

Supporting Information

Photochromism-induced multi-mode optical modulations and fluorescent temperature sensing in Sr/Er-codoped (K_{0.5}Na_{0.5})NbO₃ ceramics

Fangyuan Yu,^{a,1} Qifa Lin,^{a,1} Xiangfu Zeng,^a Ping Zhou,^a Xiao Wu,^{*a} Cong Lin,^a
Chunlin Zhao,^a Min Gao,^a Tengfei Lin,^a Xingan Jiang,^b Laihui Luo^c and Qiwei Zhang^d

^a Department of Material Science and Engineering, Fuzhou University, Fuzhou,
350108, China.

^b Institute of Micro/Nano Materials and Devices, Ningbo University of Technology,
Ningbo 315211, China.

^c Department of Microelectronic Science and Engineering, Ningbo University, Ningbo,
315211, China

^d College of Physics and Technology, Guangxi Normal University, Guilin, 541004,
China.

¹ F. Yu and Q. Lin contributed equally to this work.

E-mail: wuxiao@fzu.edu.cn (Xiao Wu).

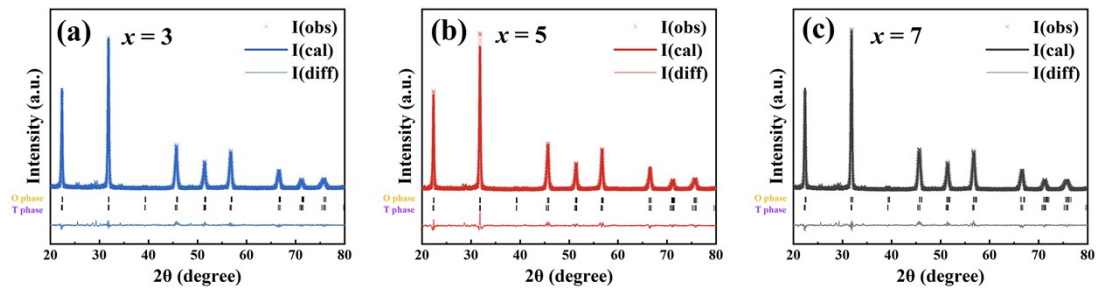


Figure S1 Rietveld refinement XRD patterns of the x Sr-1Er-KNN ceramics, (a) $x = 3$, (b) $x = 5$, and (c) $x = 7$.

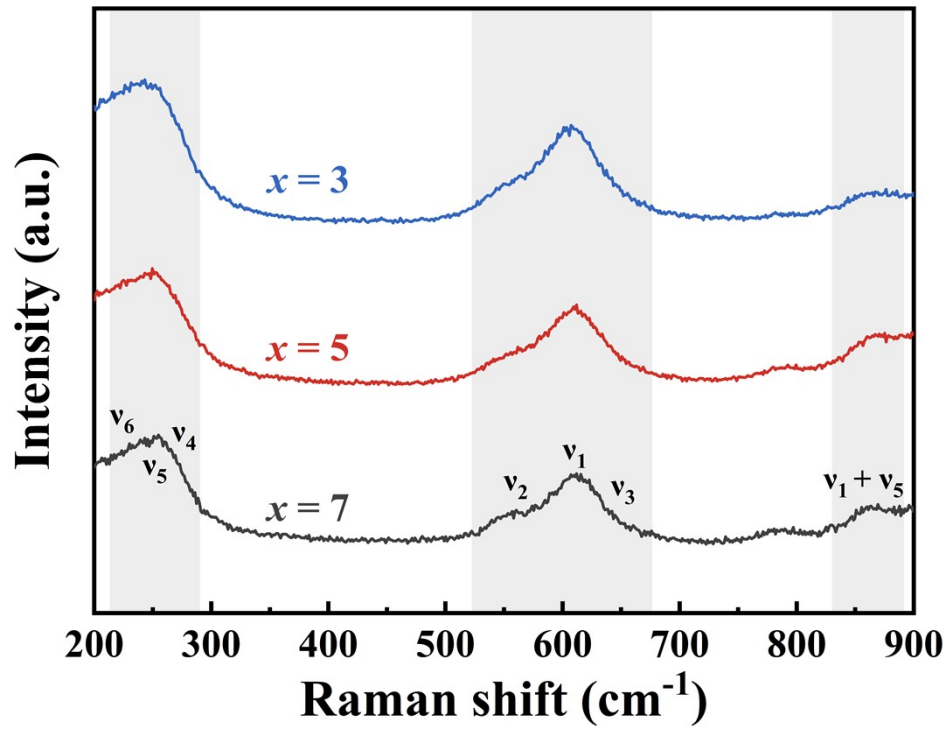


Figure S2 Raman spectra of the x Sr-1Er-KNN ceramics.

