Electronic Supplementary Material (ESI) for Dalton Transactions.


Supporting Information

# A highly luminescent $Mn^{4+}$ activated $LaAlO_3$ far-red-emitting phosphor for plant growth LEDs: Charge compensation induced $Mn^{4+}$ incorporation

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**Table S1.** The decay lifetimes of LAO:$Mn^{4+}$,$Mg^{2+}$ with different concentrations of $Mn^{4+}$.

| Concentration of $Mn^{4+}$ / mol% | Monitoring wavelength / nm | Lifetime / ms |
|---|---|---|
| 0.05 | 729 | 3.4 |
| 0.1 | 729 | 3.3 |
| 0.3 | 729 | 2.4 |
| 0.5 | 729 | 2.1 |
| 0.7 | 729 | 1.7 |

**Table S2.** The chromaticity coordinates of LAO:$Mn^{4+}$,$Mg^{2+}$ in 298–433 K.

| Temperature/ K | Chromaticity coordinates (*x*, *y*) |
|---|---|
| 298 | 0.7335, 0.2665 |
| 313 | 0.7334, 0.2666 |
| 333 | 0.7333, 0.2667 |
| 353 | 0.7332, 0.2668 |
| 373 | 0.7330, 0.2670 |
| 393 | 0.7328, 0.2672 |
| 413 | 0.7326, 0.2674 |
| 433 | 0.7317, 0.2683 |

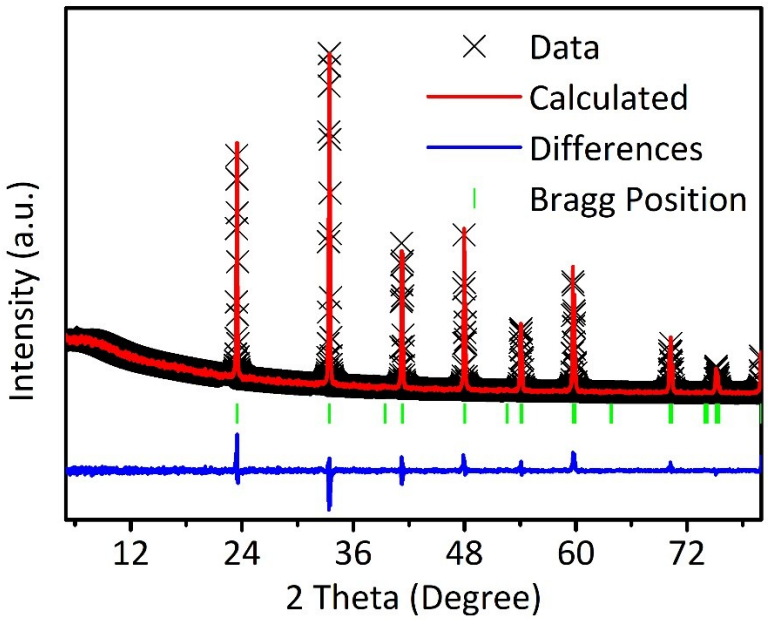


**Fig. S1.** Rietveld refinement patterns LAO:0.001$Mn^{4+}$ phosphor.

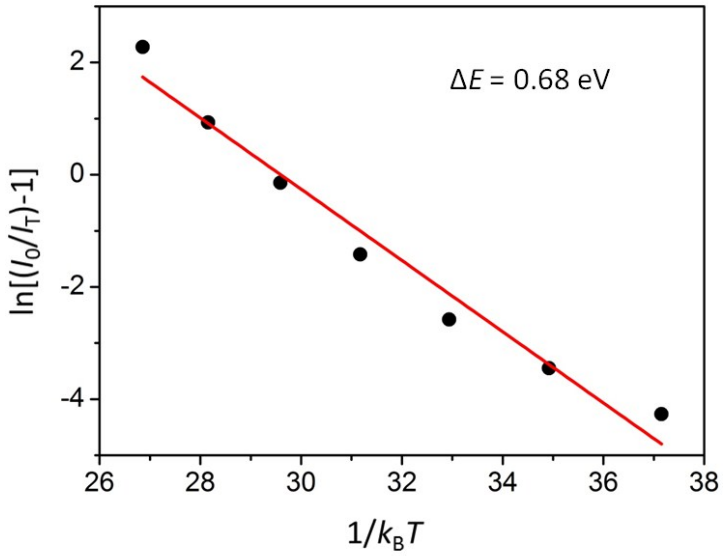


**Fig. S2.** The plotting line of ln[($I_0$/$I_T$)-1] *vs.* 1/$k_B$T for LAO:$Mn^{4+}$,$Mg^{2+}$ phosphor.

The value of Δ*E* is calculated based on a modified Arrhenius equation (S1):

