A Glass-ceramics with Thermally Stable Blue-red emission for High-power Horticultural LEDs Application

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Supplementary materials

Table S1. Main parameters of processing and refinement of the $Sr_{1.7-x}Ba_{1.3}Eu_xMg_{1-y}Mn_ySi_2O_8$ sample.

Compound	$Sr_{1.7}Ba_{1.3}MgSi_2O_8$	$Sr_{1.64}Ba_{1.3}Mg_{0.94}Si_2O_8$: 6%$Eu^{2+}$, 6%$Mn^{2+}$
Sp.Gr.	*P*-3*m*1	*P*-3*m*1
a, Å	5.50301 (13)	5.5194 (2)
c, Å	7.02584 (17)	7.0536 (3)
V, Å^3	184.26 (1)	186.09 (2)
2θ-interval, º	8-111	8-120
R_{wp}, %	8.25	5.84
R_p, %	6.00	4.40
R_{exp}, %	3.12	3.02
χ^2	2.64	1.94
R_B, %	5.66	5.16

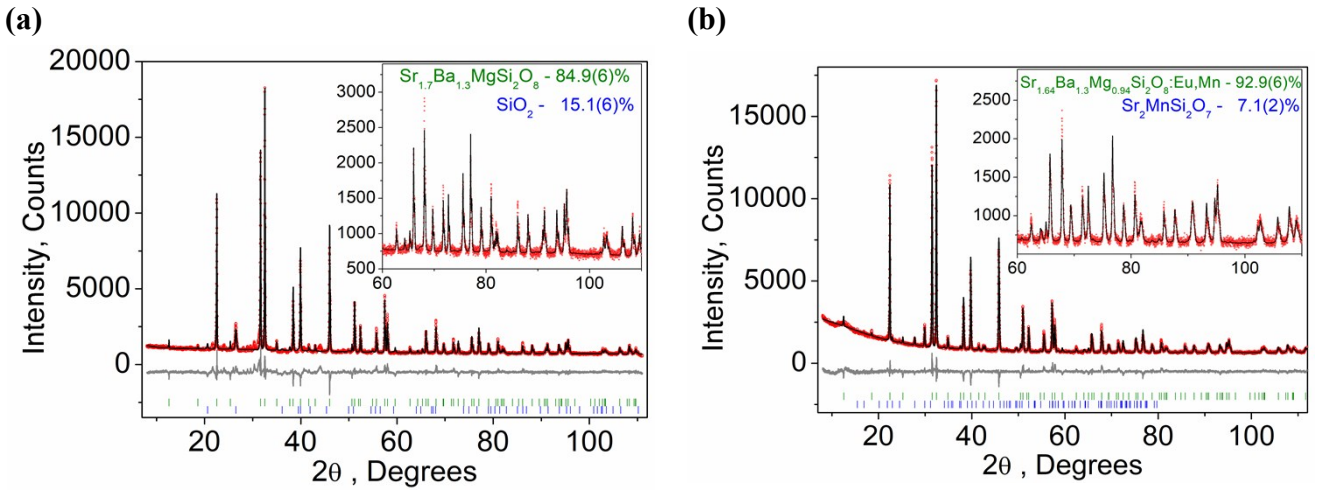


Fig. S1 Difference Rietveld plot of: (a) $Sr_{1.7}Ba_{1.3}MgSi_2O_8$; (b) $Sr_{1.64}Ba_{1.3}Eu_{0.06}Mg_{0.94}Mn_{0.06}Si_2O_8$.

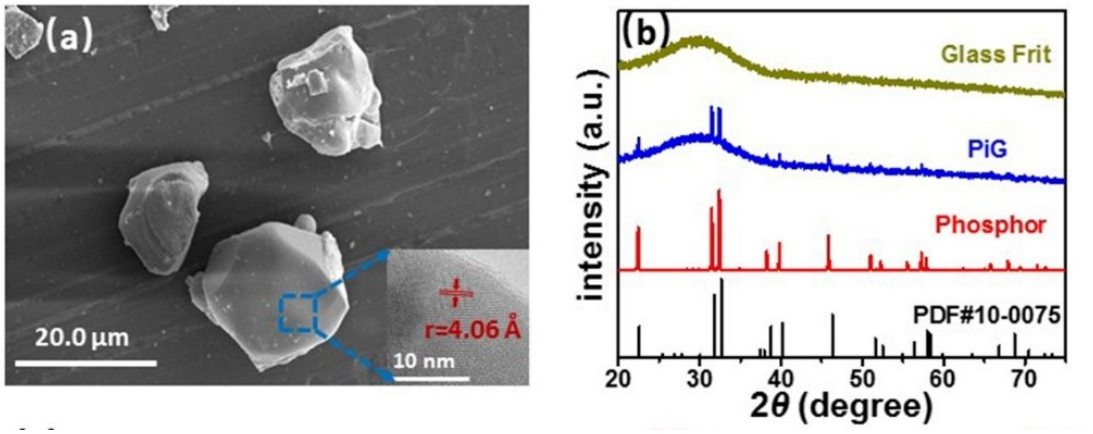
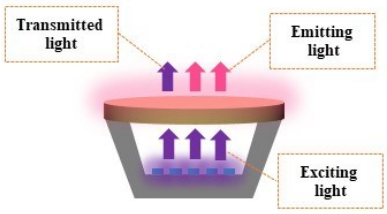


Fig. S2. (a) SEM and HRTEM images of BSMS phosphor. (b)XRD patterns of BSMS phosphor, glass frit, 7 wt% BSMS-PiG and standard data of $Sr_3MgSi_2O_8$ (PDF#10-0075).

