3)}$$

where Δx and Δy represent change in x and y coordinates, respectively, corresponding to the change in excitation density by Δp.

Table S2. CIE1931 chromatic coordinates calculated for $Na_3Sc_2(PO_4)_3:Er^{3+}$,5%Yb^{3+} and $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} as a function of excitation density.

Power density [W cm^{-2}]	**5%Yb^{3+}**		**30%Yb^{3+}**	
	x	***y***	***x***	***y***
14.15428	0.62118	0.37647	0.55575	0.43925
21.23142	0.60074	0.3975	0.51993	0.4729
28.30856	0.58638	0.41044	0.49084	0.49972
35.3857	0.57588	0.42034	0.47032	0.51856
42.46285	0.56657	0.42881	0.44874	0.53839

49.53999	0.55952	0.43581	0.43142	0.55442
56.61713	0.55138	0.44325	0.4132	0.57115
63.69427	0.54406	0.45002	0.39708	0.5858
70.77141	0.53607	0.4574	0.38219	0.59934
77.84855	0.53057	0.46257	0.37389	0.60696
84.92569	0.52244	0.47018	0.36544	0.6147
92.00283	0.51917	0.4734	0.36179	0.61806

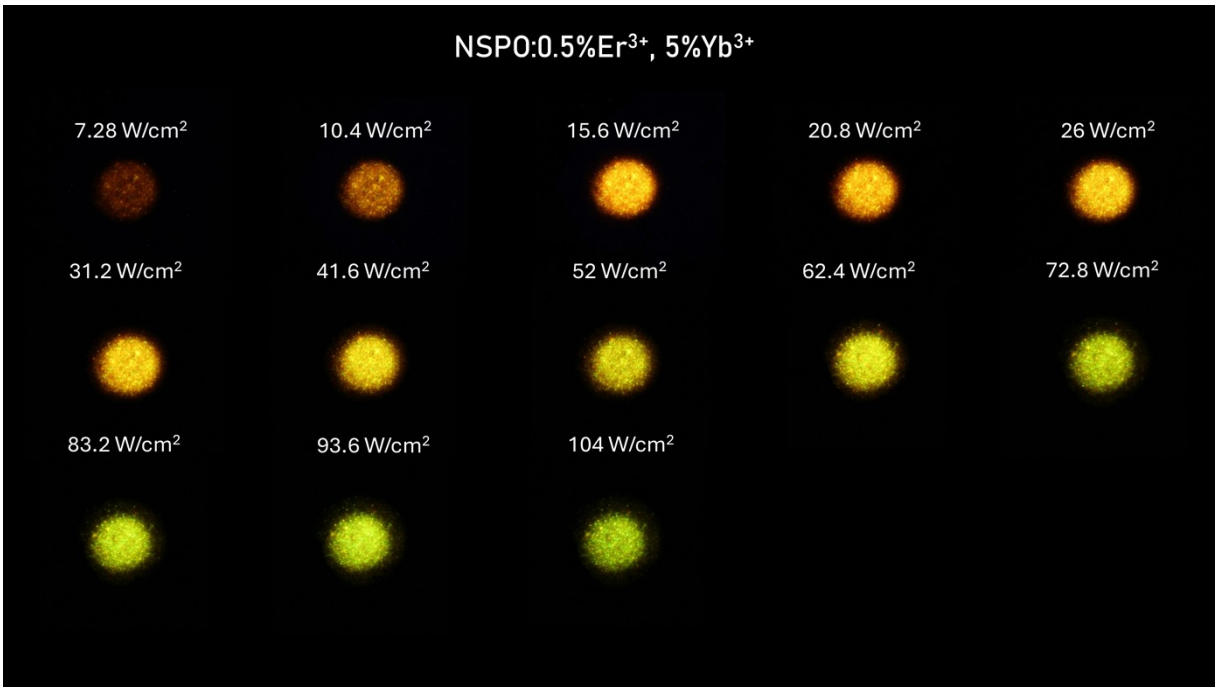

Figure S21. Photos of up-conversion emission of $Na_3Sc_2(PO_4)_3:Er^{3+}$,5%Yb^{3+} at different excitation densities.