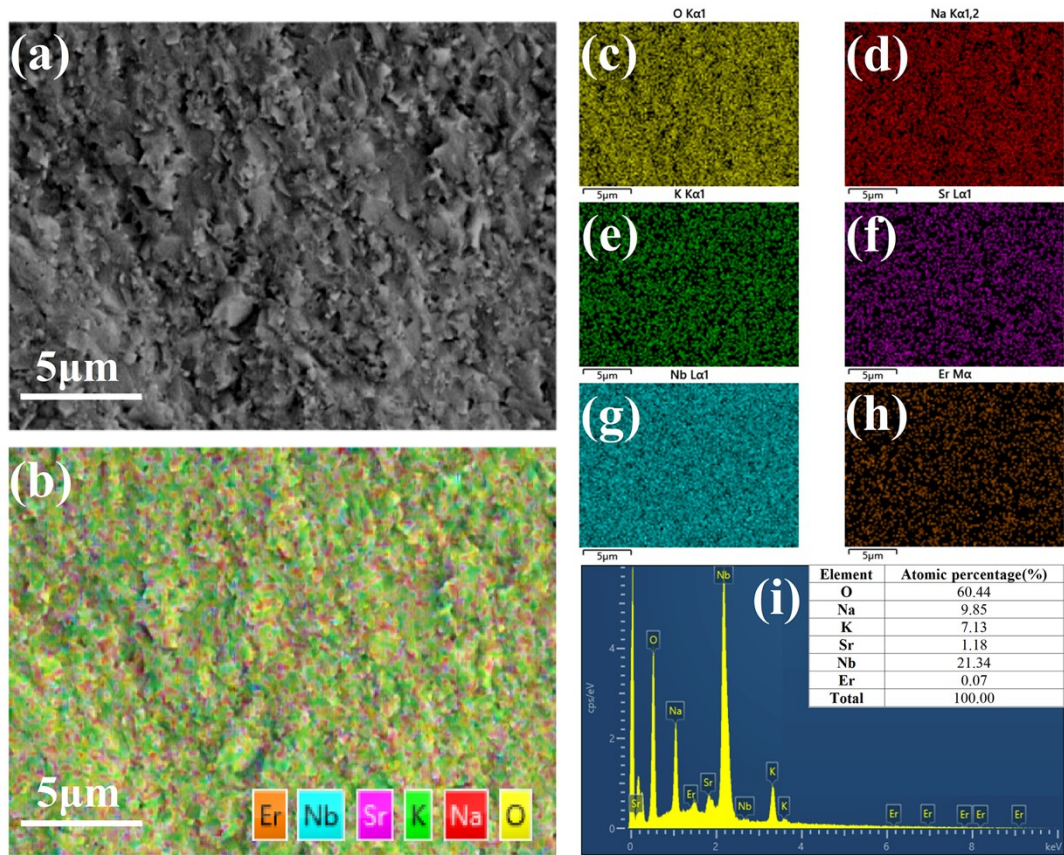


Figure S3 (a)-(h) EDS elemental mapping images of the representative 5Sr-1Er-KNN ceramic. (i) EDS spectrum of the ceramic, and inset shows the corresponding atomic percentage.

