Luminescence of co-doped $Sr_5MgLa_2(BO_3)_6:Ce^{3+},Mn^{2+}$

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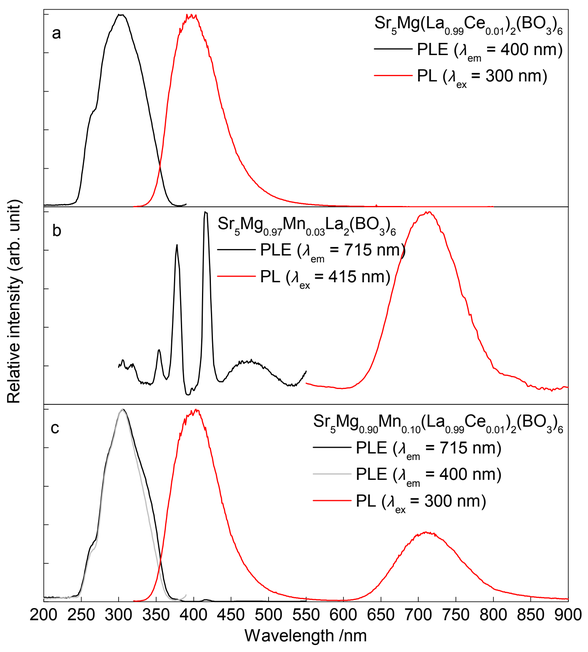
Conclusions

- Diffuse reflectance measurement prove the white body colour and high powder quality of the synthesized samples.
- Co-doped $Sr_5Mg_{1-x}Mn_x(La_{0.99}Ce_{0.01})_2(BO_3)_6$ exhibits two emission bands under UV excitation, located at 397 and 714 nm.
- Ce^{3+} occupies two distinct crystallographic sites in co-doped $Sr_5Mg_{1-x}Mn_x(La_{0.99}Ce_{0.01})_2(BO_3)_6$.
- The highest photoluminescence intensity was found for a Mn^{2+} concentration of $x = 0.10$. At higher concentrations a saturation effect sets in.
- $T_{1/2}$ of co-doped $Sr_5Mg_{0.90}Mn_{0.10}(La_{0.99}Ce_{0.01})_2(BO_3)_6$ was found to be 355 K.
- Temperature dependent fluorescence lifetime measurements revealed that thermal quenching in $Sr_5Mg_{0.90}Mn_{0.10}(La_{0.99}Ce_{0.01})_2(BO_3)_6$ is mainly caused by the Mn^{2+} ions.
- The colour point of the emission of $Sr_5Mg_{1-x}Mn_x(La_{0.99}Ce_{0.01})_2(BO_3)_6$ can be varied in the blue colour range by increasing the Mn^{2+} concentration.

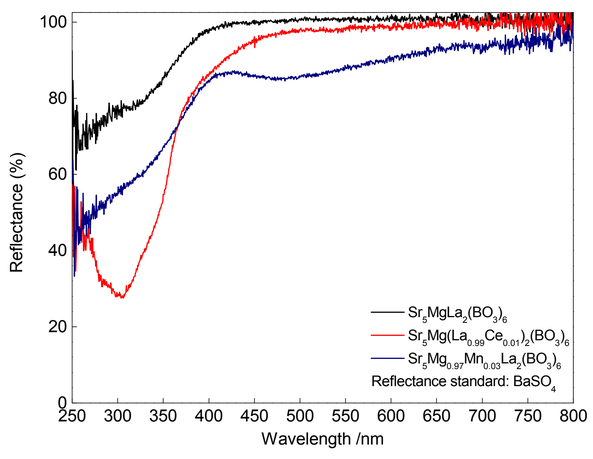
Experimental Section

- $Sr_5Mg_{1-x}Mn_x(La_{0.99}Ce_{0.01})_2(BO_3)_6$ samples were synthesized by using a high temperature solid state reaction.
- The samples were primarily annealed at 650 °C for 1 h in air and finally sintered in corundum crucibles at 1200 °C for 6 h in reducing CO atmosphere.
- Phase purity was investigated using X-ray powder diffractometry.
- Optical properties were investigated by recording photoluminescence spectra as well as by performing fluorescence lifetime measurements at different temperatures.