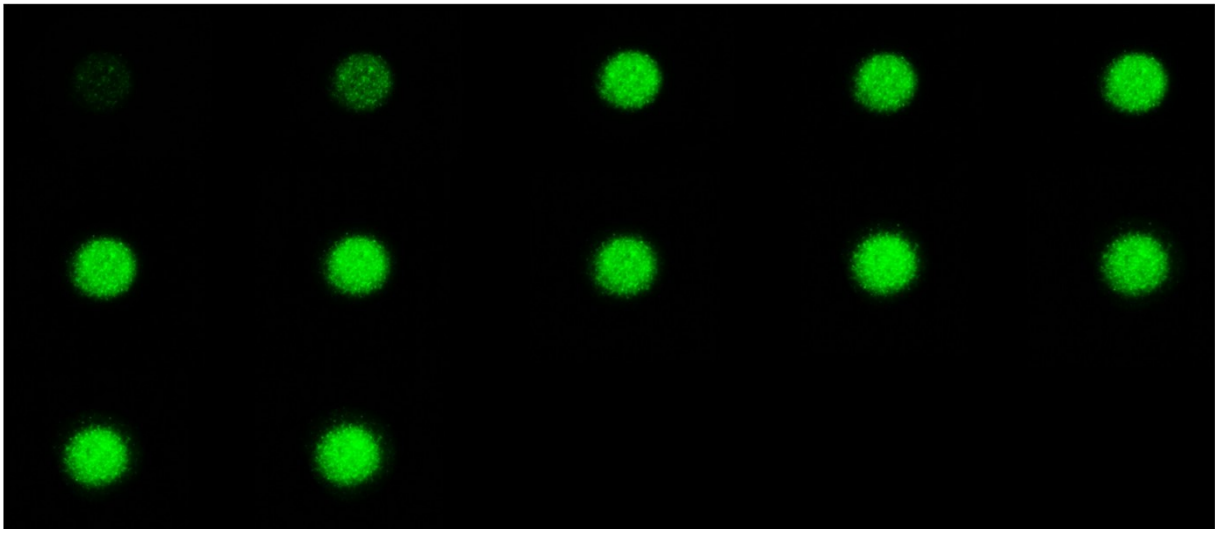

Figure S22. Maps of signal recorded in green channel extracted from photos presented in Figure S13.

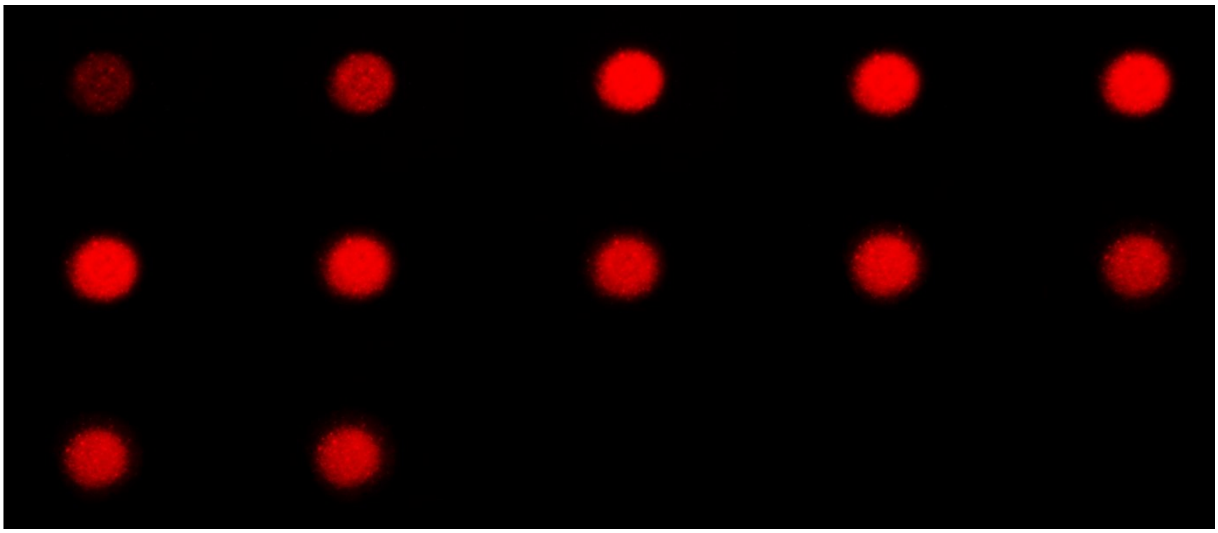

Figure S23. Maps of signal recorded in red channel extracted from photos presented in Figure S13.

