Electronic Supplementary Information

Hydrothermal synthesis and photoluminescence properties of red phosphor $BaSiF_6:Mn^{4+}$ for LED applications

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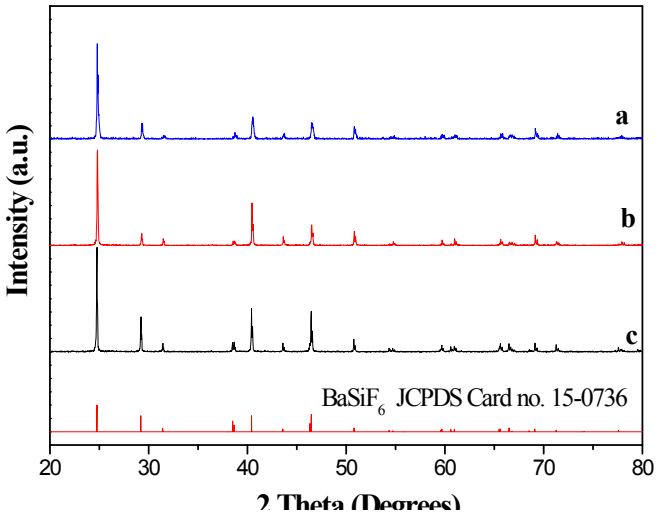

Figure S1. XRD patterns of the as-synthesized $BaSiF_6$ from starting materials $Ba(NO_3)_2$, $Mn(Ac)_2$ and (a) $(NH_4)_2SiF_6$, (b) K_2SiF_6, and (c) $NaSiF_6$ by a hydrothermal method at 120 °C for 12 h.

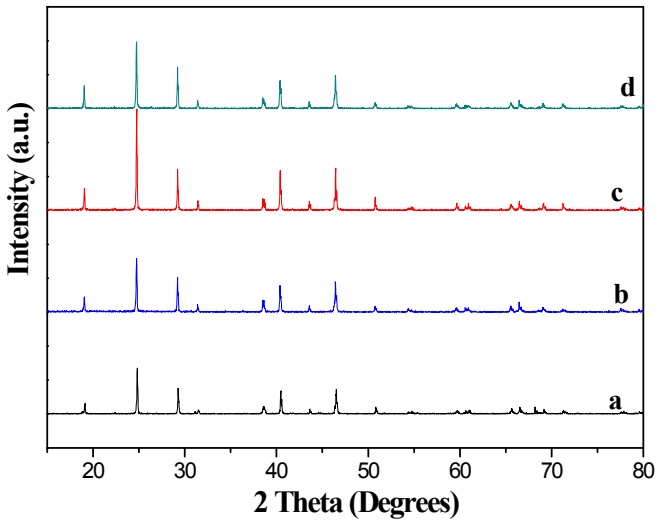

Figure S2. XRD patterns of the as-synthesized red phosphor $BaSiF_6:Mn^{4+}$ obtained from the hydrothermal system with concentration of $KMnO_4$ at (a) 0.5, (b) 2.0, (c) 5.0, (d) 8.0 mmol/L at 120 °C for 12 h.

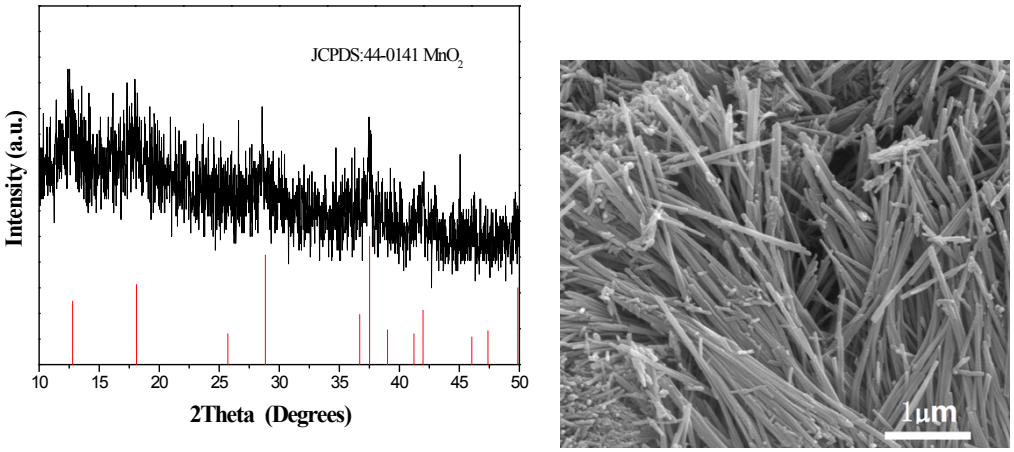

Figure S3. XRD pattern and SEM image of the brown solid sample synthesized from $KMnO_4$ (10.1 mol/L) and HF (wt.10%) in hydrothermal reaction at 120 °C for 12 h.

