Supporting Information

Co-precipitation synthesis and photoluminescence properties of 
\( \text{BaTiF}_6: \text{Mn}^{4+} \): an efficient red phosphor for warm white LEDs

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Synthesis of \( \text{BaTiF}_6: \text{Mn}^{4+} \)

The red phosphor \( \text{BaTi}_{0.97}\text{F}_6:0.03\text{Mn}^{4+} \) samples were synthesized through a hydrothermal route. The specific process is as follows: firstly, 2.5 mmol of \( \text{TiO}_2 \), 2.5 mmol of \( \text{BaF}_2 \) and 0.075 mmol of \( \text{K}_2\text{MnF}_6 \) were added into a solution containing 5 mL of HF (40% wt). secondly, the mixed solution was stirred for 10 min and then transferred into an 10 mL of Teflon lined autoclave. The autoclave was maintained at 120 °C for 15 h. As the autoclave was cooled to room temperature naturally, the final products were washed three times with ethanol. At last, the product was dried at 80 °C for 2 h.

![Fig. S1](Image)

**Fig. S1.** (a) XRD pattern of the red phosphors \( \text{BaTi}_{0.97}\text{F}_6:0.03\text{Mn}^{4+} \) by hydrothermal method at 150 °C for 12 h and (b) PL (\( \lambda_{\text{ex}} = 460 \) nm) spectra of the red phosphors \( \text{BaTi}_{0.97}\text{F}_6:0.03\text{Mn}^{4+} \) by hydrothermal method (black line) and coprecipitation method (red line).
Fig. S2 Spectrum of the excitation light without the BaTi$_{0.97}$F$_{6}$:0.03Mn$^{4+}$ sample ($E_R$), spectrum of the light used for exciting the BaTi$_{0.97}$F$_{6}$:0.03Mn$^{4+}$ sample ($E_S$), luminescence emission spectrum of the BaTi$_{0.97}$F$_{6}$:0.03Mn$^{4+}$ sample ($L_S$), and the inset shows a magnification of the emission spectrum.

Note: QE is defined as the ratio of the number of emitted photons ($I_{em}$) to the number of absorbed photons ($I_{abs}$), and can be calculated by the following equation:

$$IQE = \frac{I_{em}}{I_{abs}} = \frac{\int L_S}{\int E_R - \int E_S}$$

where $E_R$ is the spectrum of the excitation light without the sample in the sphere, $E_S$ is the spectrum of the light used for exciting the sample, and $L_S$ is the luminescence emission spectrum of the sample.

Fig. S3 The temperature-dependent PL intensity of the as-synthesized BaTi$_{0.97}$F$_{6}$:0.03Mn$^{4+}$ in the wavelength ranges of 605–623 nm ($I_a$), and 623–655 nm ($I_s$).