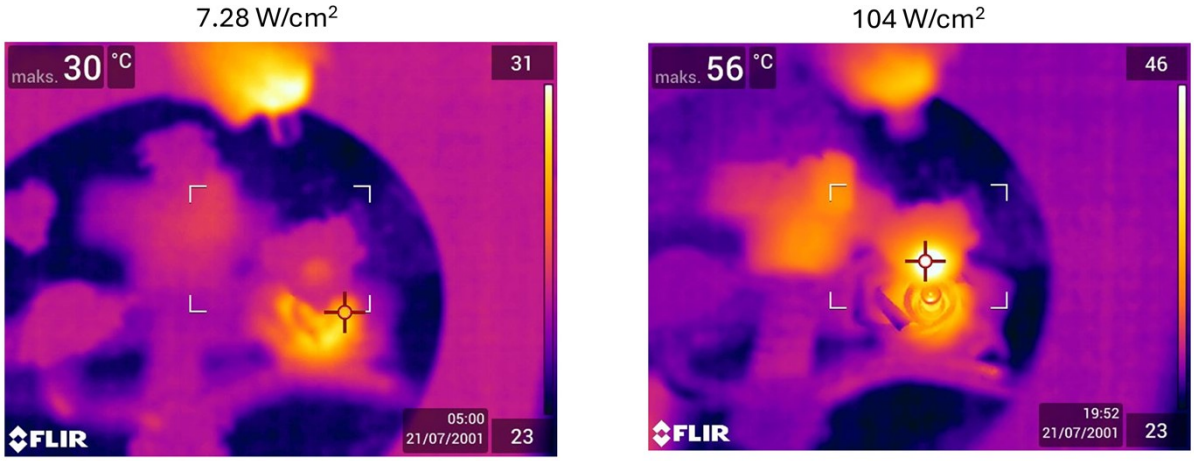

Figure S24. Temperature of $Na_3Sc_2(PO_4)_3$:Er^{3+},5%Yb^{3+} upon different excitation densities recorded using thermovision camera.

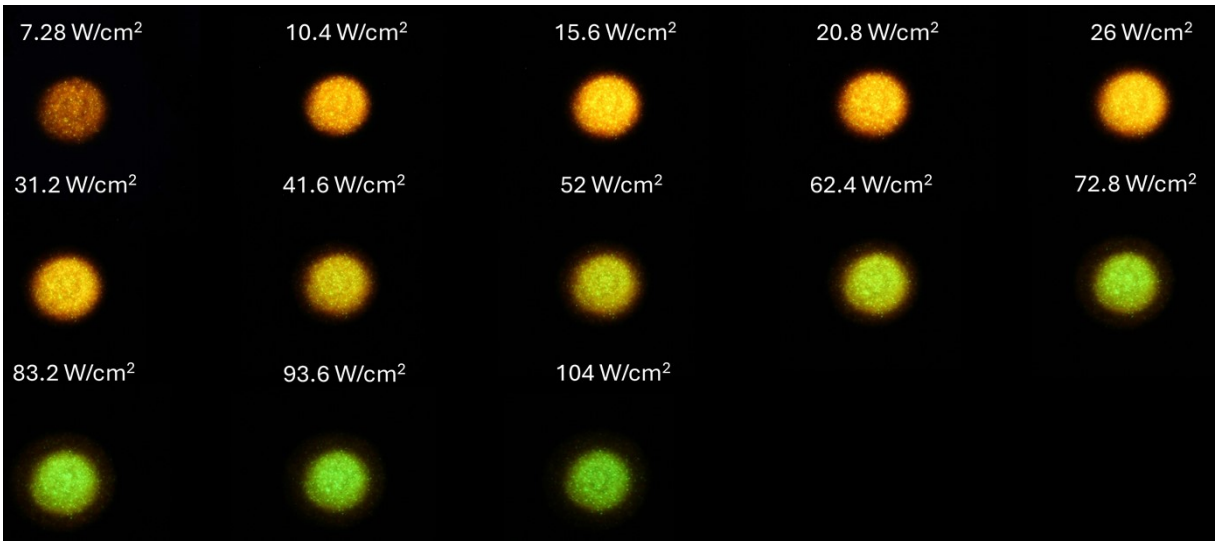

Figure S25. Photos of up-conversion emission of $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} at different excitation densities.