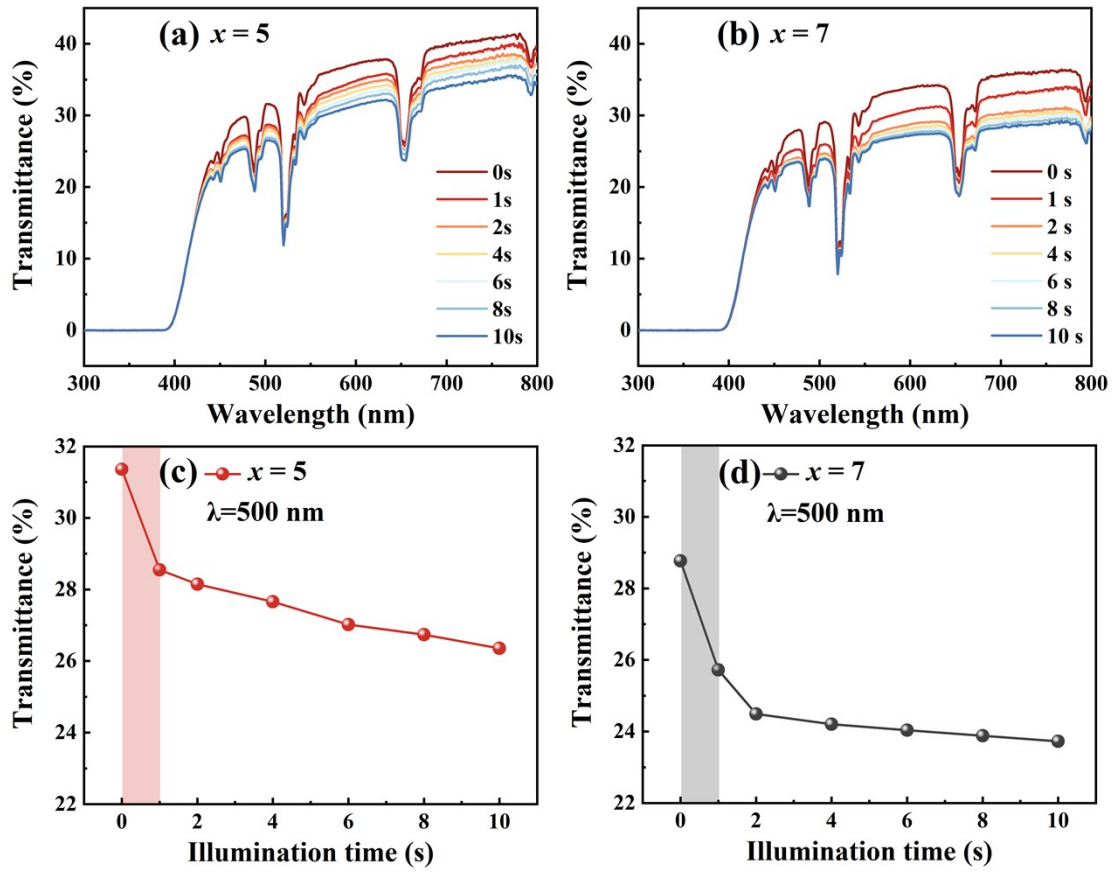


Figure S4 Optical transmittance spectra of the x Sr-1Er-KNN ceramics with (a) $x = 5$ and (b) $x = 7$ with different illumination times. Transmittance (T) values at 500 nm of the ceramics with (c) $x = 5$ and (d) $x = 7$ at different illumination times.

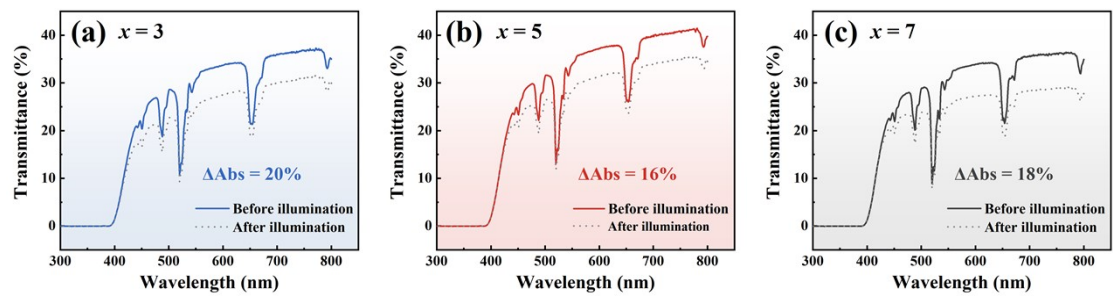


Figure S5 Optical transmittances of the x Sr-1Er-KNN ceramics with (a) $x = 3$, (b) $x = 5$ and (c) $x = 7$ before and after illumination (for 10 s).

