

## Electronic Supplementary Information

### **Mn<sup>4+</sup> non-equivalent doped fluoride phosphor towards a short fluorescence decay time for backlighting**

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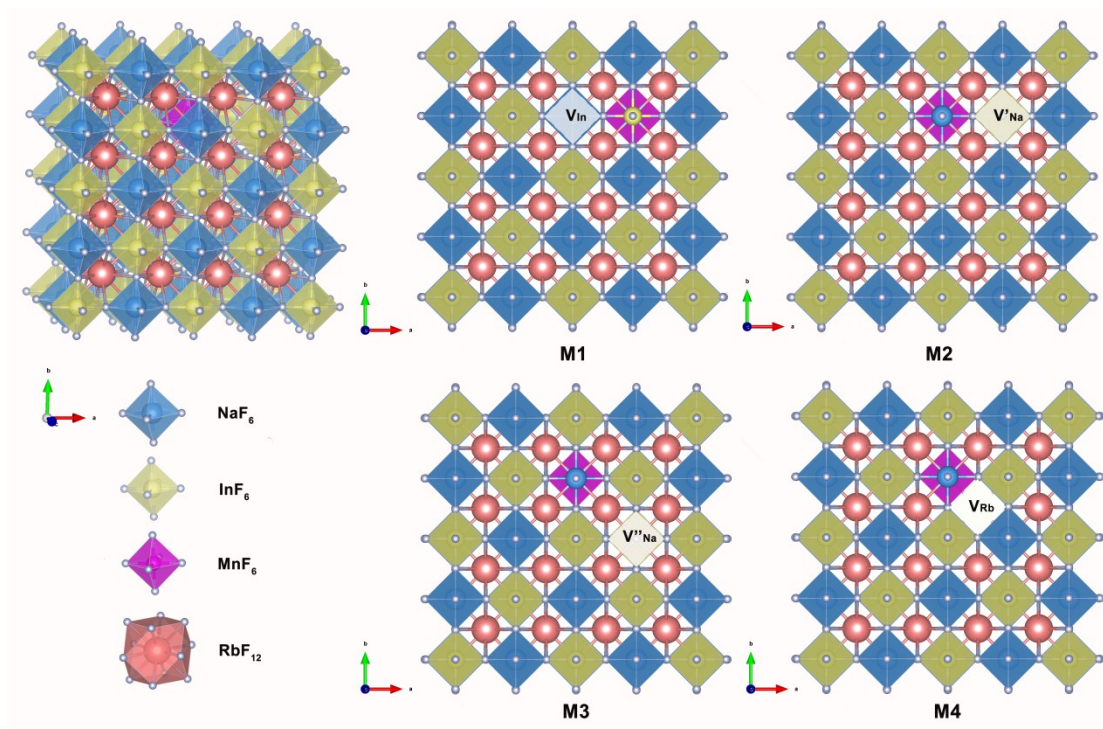
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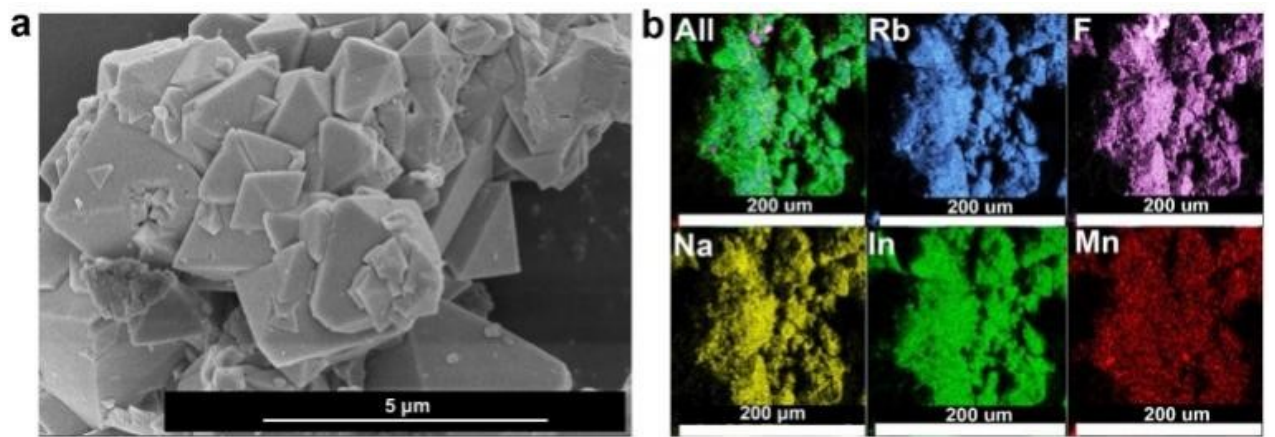
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**Fig. S1** The simulation structure diagram for four possible Mn<sup>4+</sup> substitution models



