Electronic Supplementary Information

Sensitization of Mn^{2+} luminescence via efficient energy transfer to suit the application of high color rendering WLEDs

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Table S1 The refined structure parameters of SCB host.

Atom	Wyck.	x/a	y/b	z/c	Occ.
Sc1	4c	0.3899	1.2500	0.5727	1.0000
Ca1	4c	0.5894	0.7500	0.8383	1.0000
B1	4c	0.3114	1.2500	0.8696	1.0000
O1	4c	0.5051	0.7500	0.6176	1.0000
O2	4c	0.2430	1.2500	0.7378	1.0000
O3	4c	0.2603	0.7500	0.4898	1.0000
O4	4c	0.4394	0.7500	0.8704	1.0000

Space group: *Pnma* (62) - orthorhombic.

Cell parameters: a = 10.1746 Å, b = 3.3704 Å, c = 9.4119 Å.

V = 322.75 Å^3, Z = 4.

Reliability factors: GOF = 2.86, R_p = 5.70%.

Table S2 The refined structure parameters of $Sc_{0.995}CaOBO_3$:0.005Ce^{3+} phosphor.

Atom	Wyck.	x/a	y/b	z/c	Occ.
Sc1 (Ce)	4c	0.3904	1.2500	0.5722	1.0000
Ca1	4c	0.5892	0.7500	0.8399	1.0000
B1	4c	0.3093	1.2500	0.8667	1.0000
O1	4c	0.5040	0.7500	0.6174	1.0000
O2	4c	0.2437	1.2500	0.7363	1.0000
O3	4c	0.2643	0.7500	0.4893	1.0000
O4	4c	0.4382	0.2500	0.8738	1.0000

Space group: *Pnma* (62) - orthorhombic.

Cell parameters: a = 10.2330 Å, b = 3.3651 Å, c = 9.4137 Å.

V = 324.16 Å^3, Z = 4.

Reliability factors: GOF = 2.00, R_p = 7.87%.

Table S3 The refined structure parameters of $ScCa_{0.99}OBO_3$:$0.010Mn^{2+}$ phosphor.

Atom	Wyck.	x/a	y/b	z/c	Occ.
Sc1	4c	0.3893	1.2500	0.5728	1.0000
Ca1 (Mn)	4c	0.5888	0.7500	0.8380	1.0000
B1	4c	0.3109	1.2500	0.8682	1.0000
O1	4c	0.5047	0.7500	0.6178	1.0000
O2	4c	0.2424	1.2500	0.7377	1.0000
O3	4c	0.2598	0.7500	0.4889	1.0000
O4	4c	0.4390	0.2500	0.8708	1.0000

Space group: *Pnma* (62) - orthorhombic.

Cell parameters: a = 10.1678 Å, b = 3.3630 Å, c = 9.4035 Å.

V = 321.54 Å^3, Z = 4.

Reliability factors: GOF = 2.27, R_p = 8.48%.

Table S4 The refined structure parameters of the $Sc_{0.995}Ca_{0.985}OBO_3$:0.005$Ce^{3+}$, 0.015$Mn^{2+}$ phosphor.

Atom	Wyck.	x/a	y/b	z/c	Occ.
Sc1 (Ce)	4c	0.3900	1.2500	0.5723	1.0000
Ca1 (Mn)	4c	0.5888	0.7500	0.8395	1.0000
B1	4c	0.3095	1.2500	0.8681	1.0000
O1	4c	0.5043	0.7500	0.6187	1.0000
O2	4c	0.2412	1.2500	0.7367	1.0000
O3	4c	0.2608	0.7500	0.4911	1.0000
O4	4c	0.4392	0.2500	0.8713	1.0000

Space group: *Pnma* (62) - orthorhombic.

Cell parameters: a = 10.2184 Å, b = 3.3647 Å, c = 9.4133 Å.

V = 323.64 Å^3, Z = 4.

Reliability factors: GOF = 1.82, R_p = 7.46%.