Fig. S3 Photographs of BSMS-PiG plates with different phosphor doping concentrations under fluorescent light and 365 nm UV light, respectively.



$$abs. = \frac{\int [Ex(\lambda) - T(\lambda)] d\lambda}{\int Ex(\lambda) d\lambda}$$

$$\eta_c = \frac{\int Em(\lambda) d\lambda}{\int [Ex(\lambda) - T(\lambda)] d\lambda}$$

$Ex(\lambda)$ —— Intensity per unit wavelength in exciting light
$Em(\lambda)$ ——Intensity per unit wavelength in emitting light
$T(\lambda)$ —— Intensity per unit wavelength in transmitted light of UV

Fig. S4 Schematic of absorption and conversion efficiency

Energy transfer of $Eu^{2+} \rightarrow Mn^{2+}$ in $Ba_{1.3}Sr_{1.7}MgSi_2O_8$

In order to properly understand the energy transfer process, the energy transfer efficiency (η_T) of the phosphors from Eu^{2+} to Mn^{2+} was calculated. According to Paulose et al.[1] η_T can be expressed as in equation:

$$\eta_T = 1 - \frac{I_s}{I_0}$$

where I_0 and I_s are the luminescence intensities of sensitizer Eu^{2+} in the absence and presence of activator Mn^{2+}.

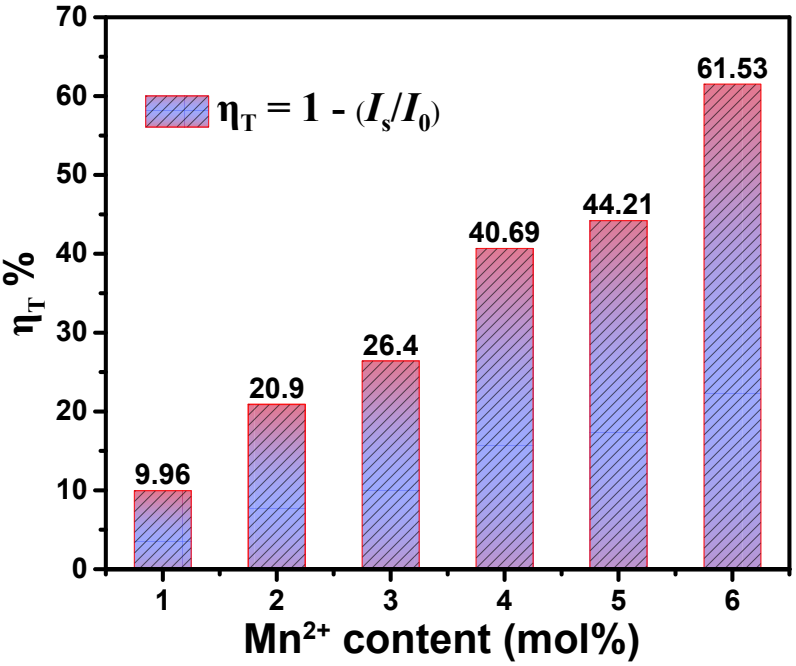


Fig. S5 Variation in η_T for $Ba_{1.3}Sr_{1.7}MgSi_2O_8$:6%$Eu^{2+}$, y%$Mn^{2+}$ ($1 \leq y \leq 6$) with Mn^{2+} concentration

The measurement of photosynthetic pigment contents

0.5g of fresh lettuce leaves were immersed in 25mL organic solvent (acetone : ethyl alcohol = 1 : 1 in Vol%) for 24h. The supernatant was measured at 645 nm, 663 nm and 440 nm. Equations for calculating were following:

$$Total\ chlorophyll\ content\ \left(mg \bullet L^{-1}\right) = 8.02 \times OD_{663} + 20.20 \times OD_{645}$$

$$\beta - carotene\ content\ \left(mg \bullet L^{-1}\right) = 4.7 \times OD_{440} - 0.27 \times \left(8.02 \times OD_{663} + 20.20 \times OD_{645}\right)$$

$$\text{Pigment content}\ \left(mg \bullet \text{g}^{-1}\right) = \frac{\text{Pigment content}\ \left(mg \bullet L^{-1}\right) \times V}{W}$$

OD is the absorbance at 645 nm, 663 nm and 440 nm; *V* is the volume of extraction liquid; *W* is the weight of fresh lettuce leaves.

The measurement of soluble protein

The 1.0 g of lettuce sample was shaken with 8 mL deionized water in a centrifuge tube, and centrifuged at 3000rpm for 10 min. 0.2 mL of the supernatant was collected, then added with 0.8 mL deionized water and 5 mL of Coomassie brilliant blue G–250. After 5 min, the above liquor was measured at 595 nm, using bovine serum albumin as protein standard.

References

[1] P. I. Paulose, G. Jose, V. Thomas, N. V. Unnikrishnan and M. K. R. Warrier, *J. Phys. Chem. Solids*, 2003, **64**, 841.