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Electronic Supporting Information

A novel ultra-high temperature zero-thermal quenching plant-protected type blue-green dual-emission $KAl_{11}O_{17}:Eu^{2+}$, Mn^{2+} phosphors for urban ecological lighting

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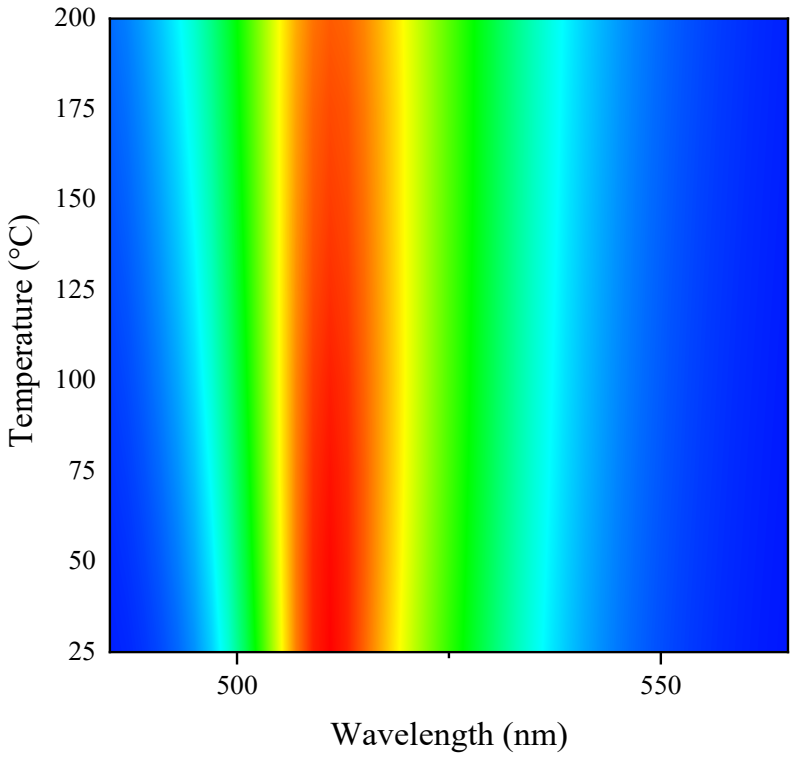

Fig.S1 Temperature dependence of $KAl_{11}O_{17}$:0.24Mn^{2+} phosphors.

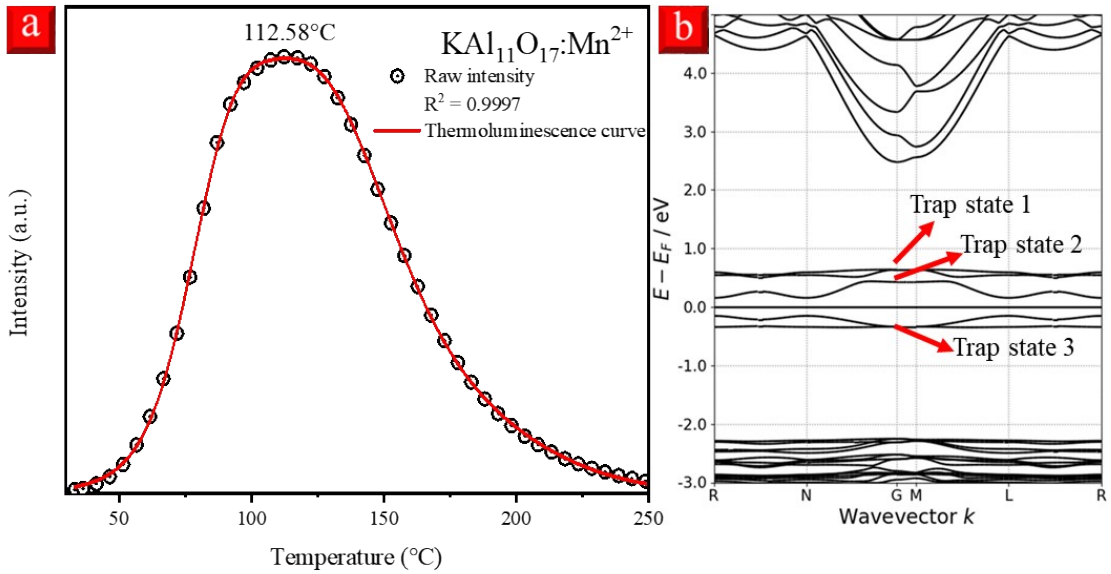

Fig.S2 (a) Thermoluminescence curves of $KAl_{11}O_{17}:0.24Mn^{2+}$ phosphors; (b) electronic band structure near the Femi energy level for $KAl_{11}O_{17}:0.24Mn^{2+}$.

Table S1 Comparison of quantum efficiency between this work and some reported blue-green dual-emission phosphors.