$$I_T = \frac{I_0}{1 + A\exp(-\Delta E / k_B T)} \qquad \text{(S1)}$$

in which $I_0$ is the initial PL intensity at room temperature; $I_T$ is the PL intensity at a given temperature *T*; Δ*E* is the activation energy; $k_B$ and *A* refer to Boltzmann constant (8.617E-5 eV/K) and an absolute constant for a definite host. According to the plots of ln[($I_0$/$I_T$)-1] *vs.* 1/$k_B$*T* for LAO:0.001$Mn^{4+}$,0.001$Mg^{2+}$ phosphor, the value of Δ*E* can be roughly derived from the slope to be 0.68 eV.

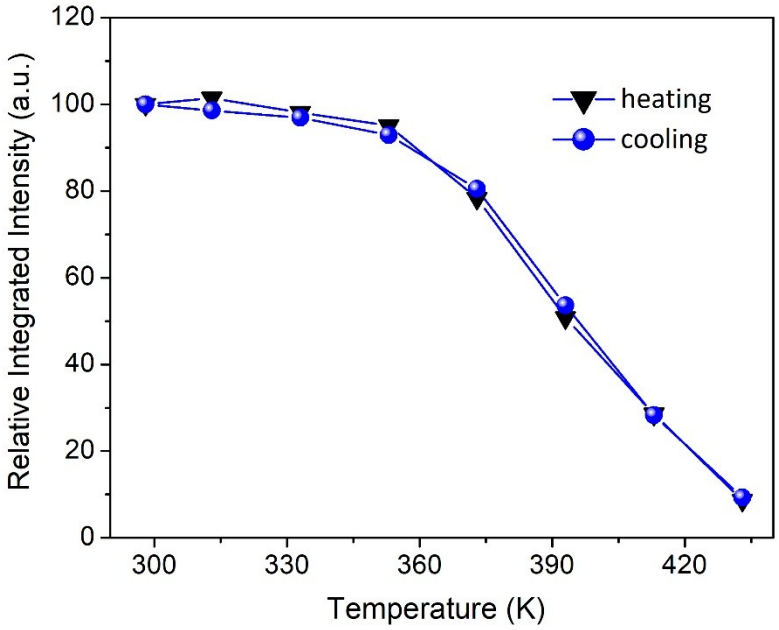


Fig. S3 The PL intensity of the LAO:$Mn^{4+}$,$Mg^{2+}$ phosphor in a heating-and-cooling cycle.

