

# Electronic Supplementary Information (ESI)

## Fabrication and application of non-rare earth red phosphors for warm white-light-emitting diodes

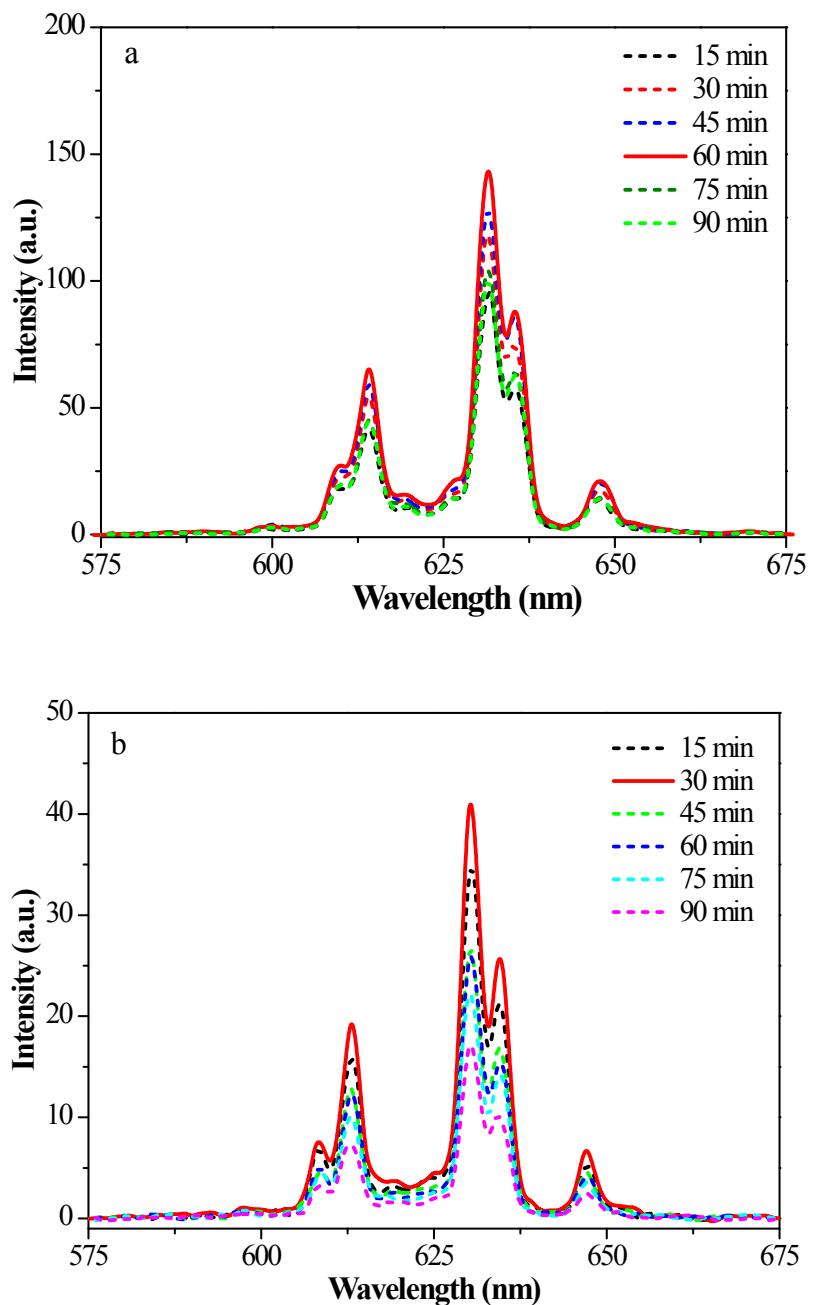