Phosphor composition	IQE (%)	EQE (%)	Ref.
$Mg_3Ca_3(PO_4)_4:Eu^{2+},Mn^{2+}$	83	---	1
$NaBa_{1-x}Sr_xB_9O_{15}:Ce^{3+}, Mn^{2+}$	---	45.8	2
$Sr_5MgLa_2(BO_3)_6:Ce^{3+},Mn^{2+}$	---	53	3
$gama\text{-}AlON:xCe^{3+},yMn^{2+}$	60.2	49.8	4
$Ca_2GdHf_2Al_3O_{12}:Ce^{3+},Tb^{3+}$	82.7	60.6	5
$NaBaBO_3:Ce^{3+},Tb^{3+}$	57	37	6
$Ba_3Y(PO_4)_3:Eu^{2+},Mn^{2+}$	23	---	7
$KSrLu(PO4)_2:Ce^{3+},Tb^{3+},Mn^{2+}$	61	55	8
$Ca_2LuHf_2Al_3O_{12}:Ce^{3+},Tb^{3+}$	77.1	55.8	9
$BaAl_{11}O_{16}N:Eu^{2+}, Mn^{2+}$	41.5	---	10
$KAl_{11}O_{17}:Mn^{2+}, Eu^{2+}$	84.18	56.86	This work

Table S2 Comparison of zero-TQ performance between these work and other advanced phosphors.

Phosphor composition	Ex (nm)	Em (nm)	zero-TQ* (%)	Optimal temperature (℃)	Ref.
$Na_{3-2x}Sc_2(PO_4)_3:Eu^{2+}$	370	453	100	250	11
$K_2BaCa(PO_4)_2:Eu^{2+}$	350	460	100	275	12
$BaMgSi_4O_{10}:Eu^{2+}$	360	464	100	227	13
β-$Ca_2P_2O_7:Bi^{2+}$	250	680	100	227	14
$Cs_2MP_2O_7:Eu^{2+}$	360	548	120	175	15
$Mg_3Y_2Ge_3O_{12}$: Eu^{3+},Mn^{4+}	420	660	120	250	16
$Sr_3SiO_5:Eu^{2+}$	468	573	100	120	17
$Sr_8ZnSc(PO_4)_7:Tb^{3+}$	370	546	100	225	18
$Sr_4Gd_3Na_3(PO_4)_6F_2:Tb^{3+}$	277	546	100	300	19
$Ca_2InSbO_6:Sm^{3+}$	407	600	100	200	20
$BaMgP_2O_7:Eu^{2+}$,Mn^{2+}	300	620	100	227	21
$CsMoO_2F_3:Mn^{4+}$	450	633	129	150	22
$Li_2CaSi_2N_4:Ce^{3+}$	431	507	100	200	23
$LaAlO_3:Mn^{4+}$	340	734	103	150	24
$LaSc_3(BO_3)_4:Eu^{3+}$	280	617	102	275	25
$Ba_2ZnGe_2O_7:Bi^{3+}$	320	500	114	150	26
$KAl_{11}O_{17}:Eu^{2+}$	365	450	162.16	300	This work
$KAl_{11}O_{17}:Eu^{2+}$,Mn^{2+}	365	450,510	120.97	150	This work

*The zero-TQ refers to the retention rate of luminescence intensity at optimal temperature relative to normal temperature.

Table S3 The defect formation energies of $KAl_{11}O_{17}:Mn^{2+}$, $KAl_{11}O_{17}:Eu^{2+}$ and $KAl_{11}O_{17}:Eu^{2+}$, Mn^{2+} phosphor calculated by using the DFT-PBE method.

Trap Types	***E* (eV)**	***E*-E_f (eV)**
$KAl_{11}O_{17}:Mn^{2+}$ sample	**E_f* = 5.71 eV**	
Trap state 1	6.34	0.63
Trap state 2	6.13	0.42
Trap state 3	5.37	-0.34
$KAl_{11}O_{17}:Eu^{2+}$ sample	**E_f = 8.14 eV**	
Trap state 1	8.19	0.05
Trap state 2	7.90	-0.24
Trap state 3	7.20	-0.94
$KAl_{11}O_{17}:Eu^{2+}$, Mn^{2+} sample	**E_f = 6.52 eV**	
Trap state 1	6.68	0.16
Trap state 2	6.47	-0.05
Trap state 3	6.28	-0.24
Trap state 4	5.81	-0.71

* E_f: Fermi level

Table S4 The pc-LED made by "$KAl_{11}O_{17}:Mn^{2+}$, Eu^{2+} + $K_2TiF_6:Mn^{4+}$" and data under different current conditions.

Current(mA)	CIE *x*	CIE *y*	CCT(K)
20	0.2972	0.3370	7276
60	0.2980	0.3355	7252
100	0.3128	0.3383	6432
140	0.3239	0.3361	5897
180	0.3240	0.3361	5895
220	0.3239	0.3264	5927

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