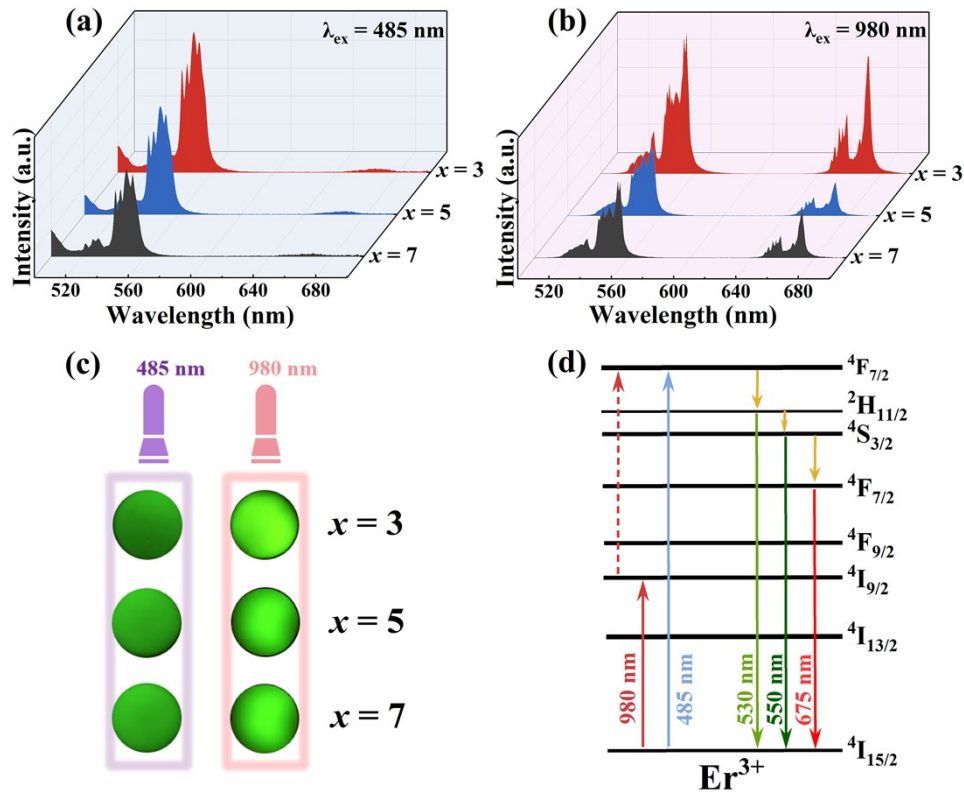


Figure S6 (a) DSPL and (b) UCPL spectra of the $x\text{Sr-1Er-KNN}$ ceramics. (c) Corresponding emission photos of the ceramics under the excitation of 485 nm or 980 nm. (d) Energy level diagram of Er^{3+} in the ceramics and possible electronic transition mechanism.

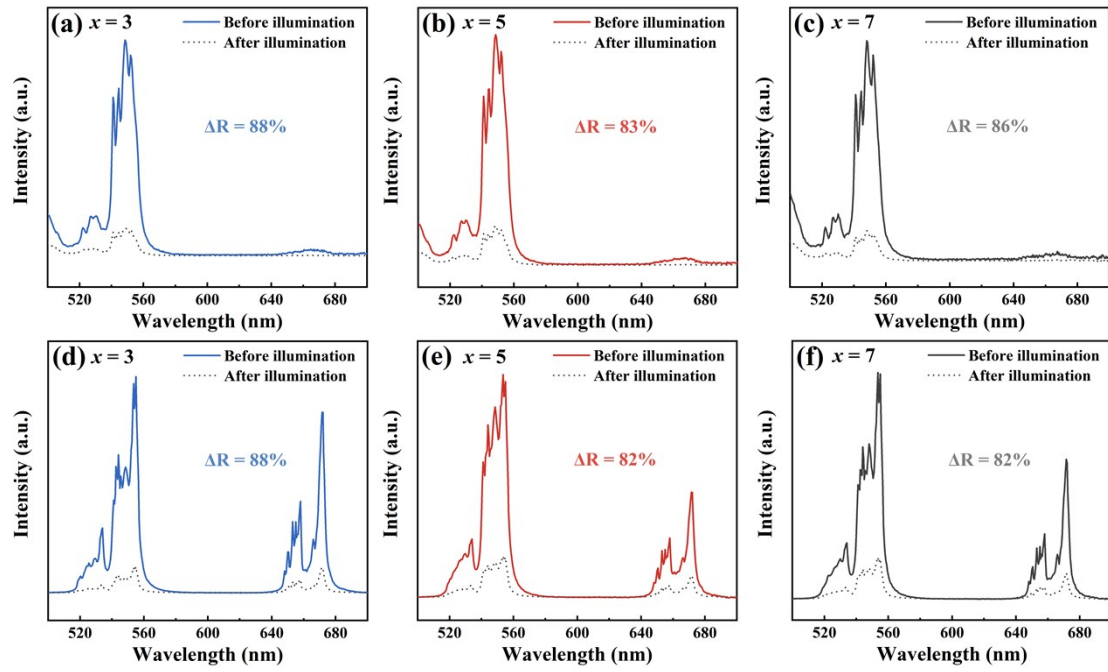


Figure S7 DSPL spectra ($\lambda_{\text{ex}} = 485 \text{ nm}$) of the $x\text{Sr-1Er-KNN}$ ceramics with (a) $x = 3$, (b) $x = 5$ and (c) $x = 7$ before and after illumination with 405 nm laser for 10 s. UCPL spectra ($\lambda_{\text{ex}} = 980 \text{ nm}$) of the ceramics with (d) $x = 3$, (e) $x = 5$ and (f) $x = 7$ before and after illumination with 405 nm laser for 10 s.