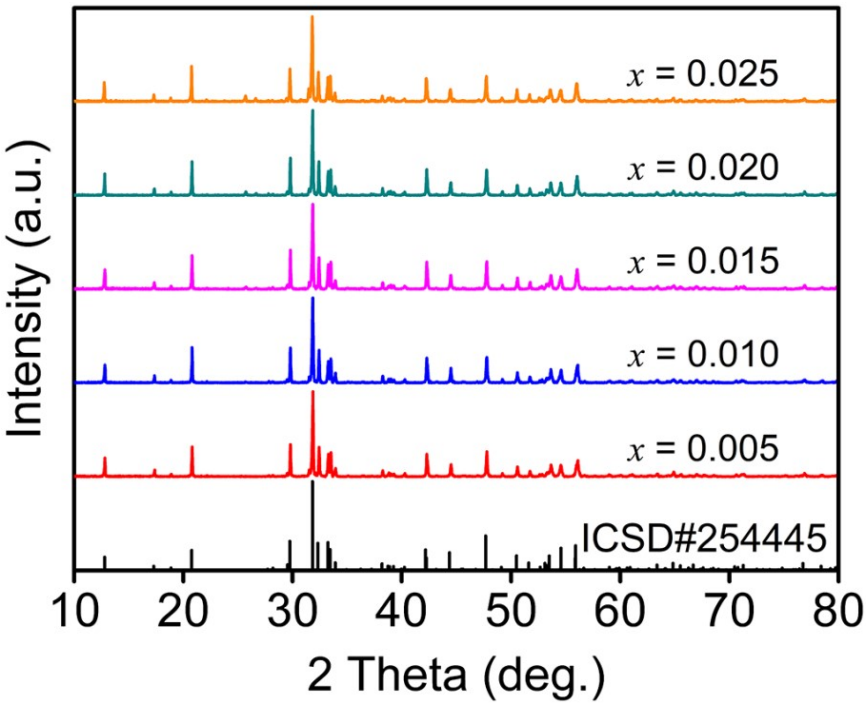

Fig. S1 The XRD patterns of $Sc_{1-x}CaOBO_3:xCe^{3+}$ (x = 0.005, 0.010, 0.015, 0.020, and 0.025) phosphors.

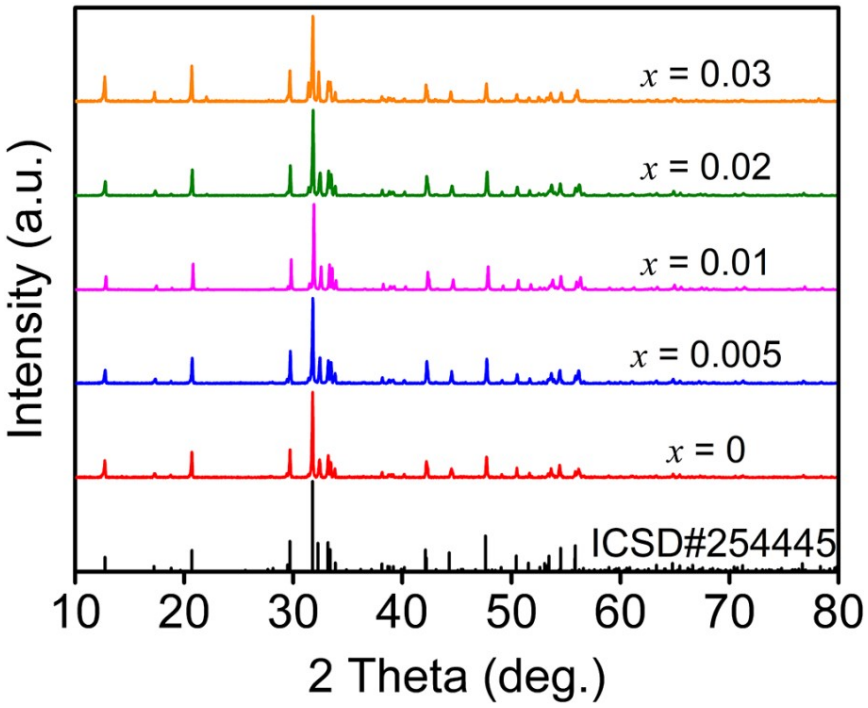

Fig. S2 The XRD patterns of $ScCa_{1-x}OBO_3:xMn^{2+}$ (x = 0, 0.005, 0.01, 0.02, and 0.03) phosphors.