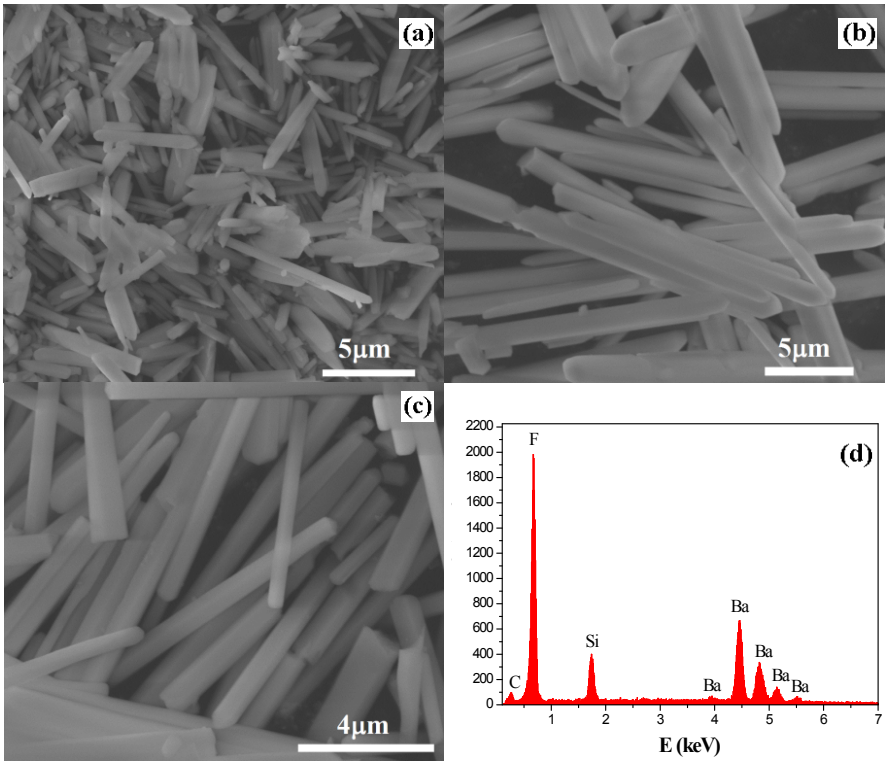

Figure S4. SEM patterns of the as-synthesized $BaSiF_6$ from starting materials $Ba(NO_3)_2$, $Mn(Ac)_2$, and (a) $NaSiF_6$, (b) K_2SiF_6, (c) $(NH_4)_2SiF_6$ by a hydrothermal method at 120 ^oC for 12 h; (d) the corresponding EDS of products synthesized from $Ba(NO_3)_2$, $Mn(Ac)_2$ and $(NH_4)_2SiF$.