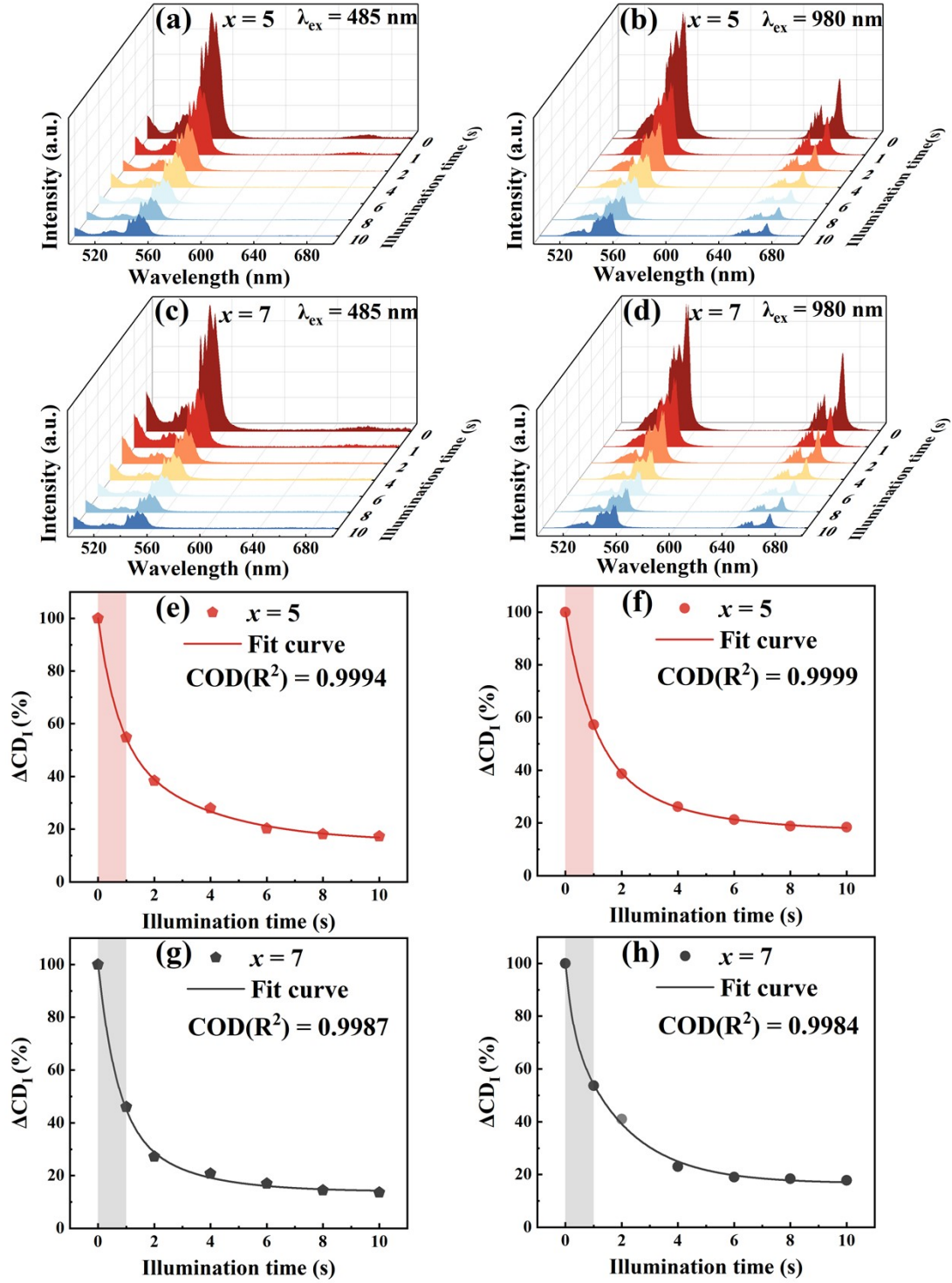


Figure S8 Effect of illumination time on DSPL and UCPL spectra of the x Sr-1Er-KNN ceramics with (a-b) $x = 5$ and (c-d) $x = 7$. Double exponential function fitting curves of ΔCD_1 for (e-f) $x = 5$ based on DSPL spectra and (g-h) $x = 7$ based on UCPL spectra.