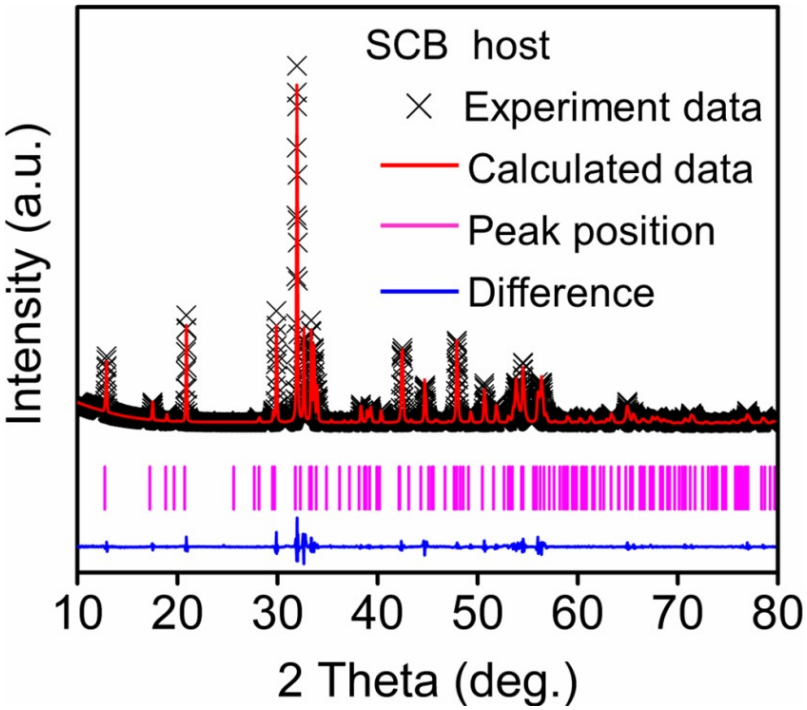

Fig. S3 The Rietveld XRD refinement pattern of SCB host.

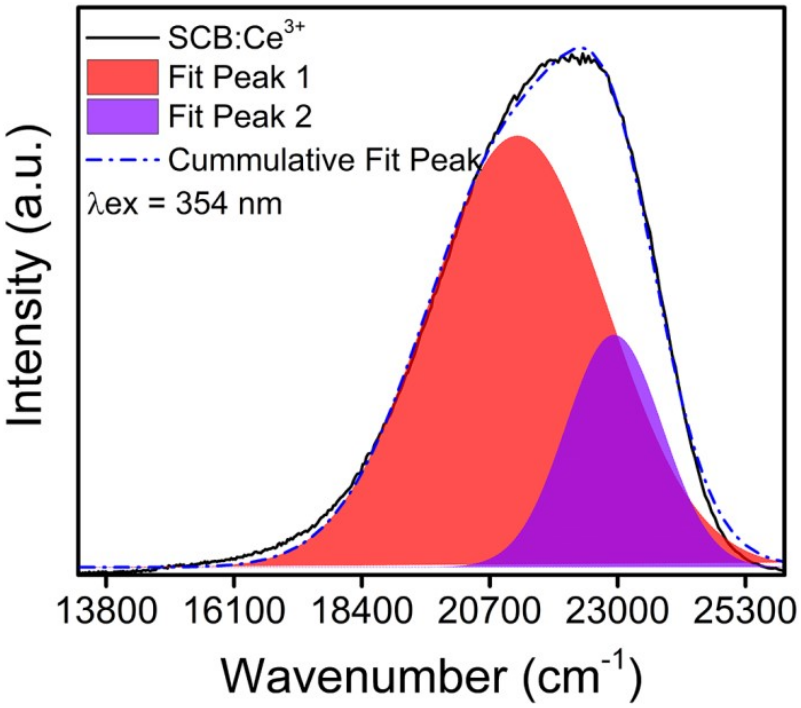

Fig. S4 PL spectrum of $Sc_{0.995}CaOBO_3:0.005Ce^{3+}$ phosphor and its Gaussian peaks