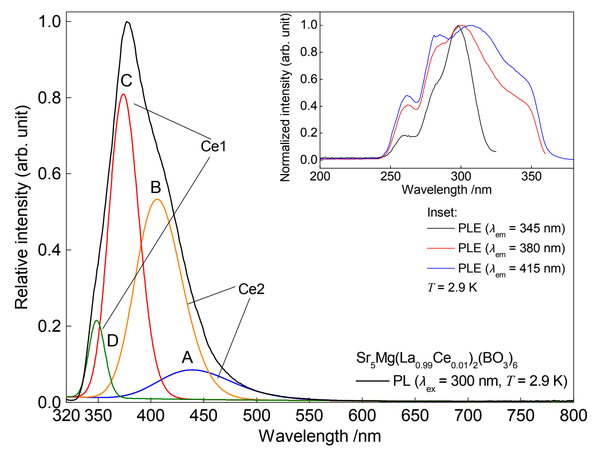
Results



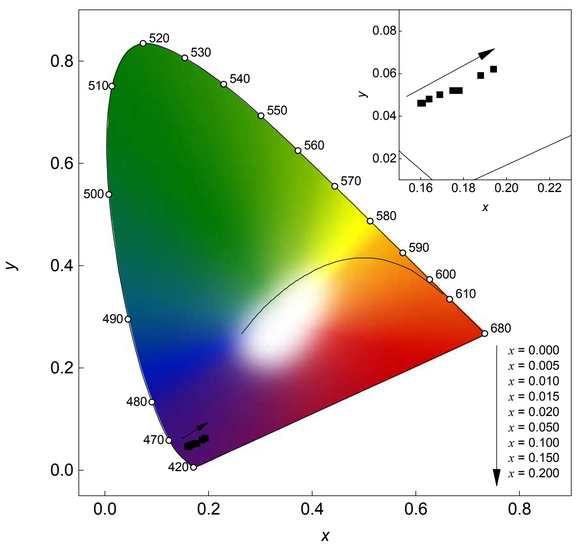
Excitation spectra of $Sr_5Mg(La_{0.99}Ce_{0.01})_2(BO_3)_6$ and $Sr_5Mg_{0.90}Mn_{0.10}(La_{0.99}Ce_{0.01})_2(BO_3)_6$ look similar in shape indicating energy transfer from Ce^{3+} to Mn^{2+}.



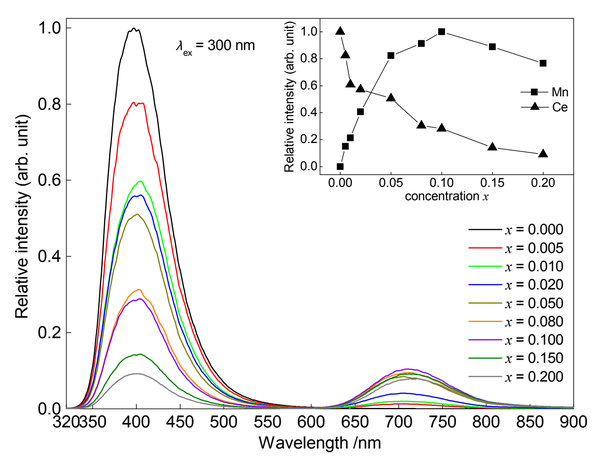
Doped and undoped $Sr_5MgLa_2(BO_3)_6$ possess white body colour.



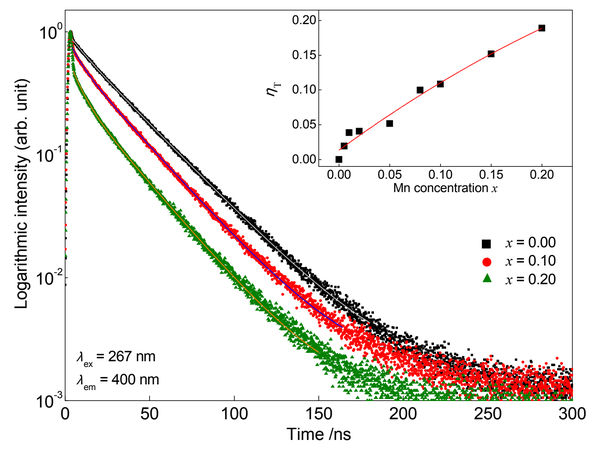
Low temperature photoluminescence measurements reveal Ce^{3+} occupies two different crystallographic sites.