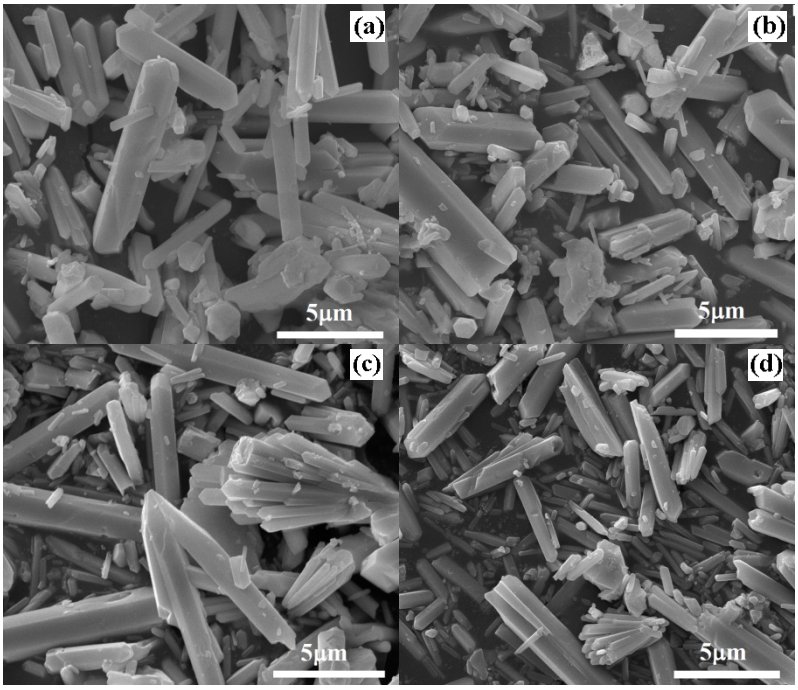

Figure S5. SEM patterns of the as-synthesized red phosphors $BaSiF_6:Mn^{4+}$ obtained from hydrothermal systems with concentrations of HF at (a) wt. 6%, (b) wt. 8%, (c) wt. 10%, (d) wt.12%.

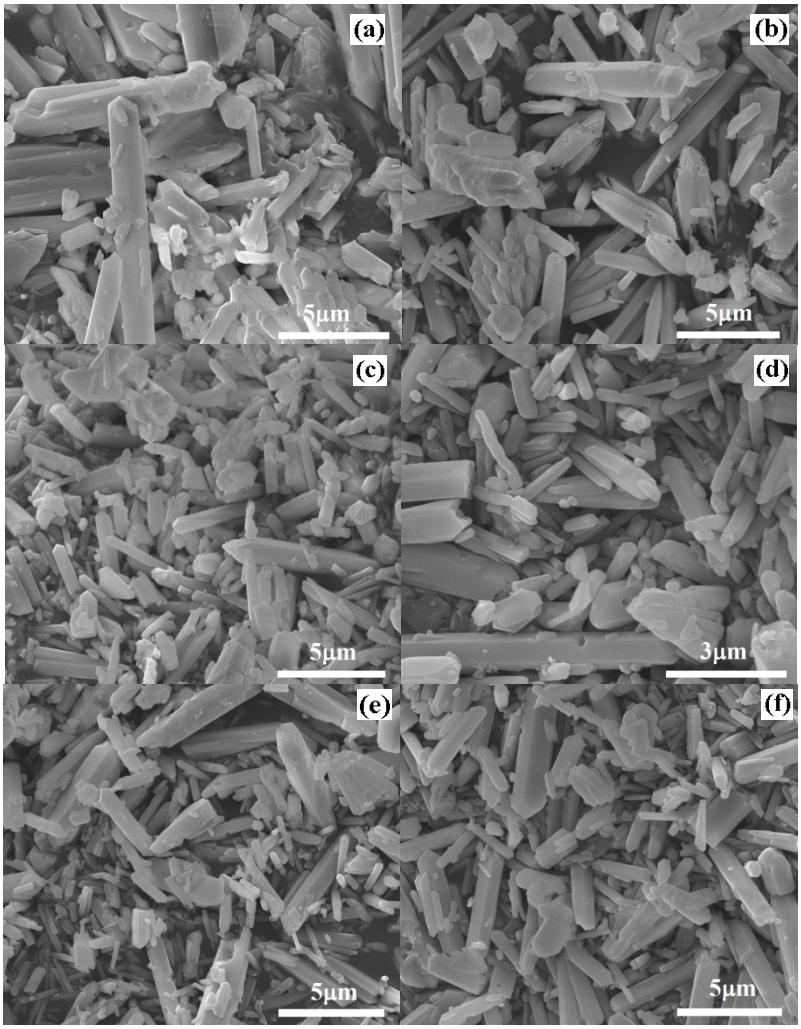

Figure S6. SEM patterns of the as-synthesized red phosphors $BaSiF_6:Mn^{4+}$ obtained from hydrothermal systems at 120 ^oC for (a) 4 h, (b) 8 h, (c) 12 h, (d) 16 h, (e) 20 h, (f) 24 h.