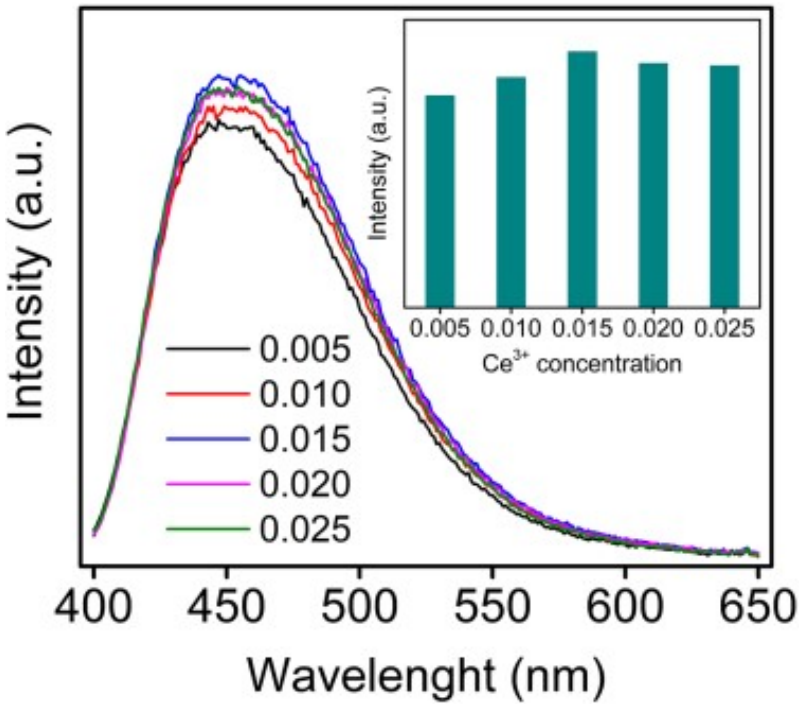

Fig. S5 The PL spectra of $Sc_{1-x}CaOBO_3$:$x$$Ce^{3+}$, ($x$ = 0.005, 0.010, 0.015, 0.020, and 0.025) phosphors.

Fig. S5 shows the PL spectra of the SCB:$x$$Ce^{3+}$ (x = 0.005, 0.010, 0.015, 0.020 and 0.025) phosphors. As shown, the intensity of emission peaks increases with increase of Mn^{2+} doping concentration until x = 0.015, and then the intensity starts to decrease because of the concentration quenching phenomenon.

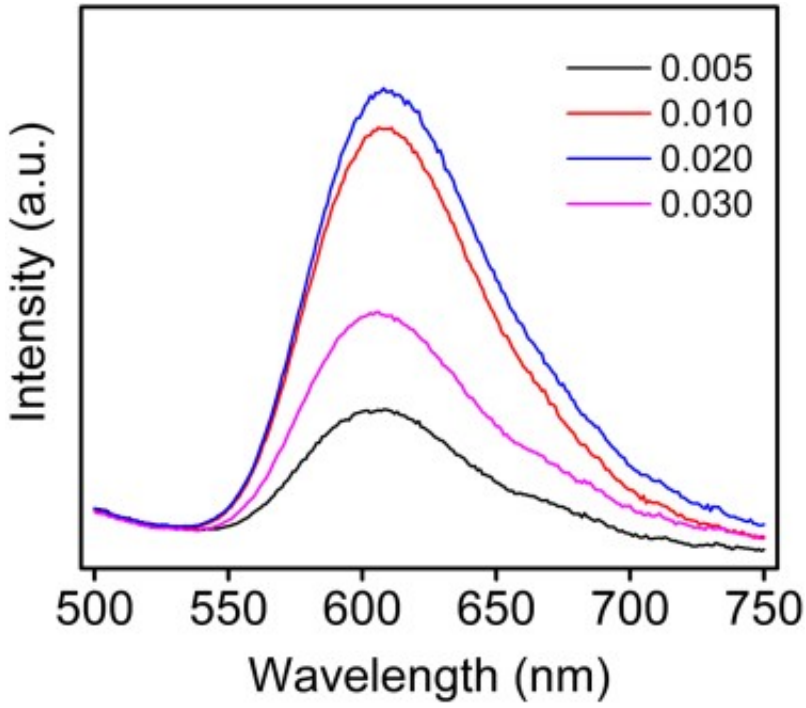

Fig. S6 The PL spectra of $ScCa_{1-x}OBO_3:xMn^{2+}$, (x = 0, 0.005, 0.01, 0.02, and 0.03) phosphors.

The concentration dependent PL spectra of the SCB:xMn^{2+} (x = 0.005, 0.010, 0.020 and 0.030) phosphors is displayed in **Fig. S6**. As shown, the intensity of emission peaks increases with increasing Mn^{2+} doping concentration until x = 0.020, and then the intensity starts to decrease owing to the concentration quenching.