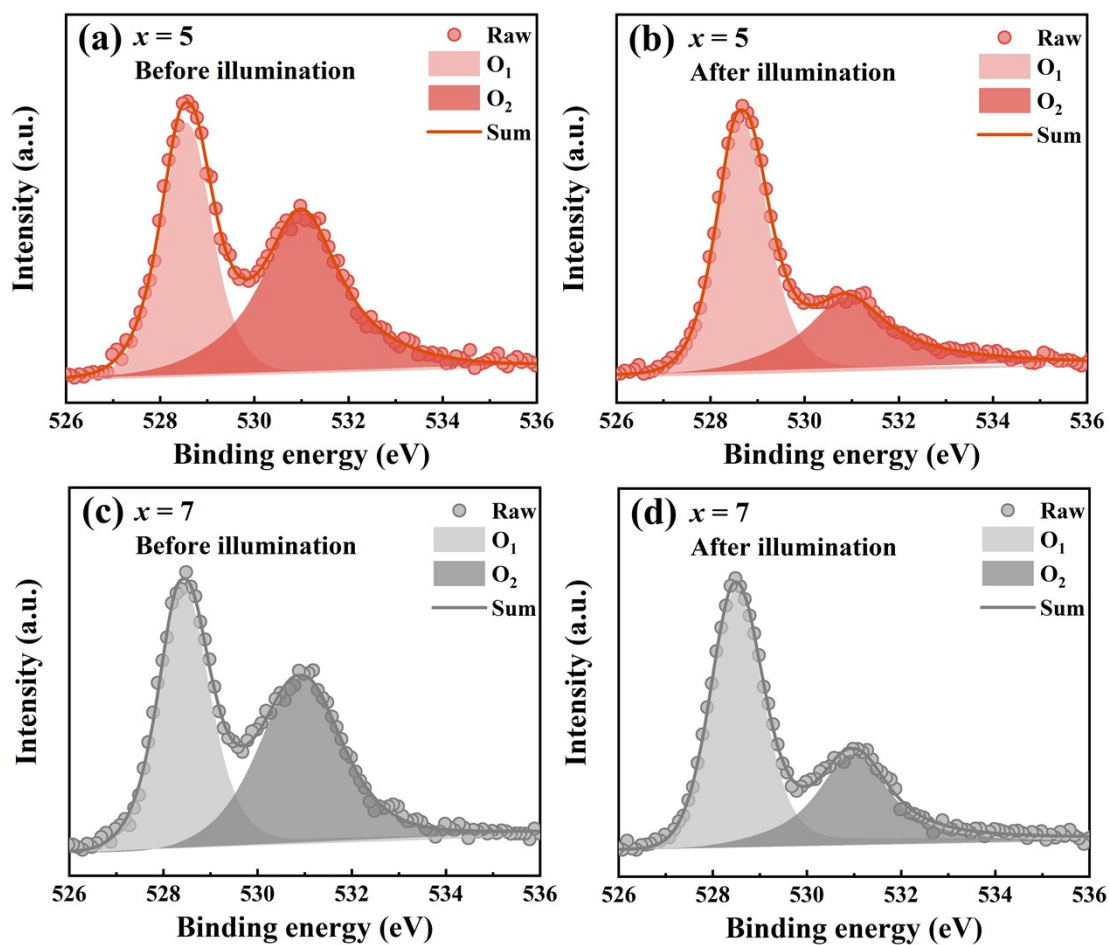


Figure S9 O 1s XPS spectra of the x Sr-1Er-KNN ceramics with (a) $x = 5$ and (c) $x = 7$ before illumination and (b) $x = 5$ and (d) $x = 7$ after illumination.