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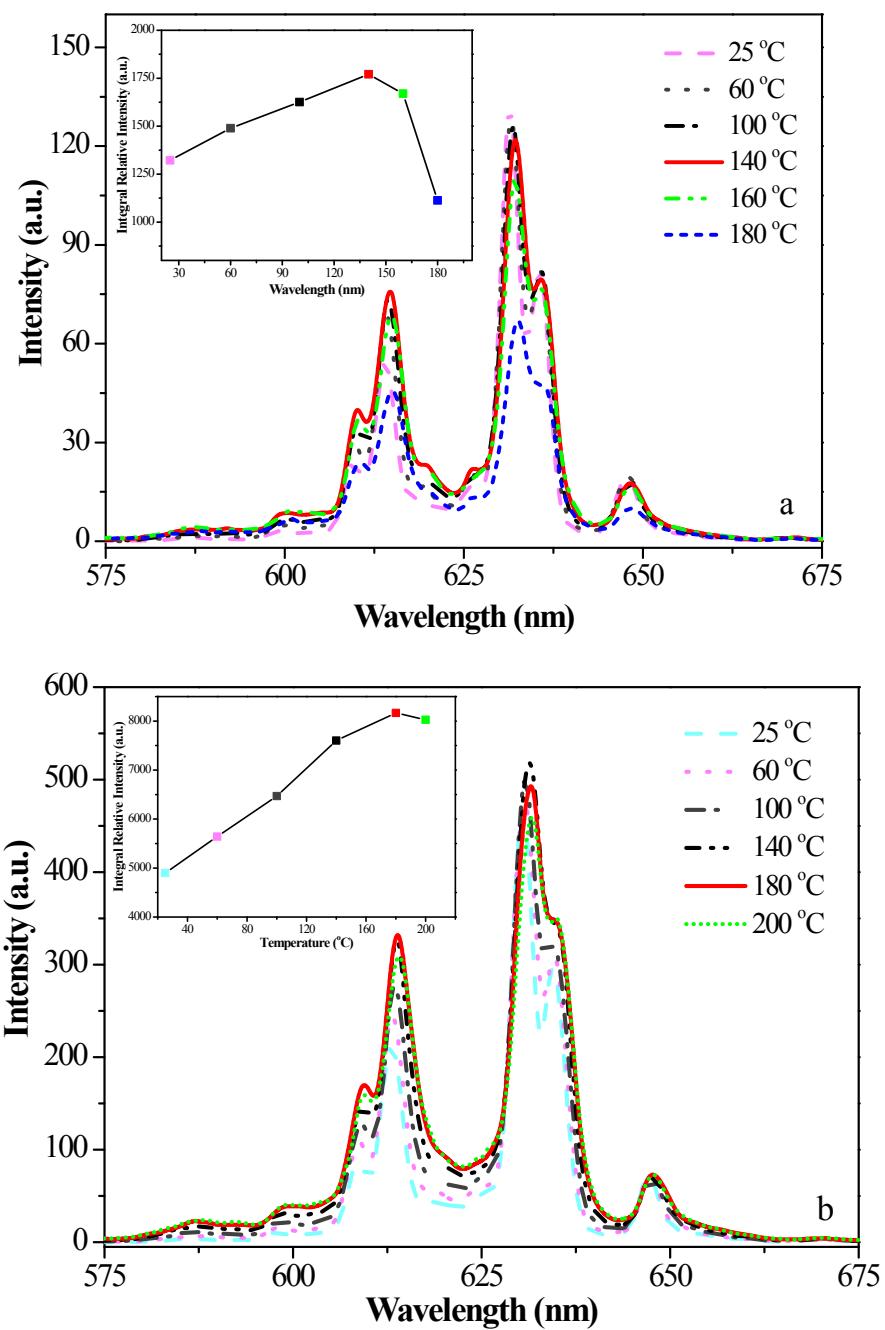
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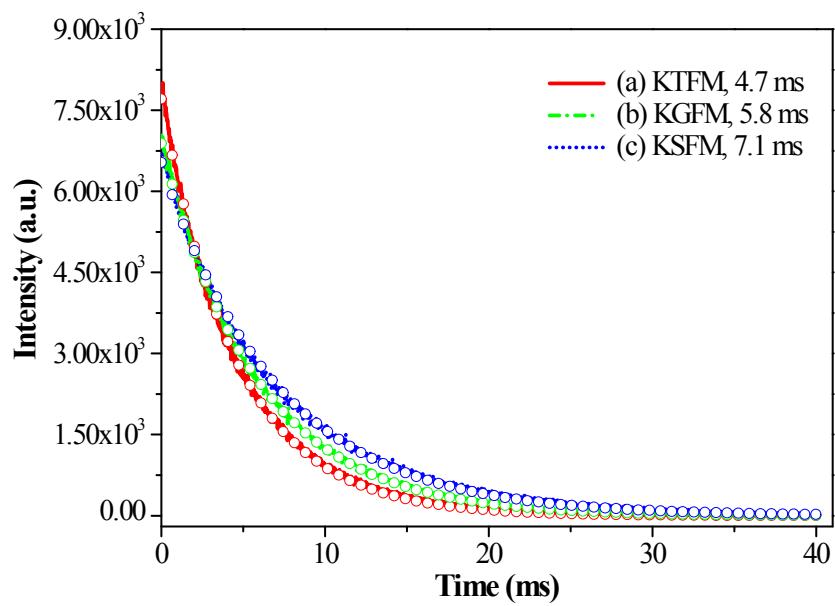
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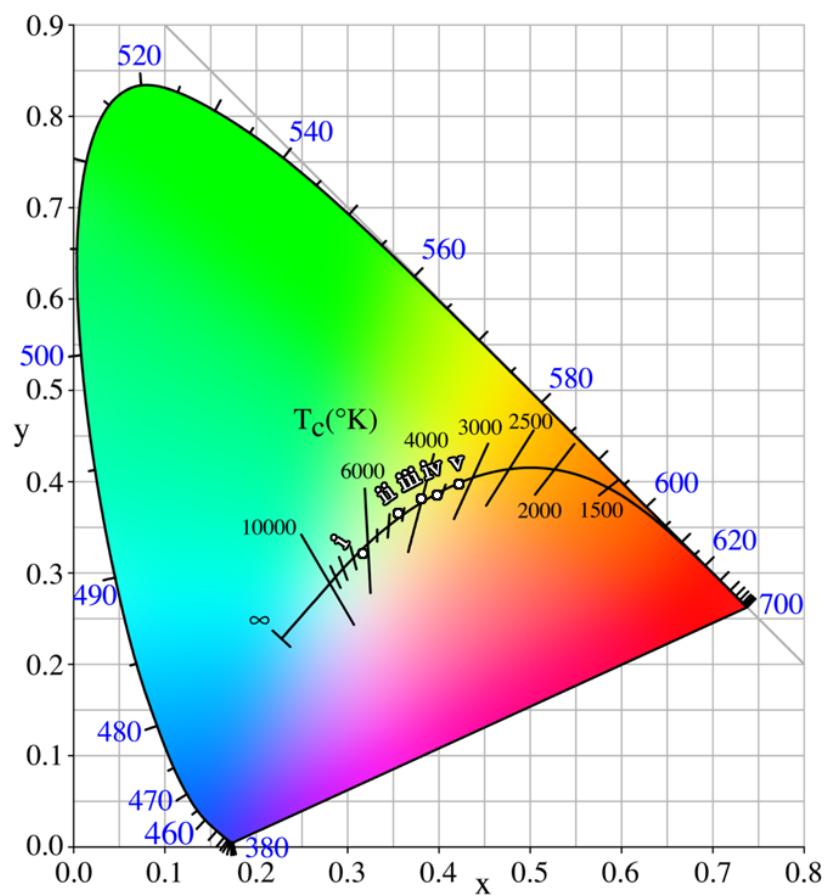
