Supporting Information

A new red phosphor for high time-resolved thermal sensitivity and plant growth

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Experimental Section

Table S1 shows the amount of raw material added without doping concentration. The change of Mn valence state is due to oxidation by oxygen in the air, and the specific reaction equation is shown as follows:

$2SrCO_3 + (1-x)TiO_2 + xMnCO_3 + x/2O_2 \rightarrow Sr_2Ti_{1-x}Mn_xO_4 + (2+x)CO_2$

Critical distance (R_c) calculations

Generally, the non-radiative energy transfer among activators triggers concentration quenching, which is determined by the distance among the dopant Mn^{4+}. The critical distance (R_c) at which the possibility of non-radiative energy transfer and radiative emission is equal, could be estimated by R_c can be calculated by the following equation:

$$R_c \approx 2[\frac{3V}{4\pi x_c N}]^{1/3} \quad (1)$$

where V stands for the cell volume, x_c is the critical concentration of Mn^{4+} and N refers to the number of available sites occupied by Mn^{4+}, respectively. For Sr_2TiO_4:0.009Mn^{4+} phosphor, V = 189.88 Å^3, x_c= 0.009 and N = 1, so the R_c is

calculated to be 34.3 Å. This value is far beyond 5 A, implying that exchange interaction mechanism is impossible for the energy transfer among Mn^{4+} in present system while it is only working for the sample with significant overlap between the excitation and emission spectra. In consequence, the multipolar interaction energy transfer will dominate the concentration quenching mechanism in Mn^{4+} doped Sr_2TiO_4 and the type of interaction The following equation which is based on the Dexter theory, can reflect the type of interaction between Mn^{4+} ions:

$$\log\left(\frac{I}{x}\right) = A - \frac{\theta}{3}\log(x) \quad (2)$$

where I and x mean the emission intensity and concentration of Mn^{4+} dopant, and θ = 6, 8, 10 refer to d–d, d–q, and q–q interactions, respectively. The specific value of θ is usually obtained by the slope of the dependence of log(I/x) versus log (x), $slope \approx -\theta/3$ (Fig. S2). So, the value of θ is 2.582, the type of interaction between Mn^{4+} ions can indicate the concentration quenching mechanism is d–d interaction in Sr_2TiO_4:$x$$Mn^{4+}$ phosphor.

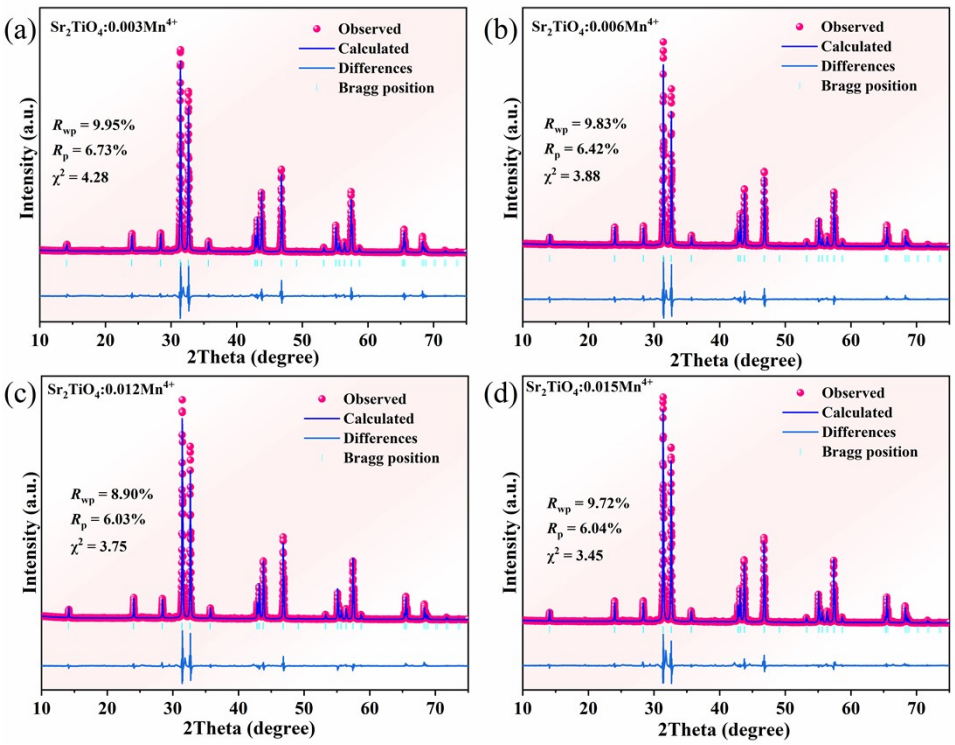

Figure S1. (a-d) Rietveld refinement of the powder XRD profiles of Sr_2TiO_4:$x$$Mn^{4+}$ (x = 0.003, 0.006, 0.012, 0.015).