**Fig. S2** (a) SEM morphology and (b) element mapping of  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$  (5.59 mol%).

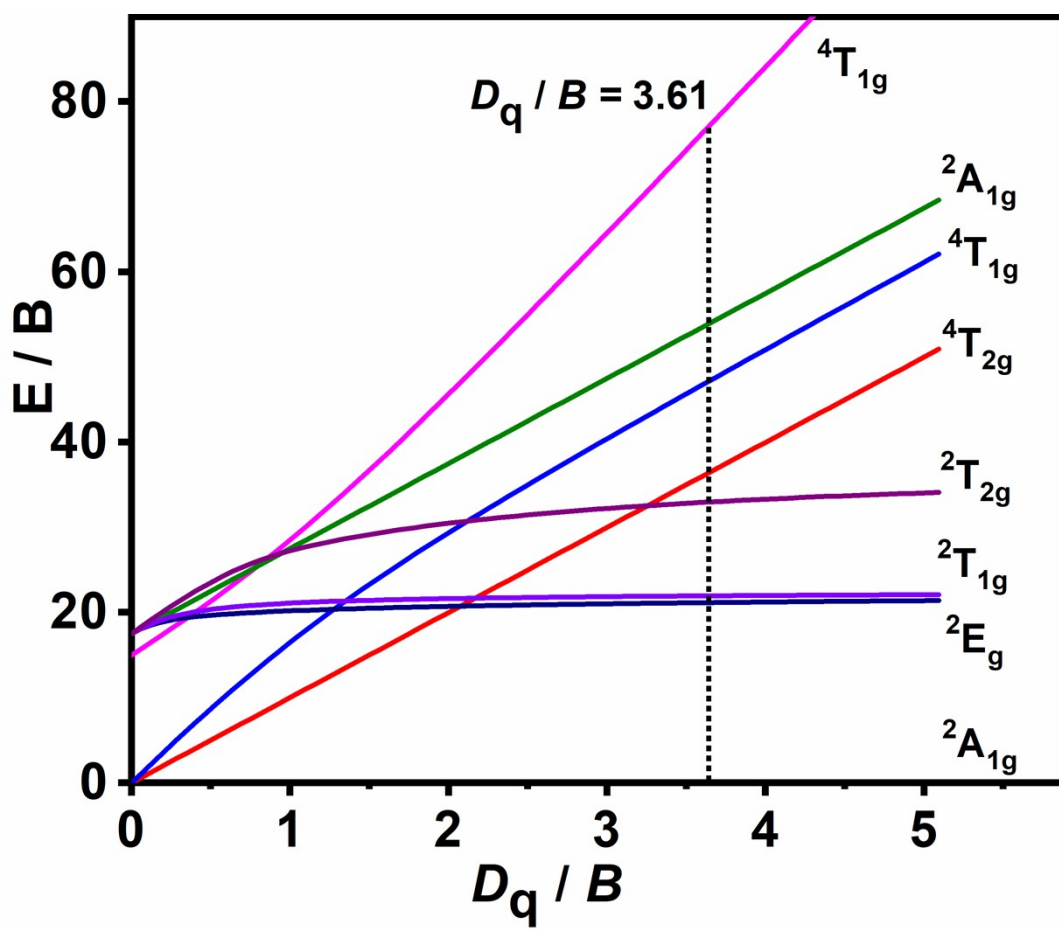
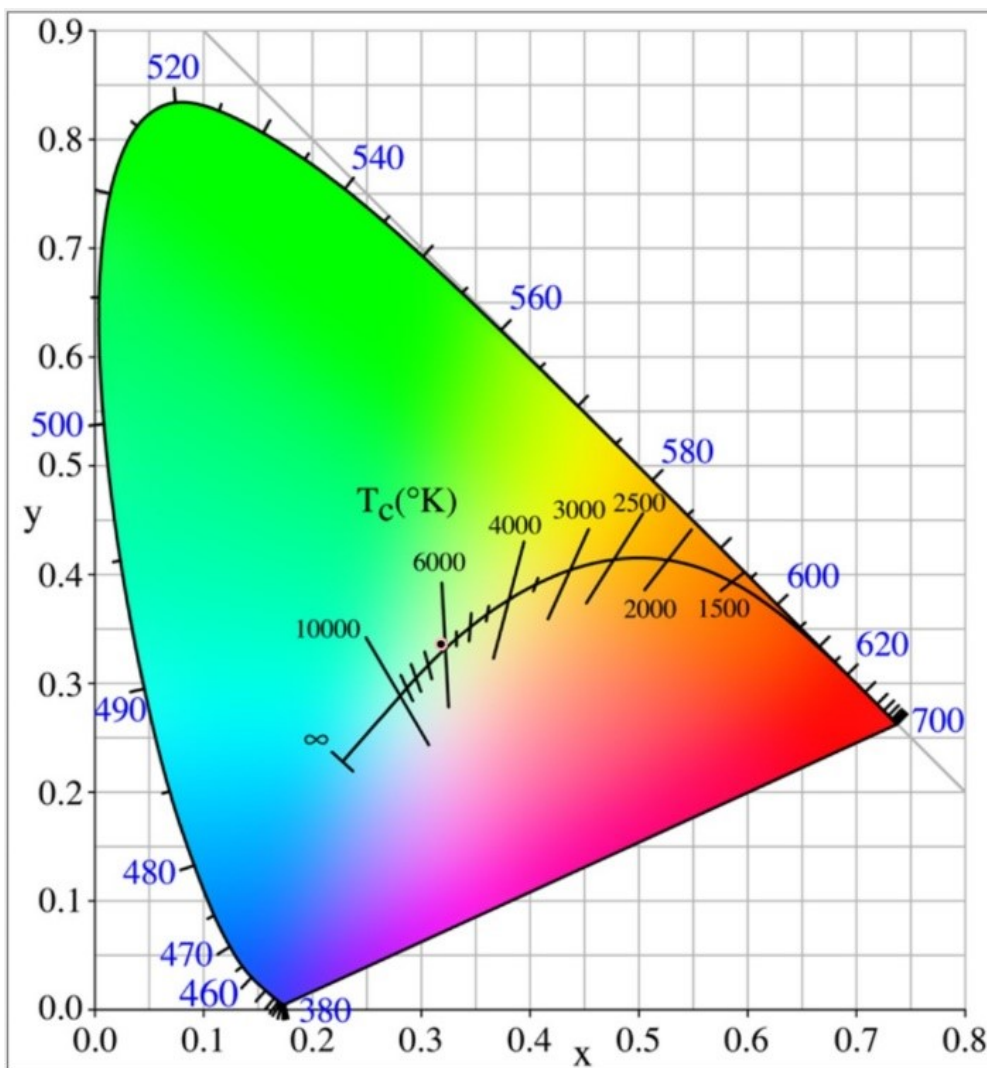


Fig. S3 Tanabe Sugano energy level diagram of  $Mn^{4+}$  in this case.



**Fig. S4** CIE coordinates of white LEDs combined with  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$ ,  $\beta\text{-SiAlON}:\text{Eu}^{2+}$ , and a blue GaN chip.