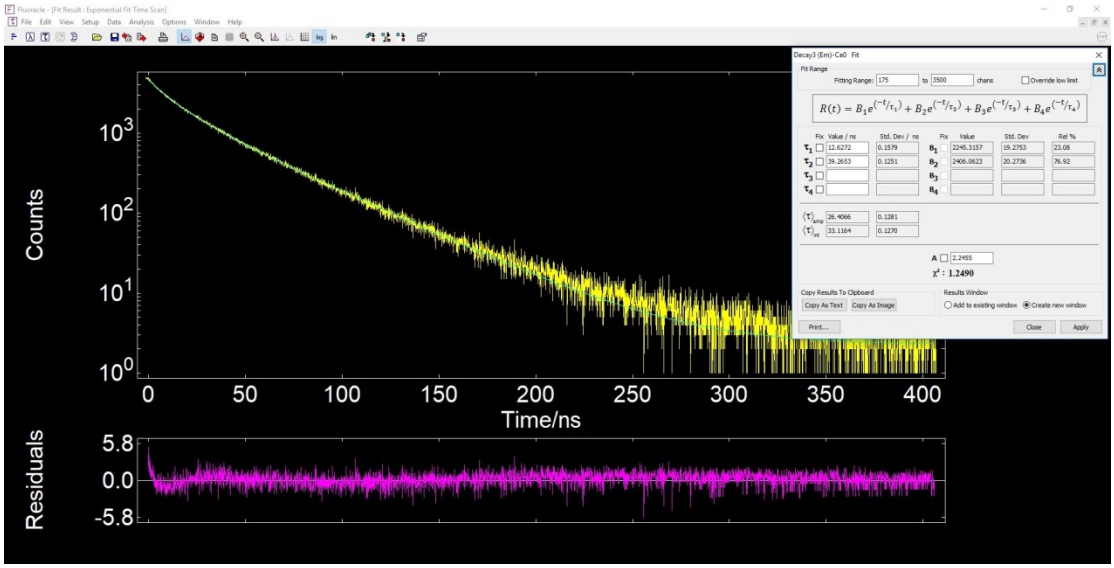

Fig. S7 The fluorescence lifetime test result of $Sc_{0.995}CaOBO_3$:0.005Ce^{3+}, 0.000Mn^{2+} phosphor.

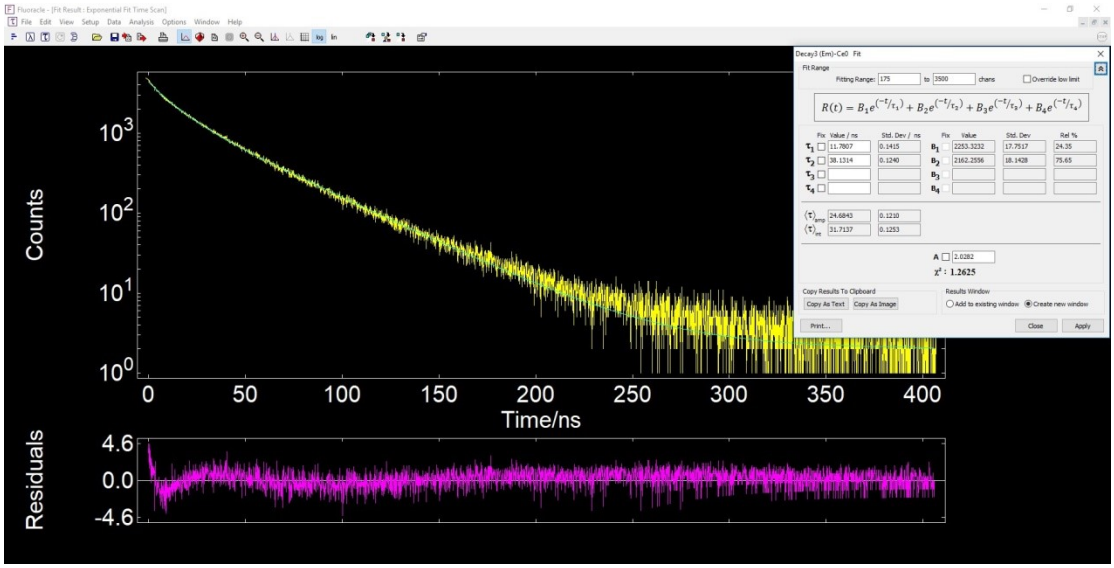

Fig. S8 The fluorescence lifetime test result of $Sc_{0.995}Ca_{0.995}OBO_3$:0.005$Ce^{3+}$, 0.005$Mn^{2+}$ phosphor.