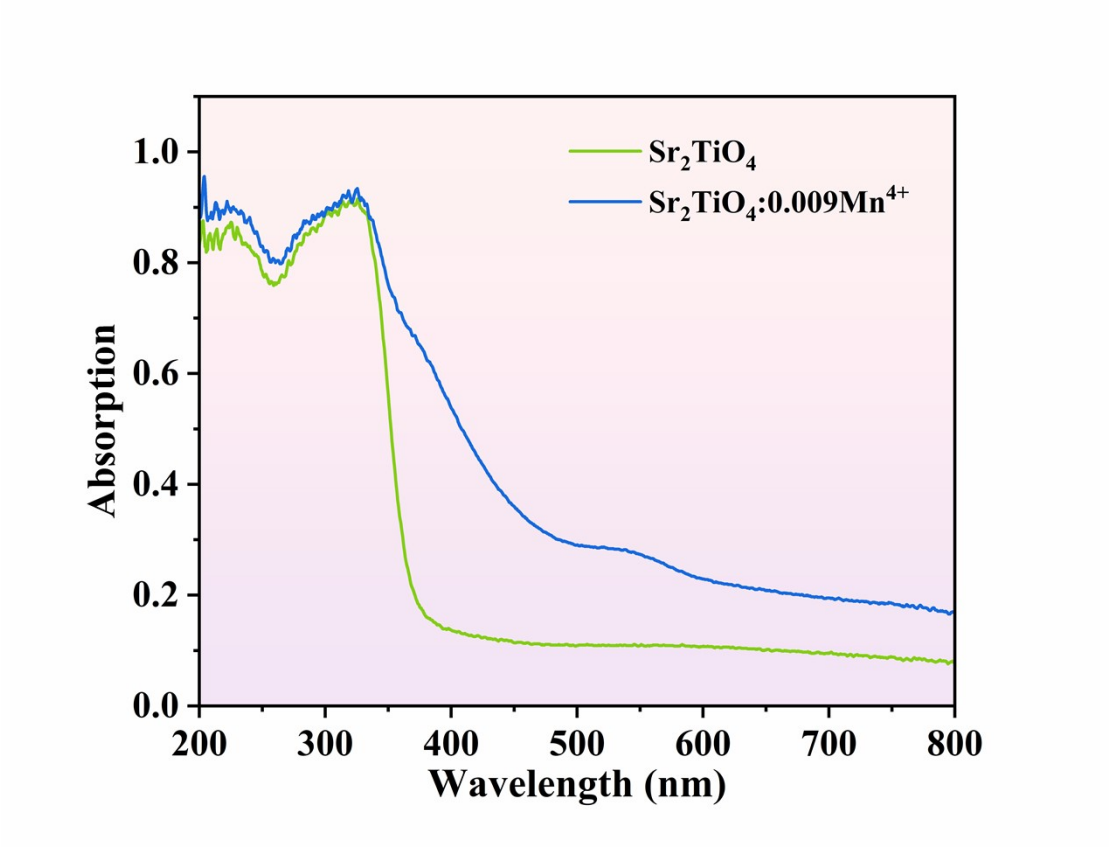

Figure S2. Diffuse reflectance spectra of Sr_2TiO_4 and Sr_2TiO_4:0.009Mn^{4+}.