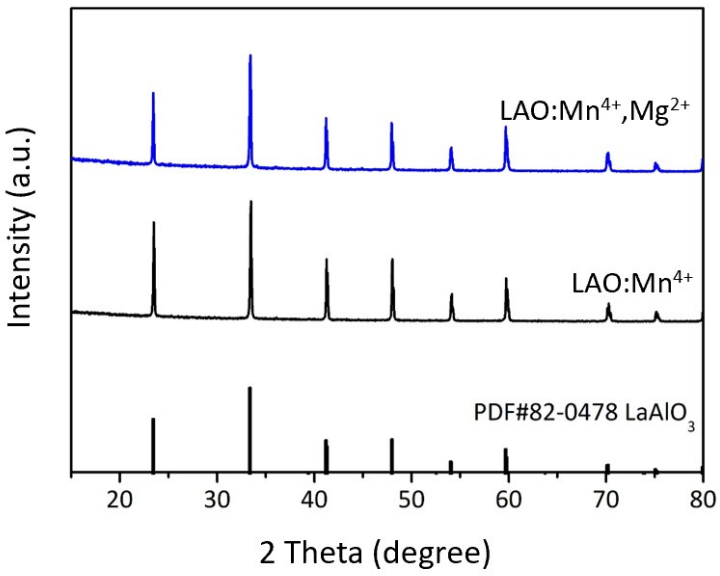


**Fig. S4.** XRD patterns of LAO:$Mn^{4+}$,$Mg^{2+}$ and LAO:$Mn^{4+}$ phosphors.

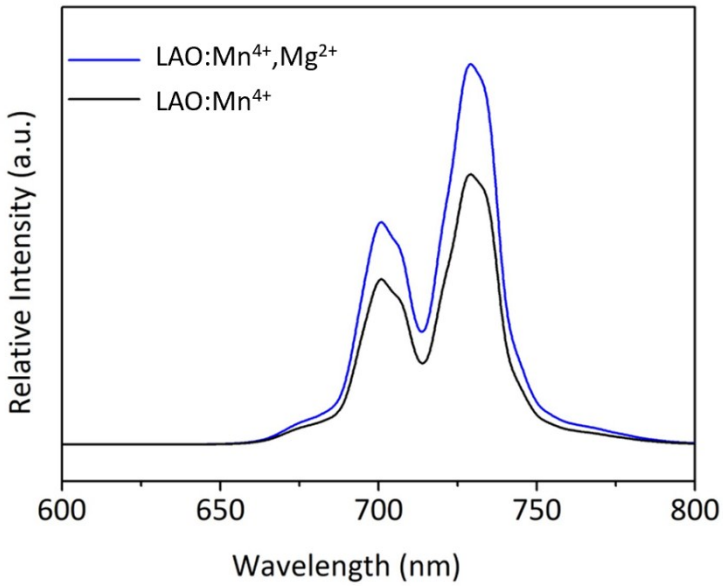


**Fig. S5.** PL spectra of LAO:$Mn^{4+}$,$Mg^{2+}$ and LAO:$Mn^{4+}$ phosphors ($\lambda_{ex}$ = 340 nm).

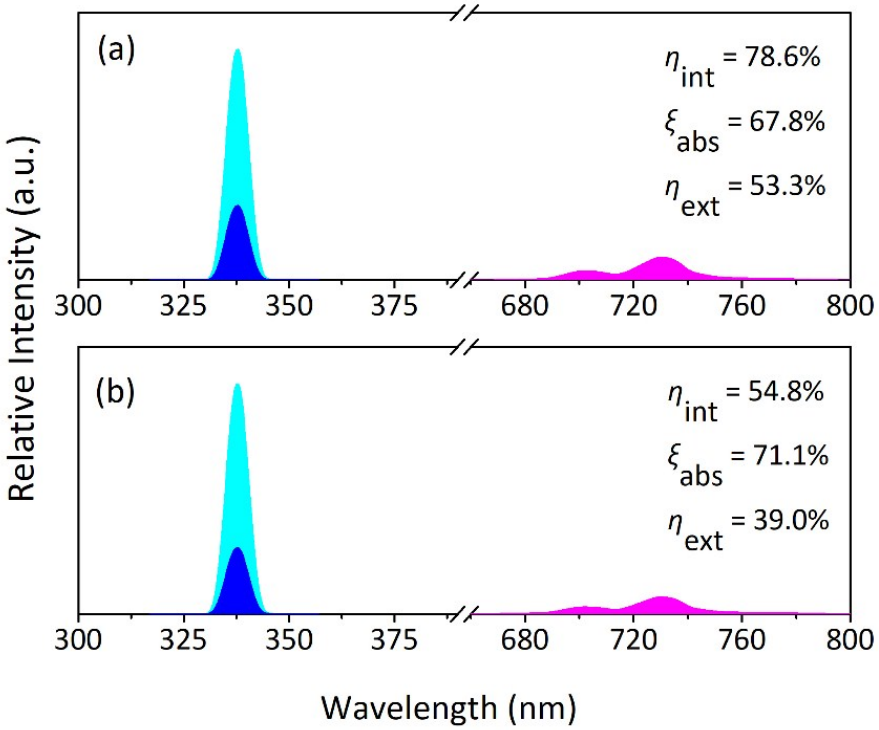


**Fig. S6.** Quantum yields of LAO:$Mn^{4+}$,$Mg^{2+}$ and LAO:$Mn^{4+}$ phosphors ($\lambda_{ex}$ = 340 nm).