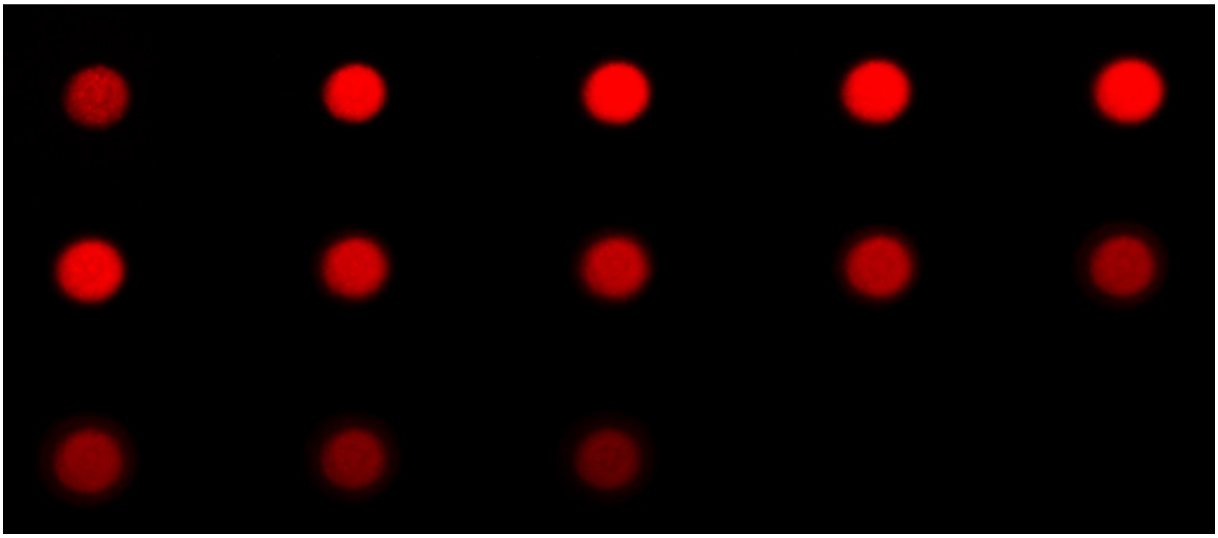

Figure S26. Maps of signal recorded in red channel extracted from photos presented in Figure S17.