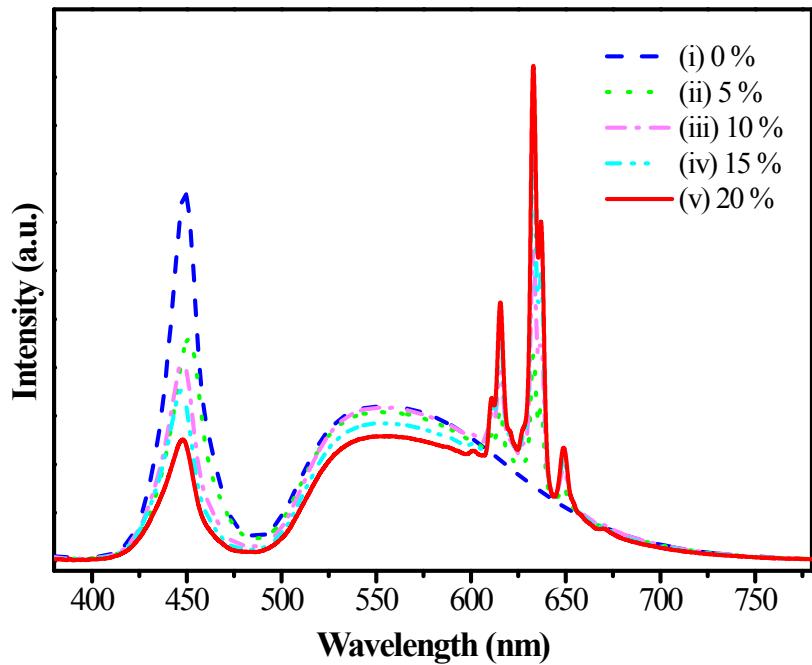
**Figure S1:** The emission spectra of (a) KGFM and (b) KSFM red phosphors obtained from 40% HF with different reaction periods at room temperature.