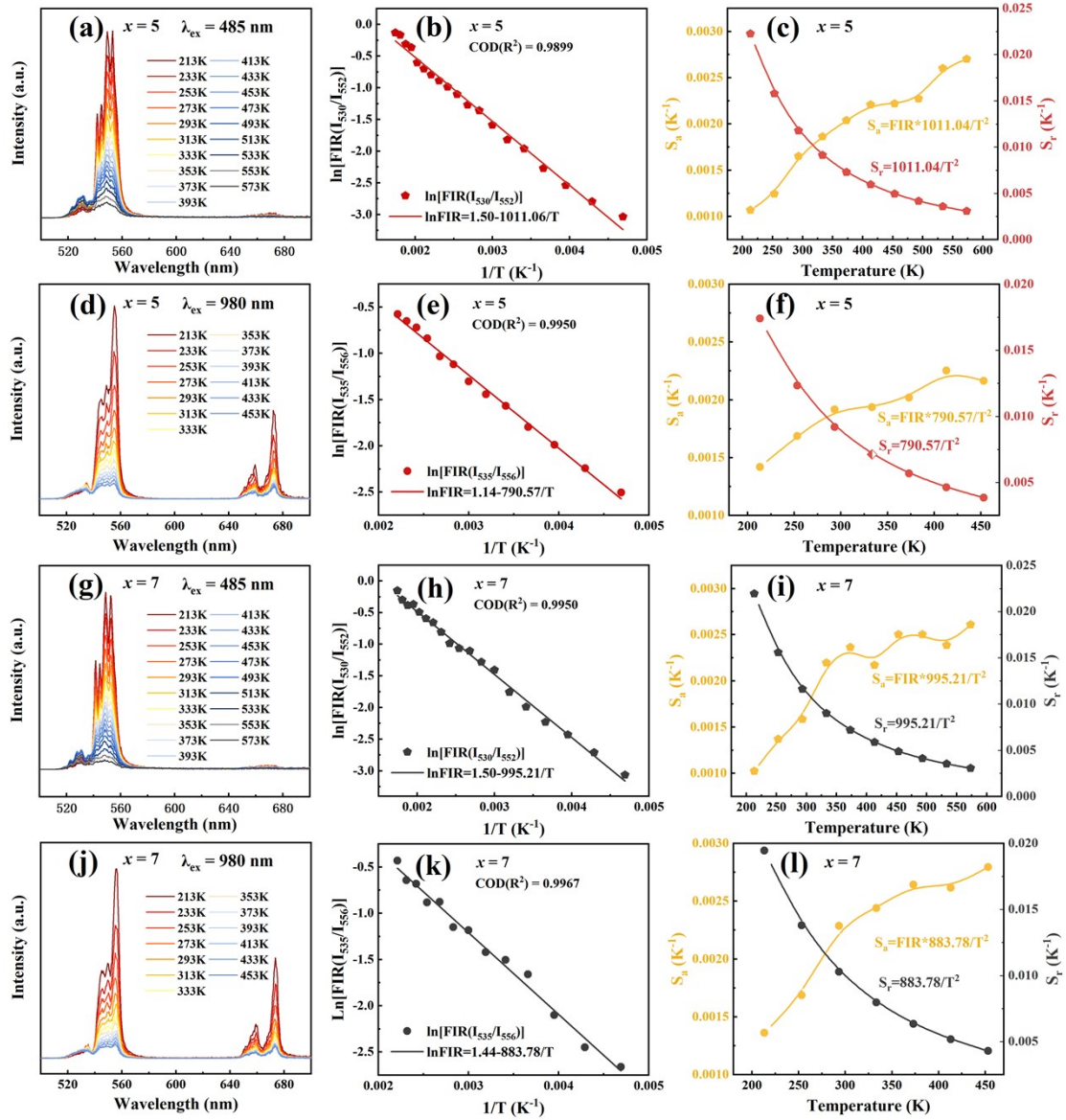


Figure S10 Temperature-dependent emission spectra of the 5Sr-1Er-KNN ceramics, (a) DSPL and (d) UCPL. Temperature-dependent emission spectra of the 7Sr-1Er-KNN ceramics, (g) DSPL and (j) UCPL. Arrhenius plots of ln FIR versus inverse temperature of 5Sr-1Er-KNN, (b) $\lambda_{\text{ex}} = 485$ nm and (e) $\lambda_{\text{ex}} = 980$ nm; and of 7Sr-1Er-KNN, (h) $\lambda_{\text{ex}} = 485$ nm and (k) $\lambda_{\text{ex}} = 980$ nm. S_a and S_r values of 5Sr-1Er-KNN, (c) $\lambda_{\text{ex}} = 485$ nm and (f) $\lambda_{\text{ex}} = 980$ nm; and of 7Sr-1Er-KNN, (i) $\lambda_{\text{ex}} = 485$ nm and (l) $\lambda_{\text{ex}} = 980$ nm.