**Tab. S1** XRF results of  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$ .

No.	Amount of $\text{K}_2\text{MnF}_6$ (mmol)	Doping amount of $\text{Mn}^{4+}$ (mol%)
1	0.05	1.89%
2	0.10	3.62%
3	0.15	5.59%
4	0.20	7.70%
5	0.25	8.99%

**Tab. S2** The unit cell parameters of  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$  phosphor samples after refining in comparison with those of  $\text{Rb}_2\text{NaInF}_6$ .

Formula	$\text{Rb}_2\text{NaInF}_6$	$\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$
Crystal	Cubic	Cubic
Space group	Fm-3m	Fm-3m
$a/\text{\AA}$	8.86060	8.6756(2)
$b/\text{\AA}$	8.86060	8.6756(2)
$c/\text{\AA}$	8.86060	8.6756(2)
$\alpha$	90	90
$\beta$	90	90
$\gamma$	90	90
$V(\text{\AA}^3)$	695.65	652.98(2)
$Z$	4	4
$R_{\text{wp}}$	/	9.62%
$R_{\text{p}}$	/	7.18%
$R_{\text{exp}}$	/	5.37%
$\chi^2$	/	3.21

**Tab. S3** The possible Substitution models for  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$  and the corresponding calculated formation energy.

Model	Host lattice	Substitution forms	Vacancy	Formation energy (eV)
M1	$\text{Rb}_2\text{NaInF}_6$	$\text{Mn}_{\text{Na}}^{\dots}$	$V_{\text{In}}^{\dots}$	14.81
M2	$\text{Rb}_2\text{NaInF}_6$	$\text{Mn}_{\text{In}}^{\cdot}$	$V_{\text{Na}1}^{\cdot}$	9.78
M3	$\text{Rb}_2\text{NaInF}_6$	$\text{Mn}_{\text{In}}^{\cdot}$	$V_{\text{Na}2}^{\cdot}$	10.15
M4	$\text{Rb}_2\text{NaInF}_6$	$\text{Mn}_{\text{In}}^{\cdot}$	$V_{\text{Rb}}^{\cdot}$	10.47



**Tab. S4** Color coordinate offset for  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$  (5.59 mol%) under different temperatures.

Temperature ( $^{\circ}\text{C}$ )	CIE coordinates (x, y)	$\Delta E$
20	0.692, 0.307	/
40	0.691, 0.309	0.0042
60	0.689, 0.310	0.0084
80	0.688, 0.312	0.0125
100	0.686, 0.313	0.0166
120	0.684, 0.316	0.0234
140	0.682, 0.318	0.0287
160	0.678, 0.321	0.0381
180	0.675, 0.325	0.0471
200	0.672, 0.328	0.0547

**Tab. S5** EQE, IQE values of  $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$  with different contents of  $\text{Mn}^{4+}$ .

Content of $\text{Mn}^{4+}$ (mol%)	EQE (%)	IQE (%)
1.89	19.4	79.9
3.62	28.8	70.4
5.59	37.5	68.8
7.70	30.4	66.4
8.99	26.2	51.3

**Tab. S6** Photoelectric parameters of the as-fabricated w-LED under different currents.

Phosphor	Current	LE	CIE		Tc	NTSC
		lm/W	x	y	(K)	(%)
$\beta$ -SiALON + $\text{Rb}_2\text{NaInF}_6:\text{Mn}^{4+}$ (5.59%)	20	30.5	0.3137	0.3341	6418	93.5
	40	27.6	0.3096	0.3332	6641	93.3
	60	24.2	0.3055	0.3310	6886	93.1
	80	23.9	0.3019	0.3290	7110	93.1
	100	23.0	0.2989	0.3268	7321	92.8
	120	21.5	0.2960	0.3246	7536	92.5
	140	20.9	0.2940	0.3237	7678	92.5
	160	19.8	0.2903	0.3169	8019	91.8
	180	18.0	0.2887	0.3236	8034	92.7
	200	19.0	0.2891	0.3224	8036	92.1
	220	17.9	0.2847	0.3199	8414	91.7
	240	16.5	0.2834	0.3133	8689	90.8
	260	16.0	0.2824	0.3142	8738	90.7
	280	15.5	0.2821	0.3157	8710	90.6
300	15.2	0.2816	0.3184	8670	91.1	