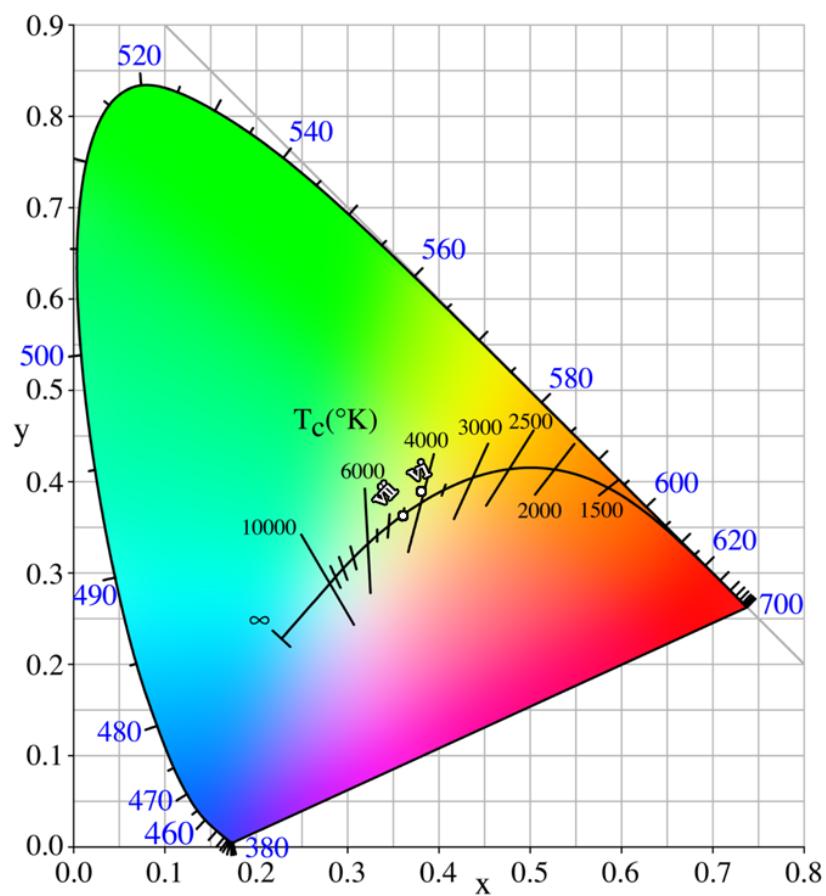
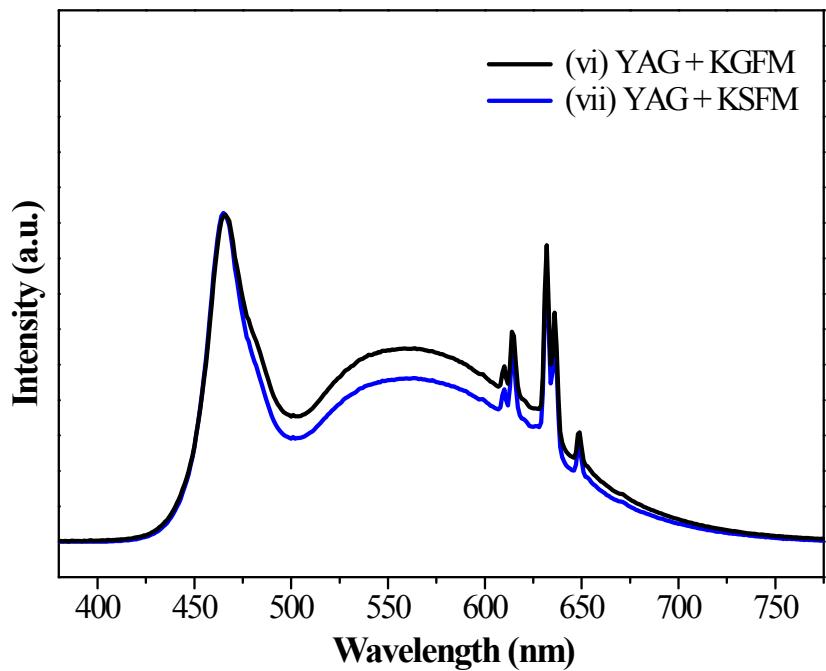
**Figure S2.** Temperature-dependent thermal luminescent spectra of (a) KGFM and (b) KSFM red phosphors and (b) the relationship between integral relative intensity and temperature.