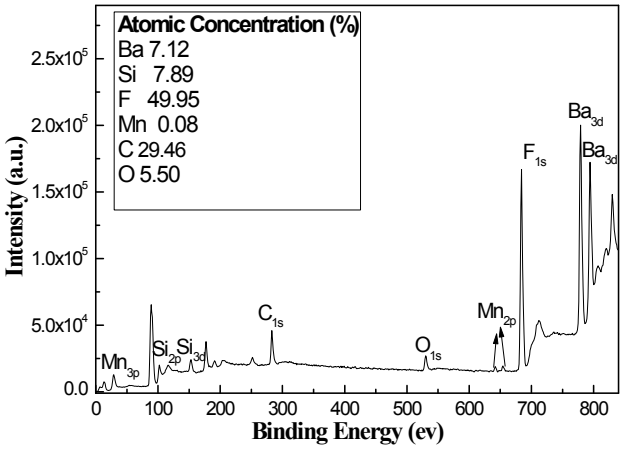

Figure S7. XPS spectrum of phosphor $BaSiF_6:Mn^{4+}$.

X-ray photoelectron spectrum (XPS) was acquired with an AXIS ULTRA DLD (Kratos, Japan) equipped with a hemispherical electron analyzer and a 450 W monochromated Al Kα X-ray source. All binding energies were referenced to the C_{1s} spectrum at 285.8 eV, which provided binding energy values with an accuracy of 70.2 eV. Element C in the spectrum is from the grids. The signal of O may be originated from O_2 or H_2O attached on the crystal surface.

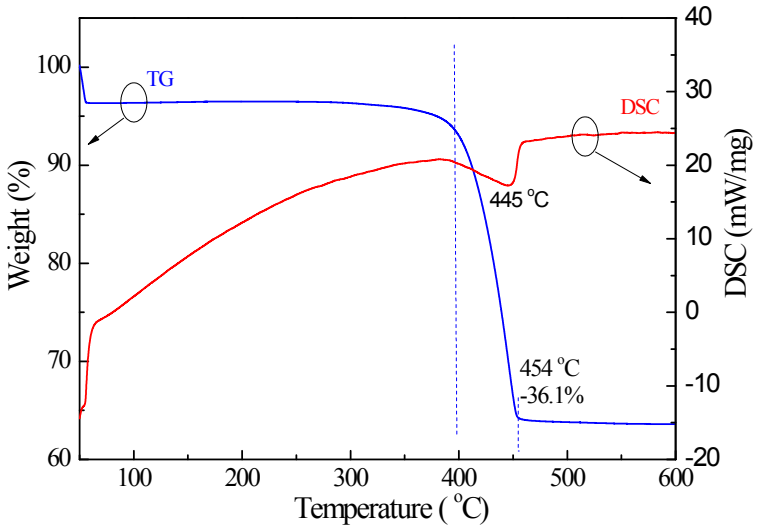

Figure S8. Thermogravimetrics (TG) and different scanning calorimeter (DSC) graphs of as synthesized $BaSiF_6:Mn^{4+}$ under N_2 atmosphere.

The thermal stability the red phosphor behavior of $BaSiF_6:Mn^{4+}$ were investigated by thermogravimetric (TG) analysis and different scanning calorimeter (DSC) on Netzsch STA 449C, at a heating rate of 10 K/min) under N_2 atmosphere.

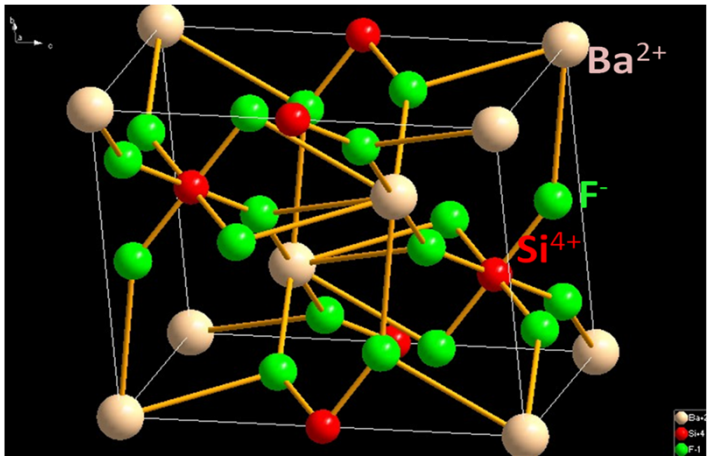

Figure S9. The structure projection of $BaSiF_6$ plotted by software Diamond 3.1.