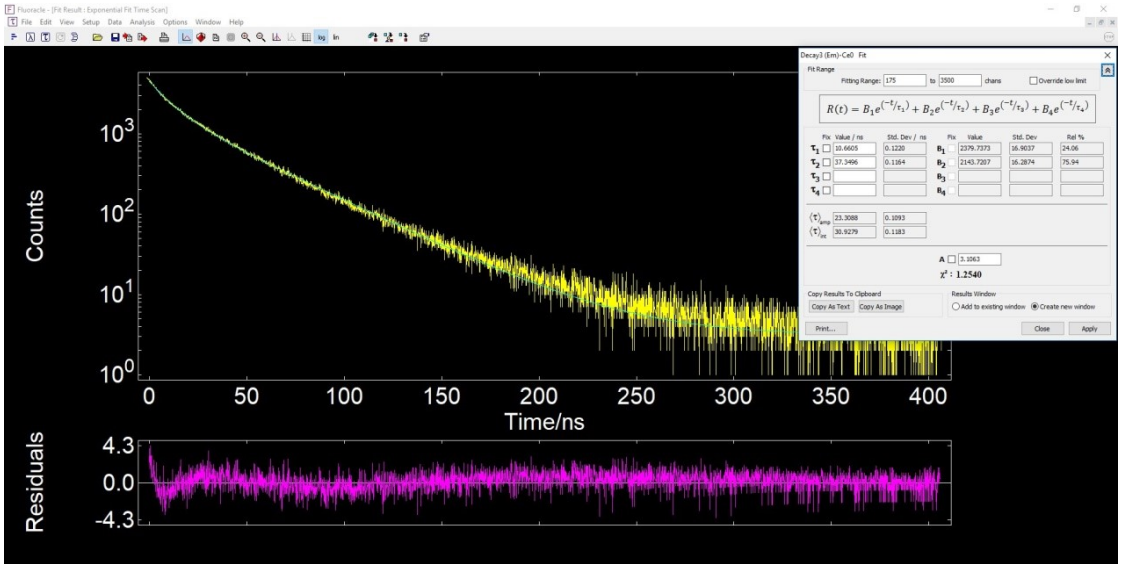

Fig. S9 The fluorescence lifetime test result of $Sc_{0.995}Ca_{0.99}OBO_3$:0.005Ce^{3+}, 0.010Mn^{2+} phosphor.

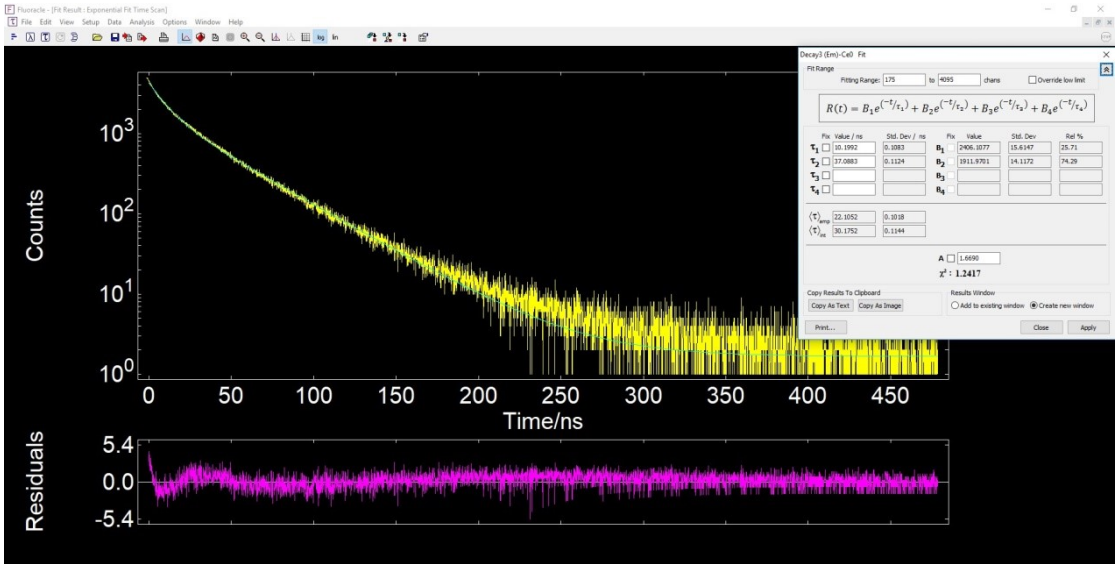

Fig. S10 The fluorescence lifetime test result of $Sc_{0.995}Ca_{0.985}OBO_3$:0.005$Ce^{3+}$, 0.015$Mn^{2+}$ phosphor.