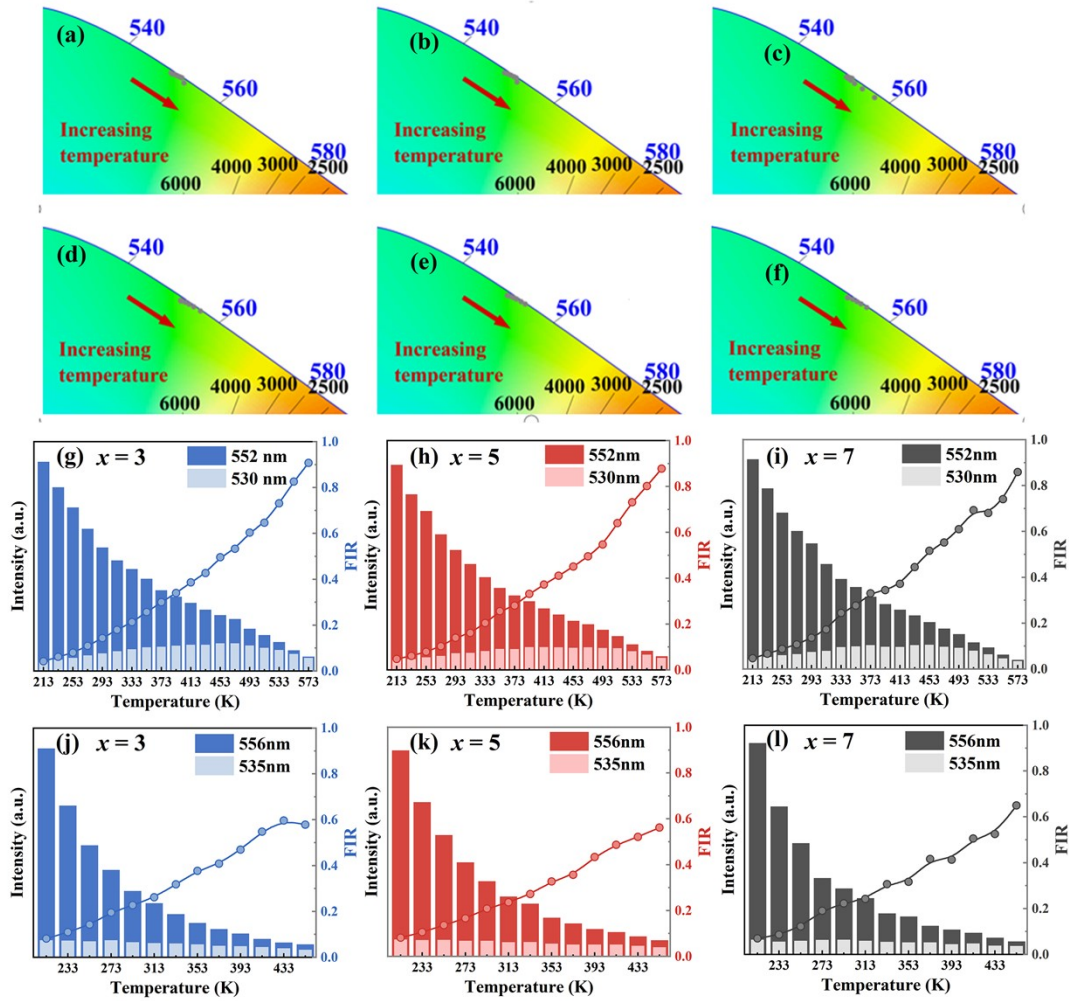


Figure S11 CIE diagrams of the x Sr-1Er-KNN ceramics with (a) $x = 3$, (b) $x = 5$ and (c) $x = 7$ ($\lambda_{ex} = 485$ nm); (d) $x = 3$, (e) $x = 5$ and (f) $x = 7$ ($\lambda_{ex} = 980$ nm). FIR ratio and logarithmic fitting results, (g) $x = 3$, (h) $x = 5$ and (i) $x = 7$ ($\lambda_{ex} = 485$ nm); (j) $x = 3$, (k) $x = 5$ and (l) $x = 7$ ($\lambda_{ex} = 980$ nm).

Table S1 Lattice parameters and error factor (R_w) of the x Sr-1Er-KNN ceramics.

Sample	Phase	Lattice parameters				c/a	R_w (%)
		a (Å)	b (Å)	c (Å)	ratio (%)		
3Sr-1Er-KNN	O	3.9334	5.5841	5.6355	34.89	1.4327	8.99
	T	3.9660	3.9660	3.9959	65.11	1.0075	
5Sr-1Er-KNN	O	3.9547	5.6083	5.6074	23.55	1.4179	8.82
	T	3.9622	3.9622	3.9872	76.45	1.0063	
7Sr-1Er-KNN	O	3.9606	5.6108	5.6338	49.24	1.4225	8.55
	T	3.9661	3.9661	3.9961	50.76	1.0076	

Table S2 Lorentzian fitting results of the x Sr-1Er-KNN ceramics based on the Raman spectra in the range of 500-700 cm^{-1} .

Sample	Vibrational modes	Parameters	
		Raman shift (cm^{-1})	Ratio (%)
3Sr-1Er-KNN	$A_{1g}(v_1)$	611.29	81.34
	$E_g(v_2)$	553.63	18.66
5Sr-1Er-KNN	$A_{1g}(v_1)$	606.98	87.52
	$E_g(v_2)$	548.44	12.48
7Sr-1Er-KNN	$A_{1g}(v_1)$	609.47	85.83
	$E_g(v_2)$	550.93	14.17

Table S3 The τ_1 and τ_2 values of double exponential function fitting curve of PL spectra for the x Sr-1Er-KNN ceramics under excitation of 485 nm or 980 nm.

Sample	Excitation wavelength	τ_1	τ_2
3Sr-1Er-KNN	485 nm	0.27	1.4
	980 nm	0.23	1.37
5Sr-1Er-KNN	485 nm	0.65	3.16
	980 nm	0.95	3.14
7Sr-1Er-KNN	485 nm	0.62	2.06
	980 nm	0.62	2.06

Table S4 O₁ area, O₂ area and area ratios of O₂/O₁ of the *x*Sr-1Er-KNN ceramics based on the O 1s XPS spectra.

Sample	O ₁ area	O ₂ area	O ₂ /O ₁ area ratio
3Sr-1Er-KNN (Before illumination)	31323	65304	2.08
3Sr-1Er-KNN (After illumination)	67583	54552	0.81
5Sr-1Er-KNN (Before illumination)	41172	24335	0.59
5Sr-1Er-KNN (After illumination)	72352	16498	0.23
7Sr-1Er-KNN (Before illumination)	43132	26952	0.62
7Sr-1Er-KNN (After illumination)	65854	22820	0.35

Table S5 The S_r values of x Sr-1Er-KNN under excitation of 485 nm or 980 nm.

Excitation	Sample	S_r (K^{-1})	Temperature (K)
485 nm	3Sr-1Er-KNN	0.023	213
	5Sr-1Er-KNN	0.022	213
	7Sr-1Er-KNN	0.022	213
980 nm	3Sr-1Er-KNN	0.018	213
	5Sr-1Er-KNN	0.017	213
	7Sr-1Er-KNN	0.019	213