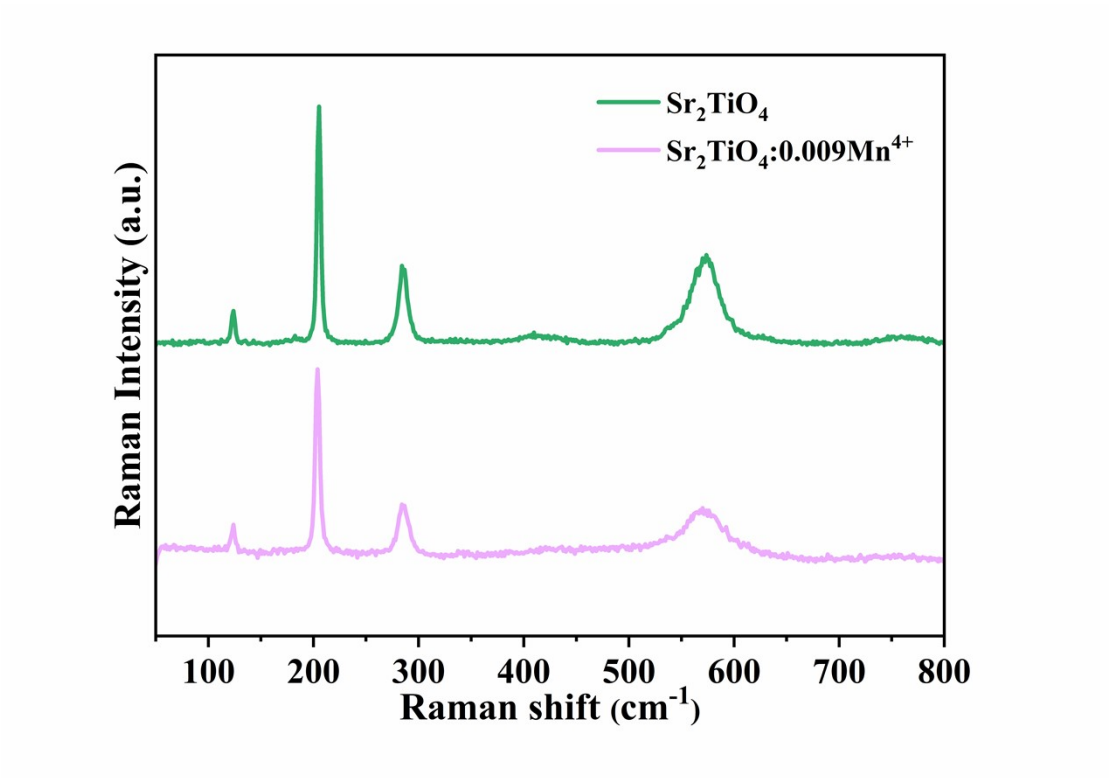

Figure S3. Raman spectra of Sr_2TiO_4 and Sr_2TiO_4:0.009Mn^{4+}.

Table S1. The phosphor $Sr_2Ti_{1-x}O_4$:$x$$Mn^{4+}$ (x = 0.003, 0.006, 0.009, 0.012, 0.015)

detailed quantities (g) of raw materials.

Samples	x = 0.003	x = 0.006	x = 0.009	x = 0.012	x = 0.015
$SrCO_3$	2	2	2	2	2
TiO_2	0.5394	0.5378	0.5361	0.5345	0.5329
$MnCO_3$	0.0023	0.0047	0.0070	0.0093	0.0117

Table S2. Crystallographic parameters for $Sr_2Ti_{1-x}O_4$:xMn^{4+} (x = 0.003, 0.006, 0.009, 0.012, 0.015) from Rietveld Refinements.

Samples	x = 0.003	x = 0.006	x = 0.009	x = 0.012	x = 0.015
Crystal System			tetragonal		
Space Group			14/*mmm*		
a (Å)	3.8839	3.8834	3.8839	3.8839	3.8835
b (Å)	3.8839	3.8834	3.8839	3.8839	3.8835
c (Å)	12.5876	12.5876	12.5889	12.5894	12.5876
β (Å)	90	90	90	90	90
γ (Å)	90	90	90	90	90
V (Å^3)	189.835	189.847	189.882	189.907	189.913
R_{wp} (%)	9.95	9.83	9.77	8.90	9.72
R_p (%)	6.73	6.42	6.36	6.03	6.04

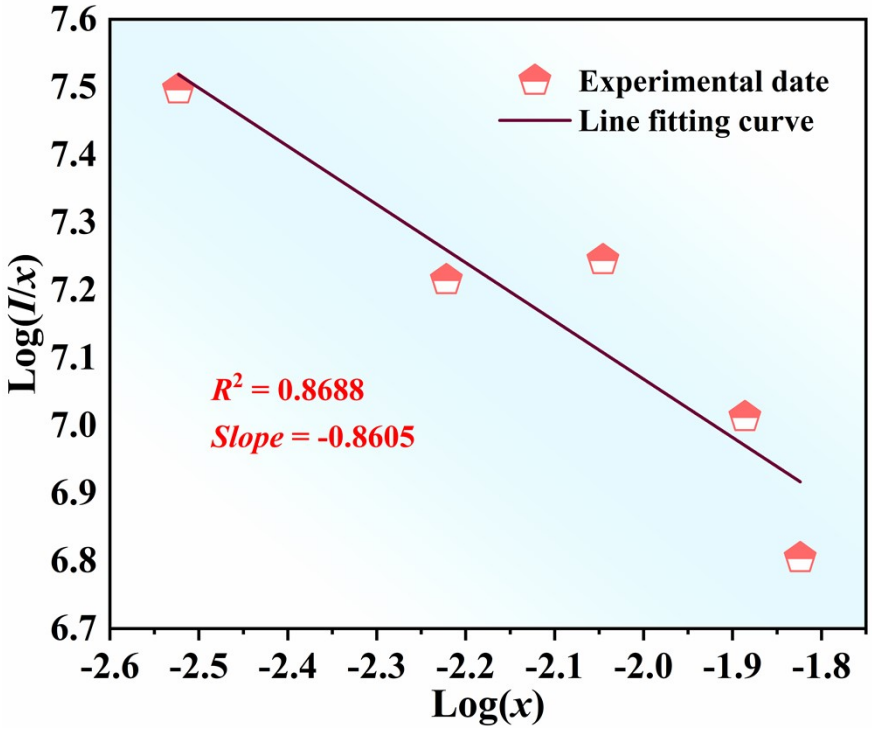

Figure S4. Functional relationship between log(I/x) and log(x) for the

Sr_2TiO_4:0.009Mn^{4+} phosphors.