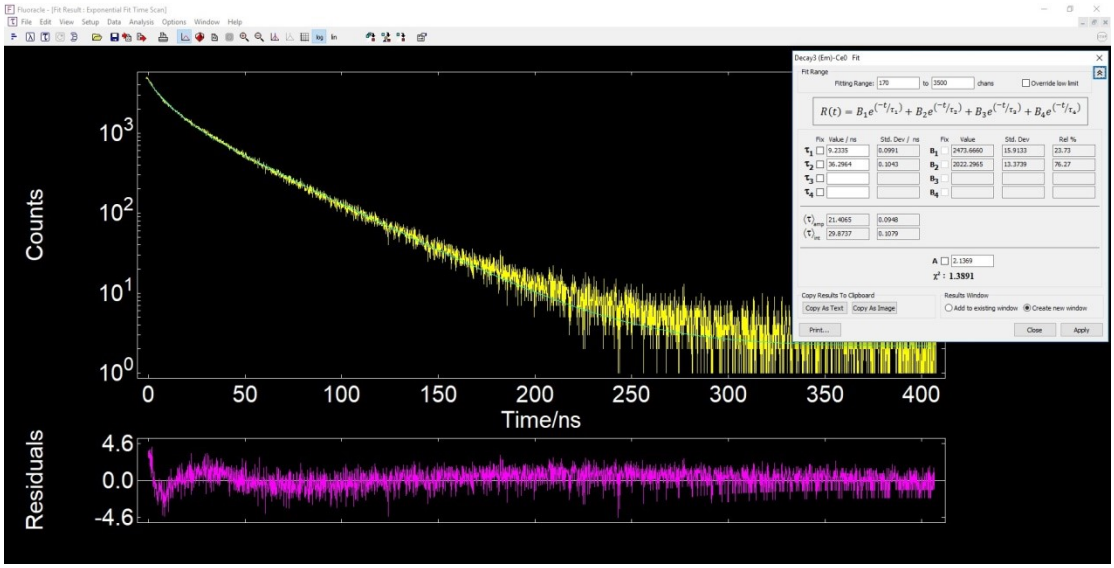

Fig. S11 The fluorescence lifetime test result of $Sc_{0.995}Ca_{0.98}OBO_3$:0.005Ce^{3+}, 0.020Mn^{2+}phosphor.

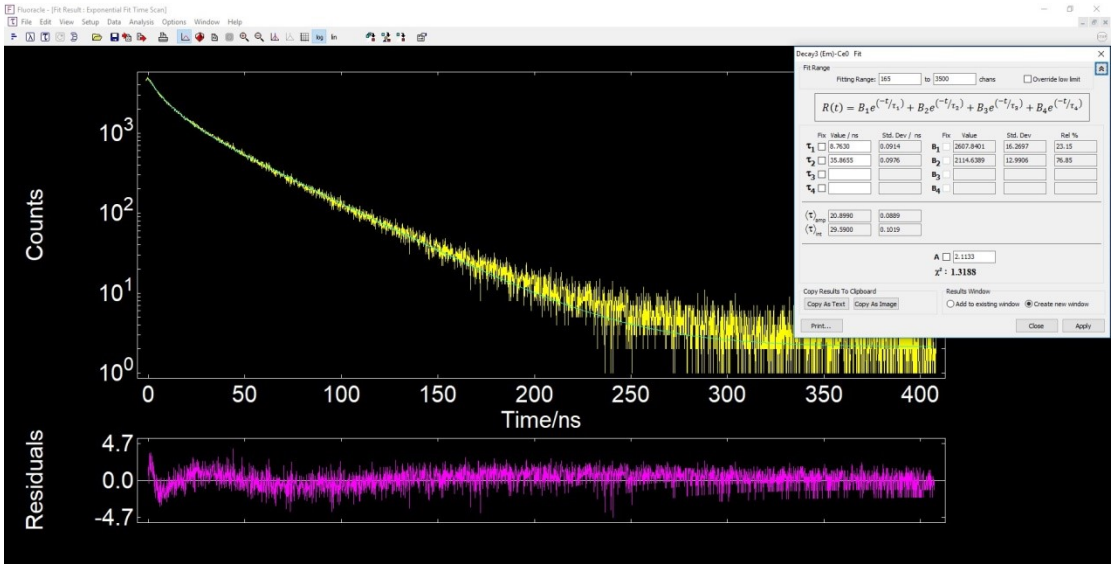

Fig. S12 The fluorescence lifetime test result of $Sc_{0.995}Ca_{0.975}OBO_3$:0.005$Ce^{3+}$, 0.025$Mn^{2+}$ phosphor.