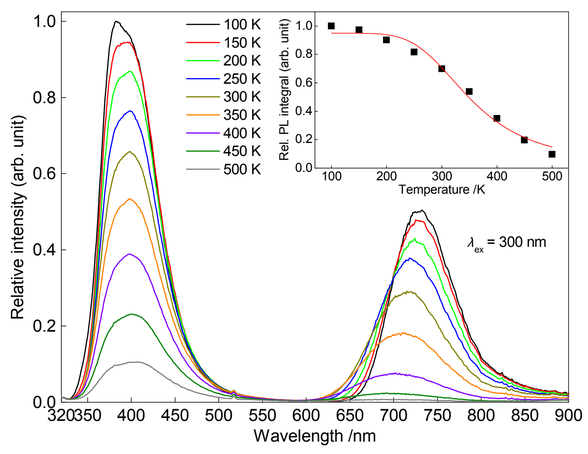
Colour points show a slight shift from the violet region to the red region of the colour coordinates diagram.



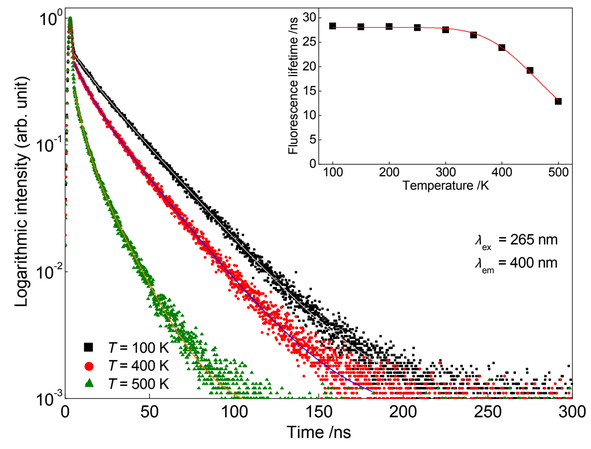
Highest photoluminescence intensity was found for a Mn^{2+} content of $x = 0.100$.



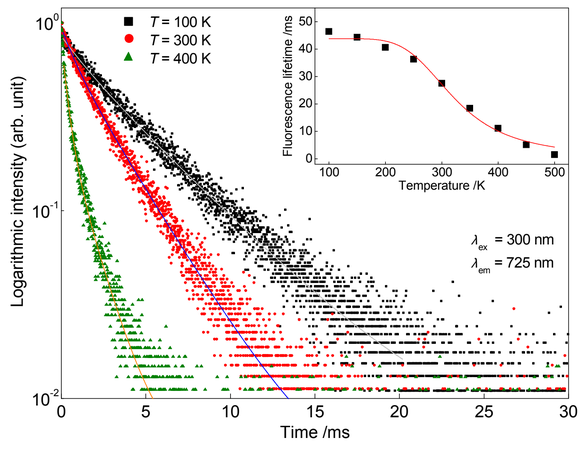
Fluorescence lifetimes gradually decrease with increasing Mn^{2+} concentration suggesting energy transfer from Ce^{3+} to Mn^{2+}. Energy transfer efficiency η_T gradually increases with increasing Mn^{2+} concentration.



With increasing temperature the emission maximum of Mn^{2+} shows a slight shift towards higher energy due to lower crystal field splitting.



Fluorescence lifetimes of Ce^{3+} remain constant up to about 350 K reflecting the good temperature stability of the internal quantum efficiency of Ce^{3+}.



Fluorescence lifetimes of Mn^{2+} start to decrease at lower temperature compared to those of Ce^{3+} indicating that thermal quenching is mainly caused by Mn^{2+}.

Background

- Nowadays, most of the commercially available white light emitting pcLEDs comprise a blue emitting (In,Ga)N chip pumping a green-yellow emitting phosphor, e.g. $(Y,Gd)_3Al_5O_{12}:Ce^{3+}$.
- Unfortunately, these light sources are unpopular for domestic lighting due to high colour temperature and low colour rendering index (CRI).
- One approach to obtain reasonable CRIs, is to use a phosphor blend comprising a blue, green, and red phosphor, which is excited by an ultraviolet emitting LED.
- However, these packages underlie a loss in blue emission due to re-absorption by the green and red phosphor.
- Alternatively, the ion couple Ce^{3+} and Mn^{2+} can be used. The broad emission bands in the blue and red spectral range of Ce^{3+} and Mn^{2+} in many host materials complement each other to white light due to additive colour mixing.
- Ce^{3+} usually exhibits a broad excitation band in the UV range and is well appropriate for pumping by UV LEDs. Additionally, the blue emission band of Ce^{3+} is also suitable to sensitize the spin and parity forbidden $[Ar]3d^5$-$[Ar]3d^5$ transitions of Mn^{2+} *via* energy transfer.

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TOM Tailored Optical Materials

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