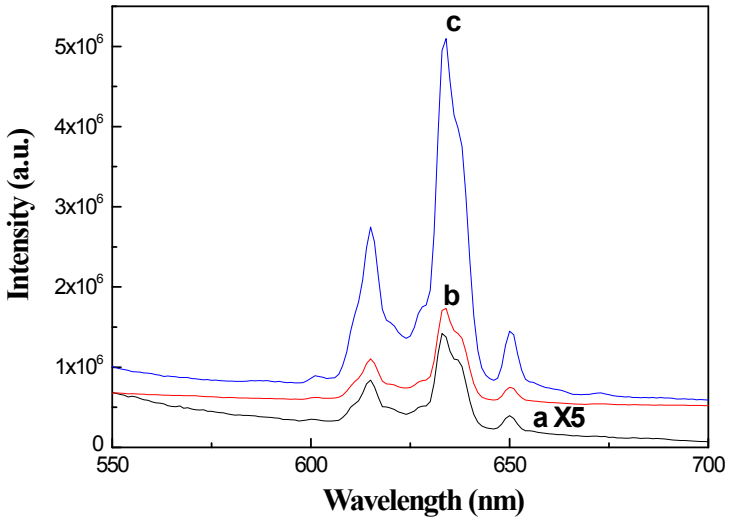

Figure S10. Emission spectra of red phosphor $BaSiF_6:Mn^{4+}$ excited at (a) 250 nm, (b) 365 nm and (c) 466 nm.

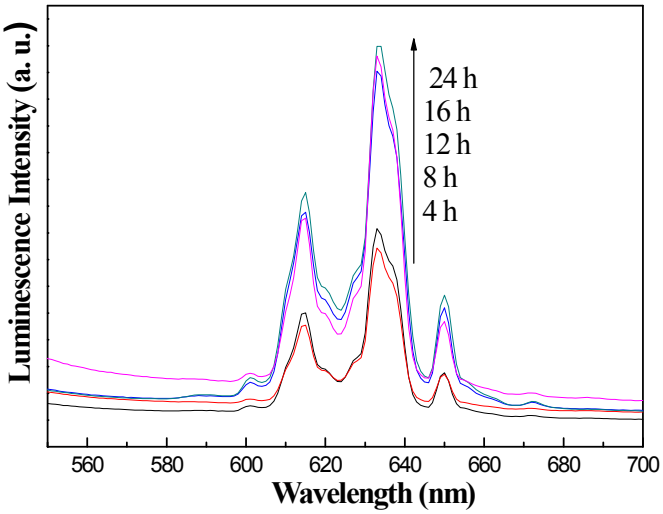

Figure S11. Emission spectra of red phosphor $BaSiF_6:Mn^{4+}$ obtained from the hydrothermal system for various reaction time.

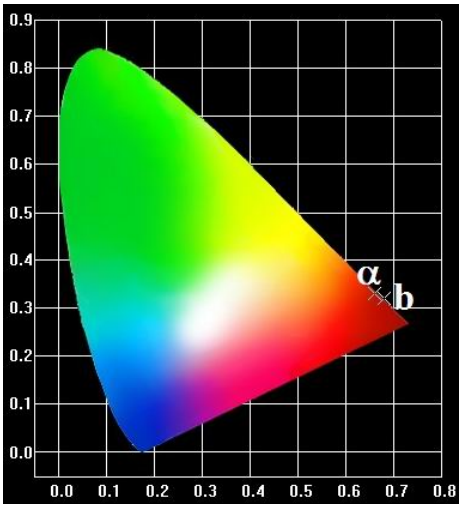

Figure S12. Commission International de L'Eclairage (CIE) chromaticity diagram for (a) $BaSiF_6:Mn^{4+}$ and (b) National Television Standards Committee (NTSC) "ideal red".

Table S1 The performance parameters of the white LEDs (WLED): (a) fabricated with InGaN chip and yellow phosphor YAG:Ce; and (b) fabricated with InGaN chip, yellow phosphor YAG:Ce, and red phosphor.

WLED	Efficiency (lm/W)	Color temperature (K)	Color Rendering index	Images
(a)	115	6506	68.2	
(b)	112	3931	82.1