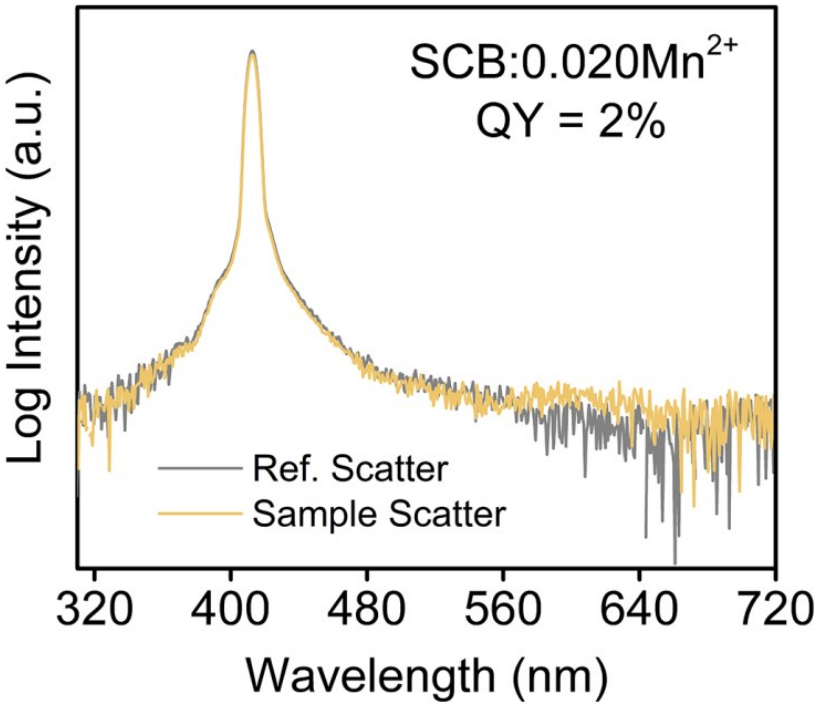

Fig. S13 The QY of the $ScCa_{0.98}OBO_3$:0.020Mn^{2+} phosphor.

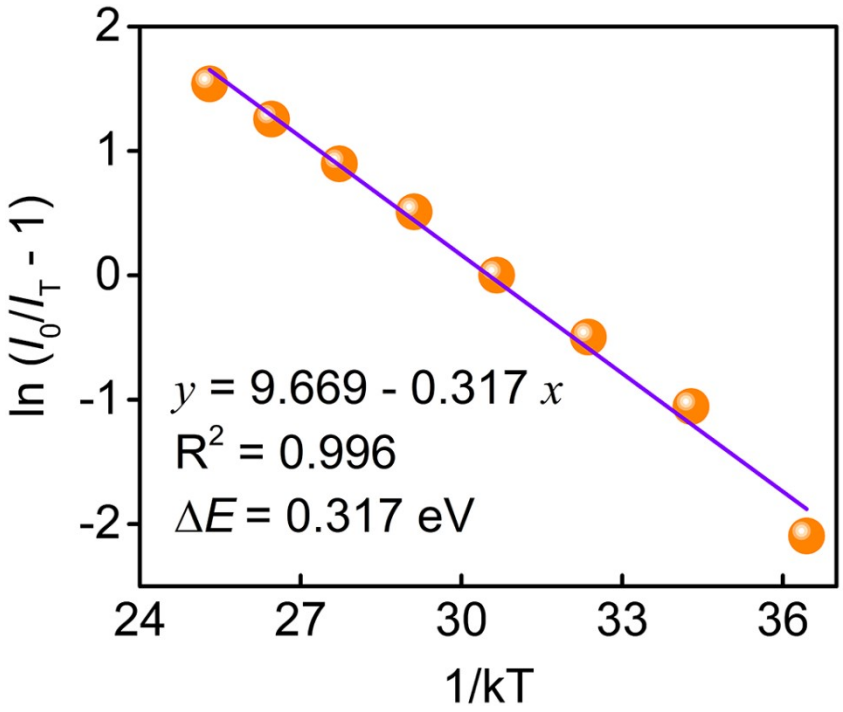

Fig. S14 The plot and linear fit of ln(I_0/I_t-1) versus 1/KT for $Sc_{0.995}Ca_{0.985}OBO_3$: $0.005Ce^{3+}$, $0.015Mn^{2+}$ phosphor.

The activation energy of thermal quenching (ΔE) was computed using the Arrhenius formula:

$$I_T = \frac{I_0}{1 + C \cdot \exp(-\frac{\Delta E}{kT})} \quad (1)$$

In formula (1), I_0 and I_T are the initial emission intensity and the emission intensity at temperature T, respectively. C is a constant, and k represents the Boltzmann's constant (8.629×10^{-5} eV/K). As shown in Fig. S14, the value of ΔE is calculated to be 0.317 eV.