Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
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Synthesis and warm-white LED applications of efficient narrow-band red emitting phosphor $Rb_2ZrF_6:Mn^{4+}$

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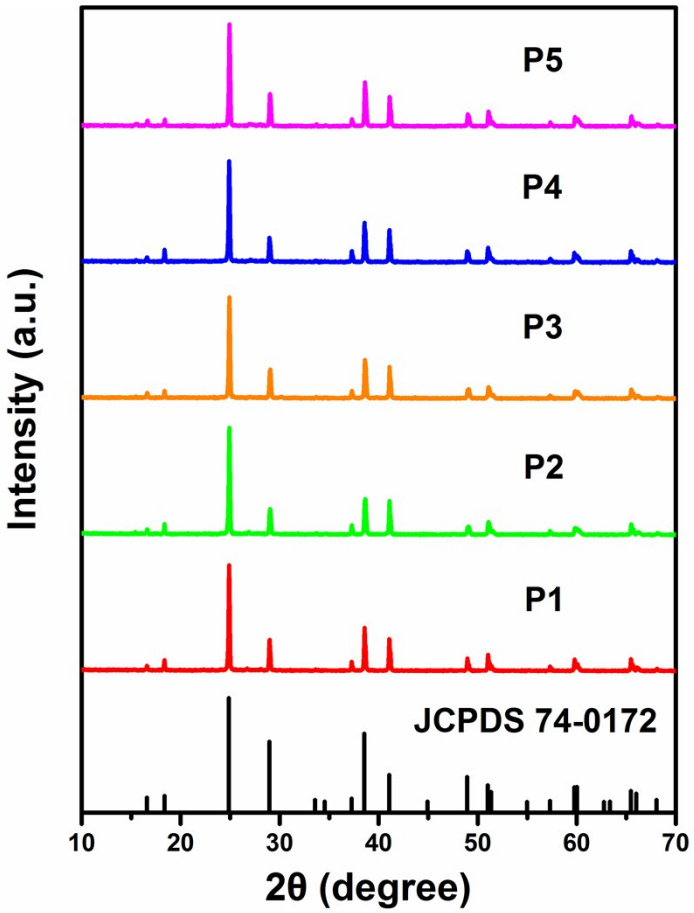

Fig. S1. XRD patterns of $Rb_2ZrF_6:Mn^{4+}$ phosphors doped with different Mn^{4+} concentration.

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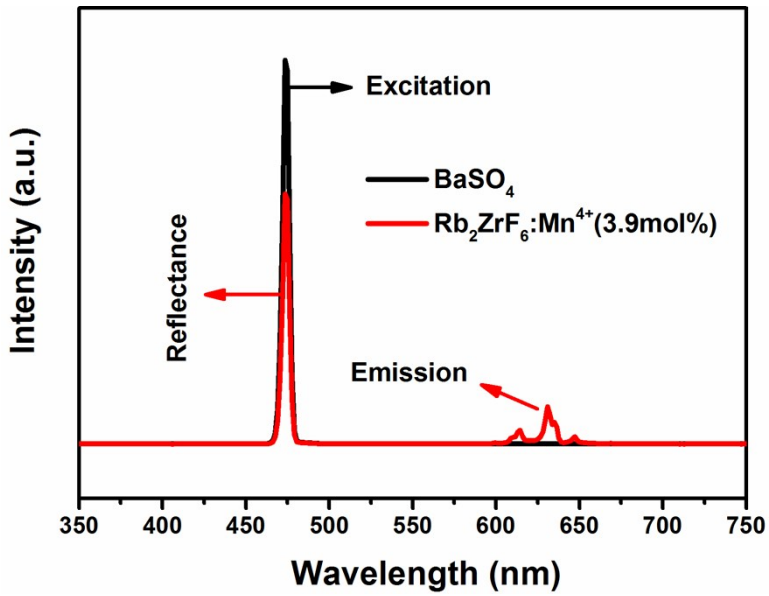

Fig. S2. Excitation spectra of $BaSO_4$, reflectance and emission spectra of $Rb_2ZrF_6:Mn^{4+}$ (3.9 mol.%).

The quantum efficiency (QE) was calculated as follows:

$$QE = \frac{\int \lambda \cdot P(\lambda) d\lambda}{\int \lambda \{E(\lambda) - R(\lambda)\} d\lambda} \quad (1)$$

where E(λ)/hυ, R(λ)/hυ and P(λ)/hυ are the number of photons in the spectrum of excitation, reflectance and emission of the phosphor, respectively. All of spectra were recorded by an optical integrating sphere coupled to the QE-2100 spectrophotometer from Otsuka Photal Electronics at room temperature.

Eq. S1

$$\Delta E = \sqrt{(u_t' - u_0')^2 + (v_t' - v_0')^2 + (w_t' - w_0')^2}$$

where u' = 4x/(3 - 2x + 12y), v'= 9y/(3 -2x + 12y), and w'= 1- u'- v'. x and y are the chromaticity coordinates in CIE 1931, 0 and t are the chromaticity shift at 20 °C and a given temperature, respectively. u' and v' are the chromaticity coordinates in u' v ' uniform color space.