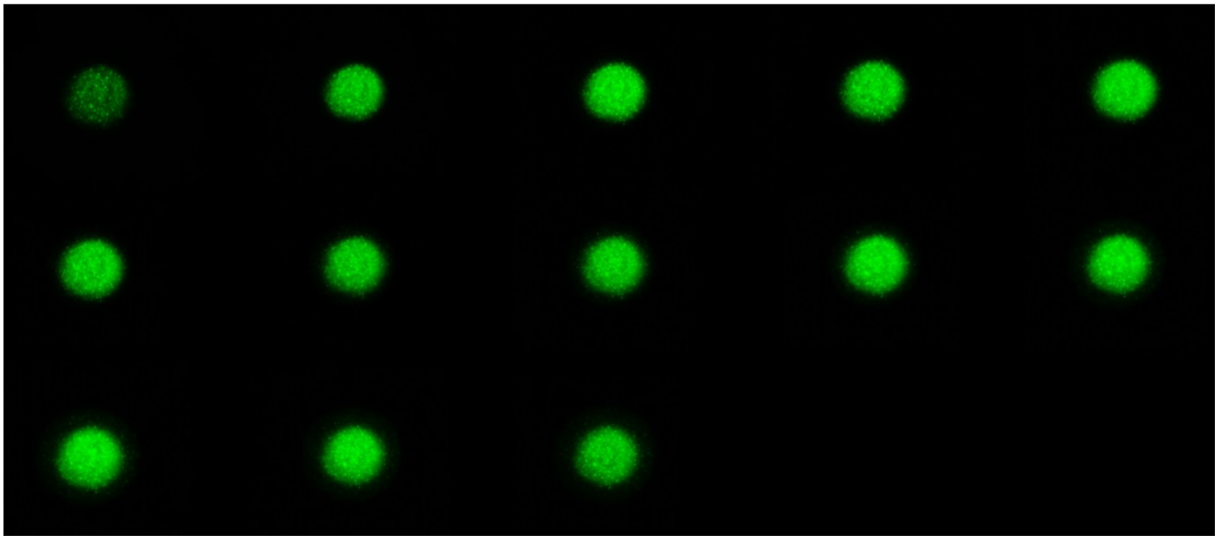

Figure S27. Maps of signal recorded in green channel extracted from photos presented in Figure S17.

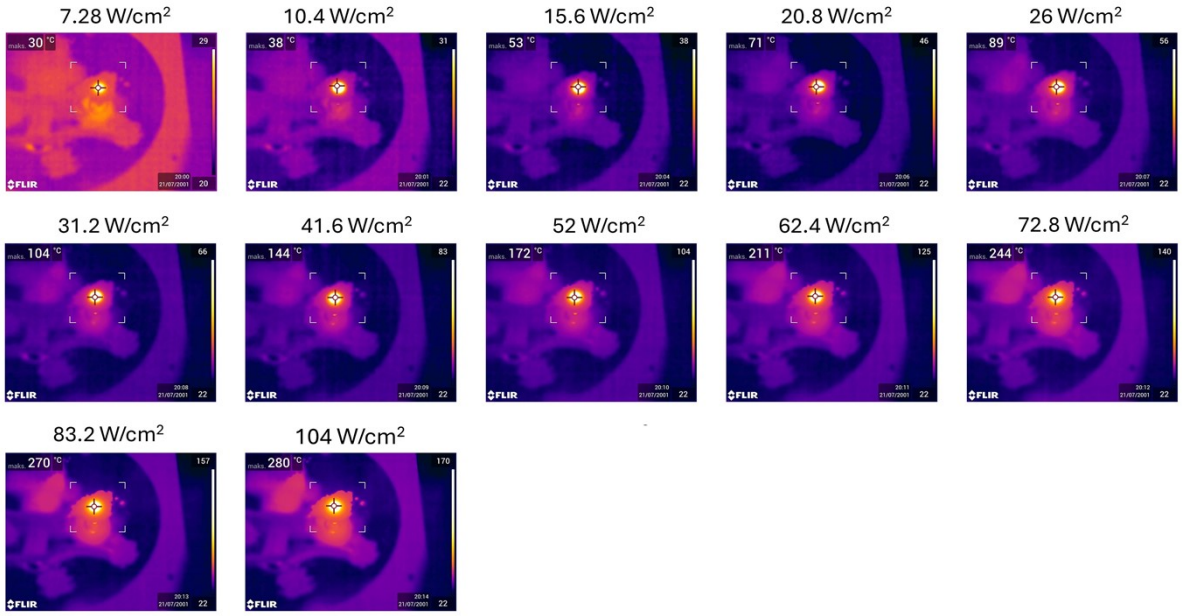

Figure S28. Temperature of $Na_3Sc_2(PO_4)_3:Er^{3+}$,30%Yb^{3+} upon different excitation densities recorded using thermovision camera.

Table S3. The values of the CIE1931 chromatic coordinates obtained for up-conversion emission for 4 different system alignments (changed excitation power and distance from the focal point).

Power [W]	Spot diameter [cm]	Distance from the focal [cm]	Excitation density [W cm-2]	CIE 1931	
				x	*y*
0.8	0.12	~0.1	70.77	0.379	0.597
1.7	0.175	0.15	70.71	0.379	0.596
1.44	0.16	0.138	71.65	0.378	0.601

2.4	0.21	0.18	69.32	0.384	0.594