**Figure S3.** Decay curves of the (a) KTFM, (b) KGFM and (c) KSFM red phosphors examined at room temperature. The monitoring wavelength is at 631 nm with a 460 nm light excitation.



**Figure S4:** EL spectra and CIE chromaticity diagram for the YAG-KTFM type WLEDs with different amount of KTFM in phosphor mixture: (i-v) 0, 5 %, 10 %, 15 %, 20 %.



**Figure S5:** EL spectra and CIE chromaticity diagram for WLEDs fabricated with the existence of  $\text{K}_2\text{GeF}_6:\text{Mn}^{4+}$  and  $\text{K}_2\text{SiF}_6:\text{Mn}^{4+}$  phosphors respectively.

**Table S1.** AAS results of  $\text{K}_2\text{TiF}_6:\text{Mn}^{4+}$  red phosphors prepared for different reaction times.

Samples	Reaction time (min)	Molar ratio of $\text{Mn}^{4+}$ (mol %)
1	5	3.16
2	10	4.06
3	15	4.90
4	20	5.22
5	30	5.43

**Table S2:** Performance of the GaN-based WLEDs coated with: (i) YAG, (ii-v) YAG-KTFM, (vi) YAG-KGFM and (vii) YAG-KSFM at 20 mA forward current.

Devices	CT(K)	CRI	Luminous Efficiency (lm/W)	CIE ( $x, y$ )
i	6315	72.8	157.3	(0.317, 0.321)
ii	4668	76.5	152.8	(0.356, 0.365)
iii	4025	77.1	148.1	(0.381, 0.382)
iv	3589	81.5	143.6	(0.399, 0.386)
v	3156	84.9	138.4	(0.423, 0.397)
vi	4042	79.8	130.1	(0.382, 0.389)
vii	4470	78.7	129.3	(0.362, 0.363)