Synthesis and Optical Properties of $Ba_2Zr_2Si_3O_{12}:Eu^{2+}$

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Introduction

There are no doubts already that future lighting belongs to solid-state light sources, i.e. white LEDs. The invention of efficient blue LED enabled scientists to produce white light as a combination of blue and yellow components. But such light sources, however, possess high color temperatures and low color rendering indexes. The other possible way for producing white light is based on application of near-UV LED and several phosphors emitting in blue, green and red, therefore the demand of new phosphors emitting in those spectral regions is rapidly increasing.

We demonstrate, that Eu^{2+} doped $Ba_2Zr_2Si_3O_{12}$ shows emission in cyan-green spectral region. The optical properties of synthesized phosphors are discussed as a function of Eu^{2+} concentration.

Experimental Part

All samples were prepared by 2 step solid state reaction from oxides and carbonates. First, starting materials were annealed at 1400°C for 5 hours under CO atmosphere in order to obtain the desired phase and partially reduce Eu^{3+} to Eu^{2+}. The complete reduction of europium ions to Eu^{2+} was obtained by annealing target samples under 5% H_2 / 95% N_2 gas flow for 2 hours in the tube furnace.

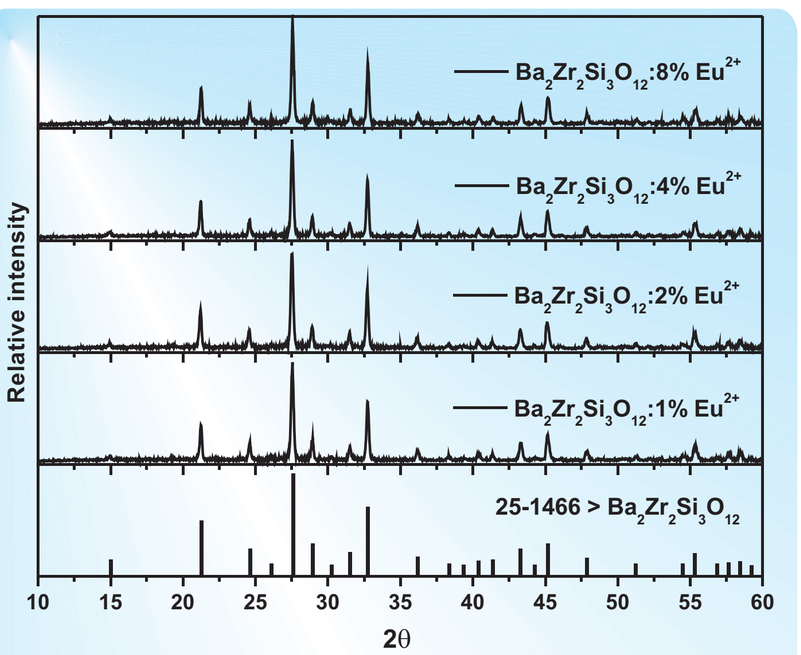

Fig. 1. XRD patterns of $Ba_2Zr_2Si_3O_{12}$ samples with various Eu^{2+} concentrations.

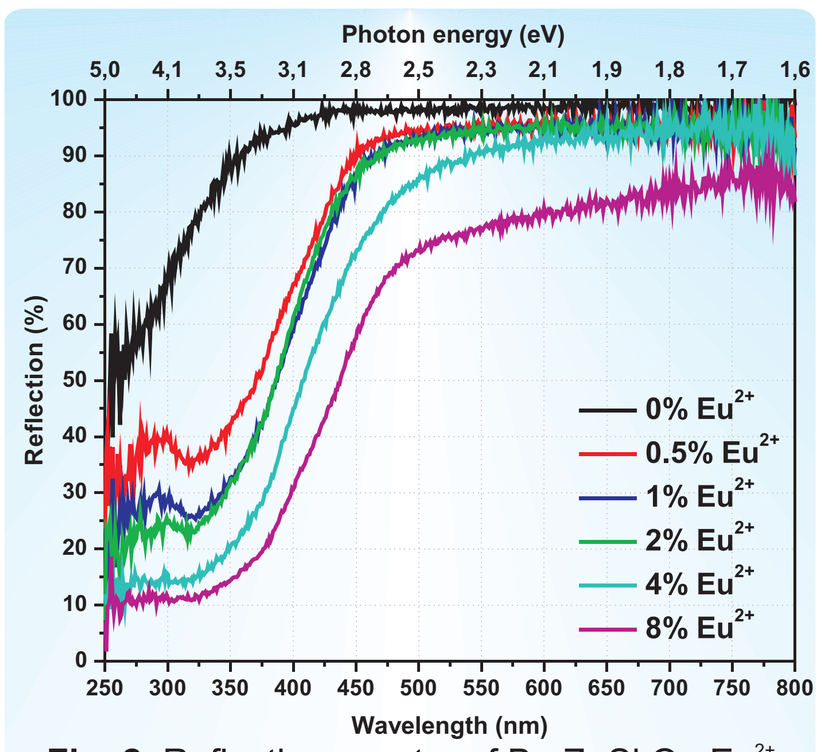

Fig. 2. Reflection spectra of $Ba_2Zr_2Si_3O_{12}:Eu^{2+}$.

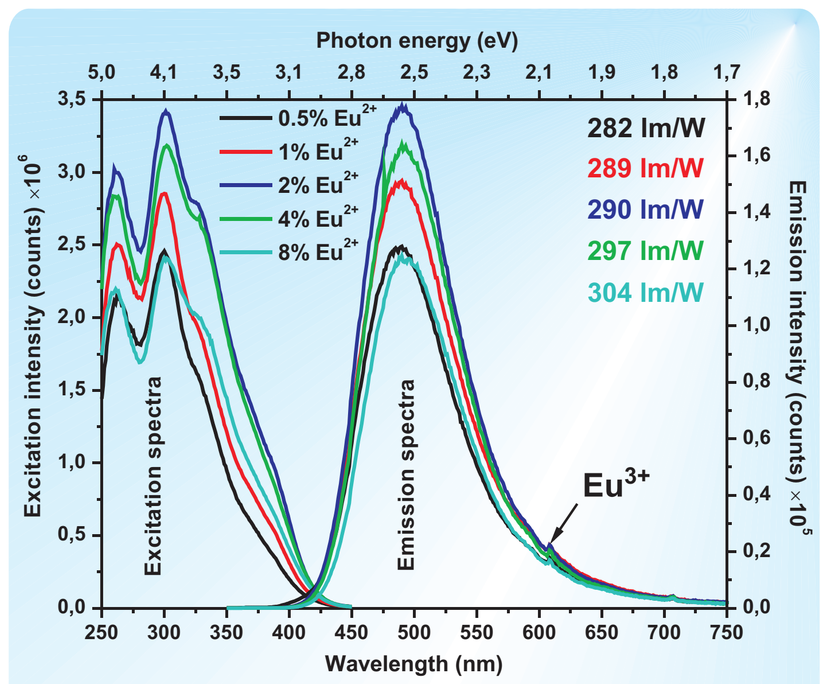

Fig. 3. Excitation and emission spectra of $Ba_2Zr_2Si_3O_{12}:Eu^{2+}$.

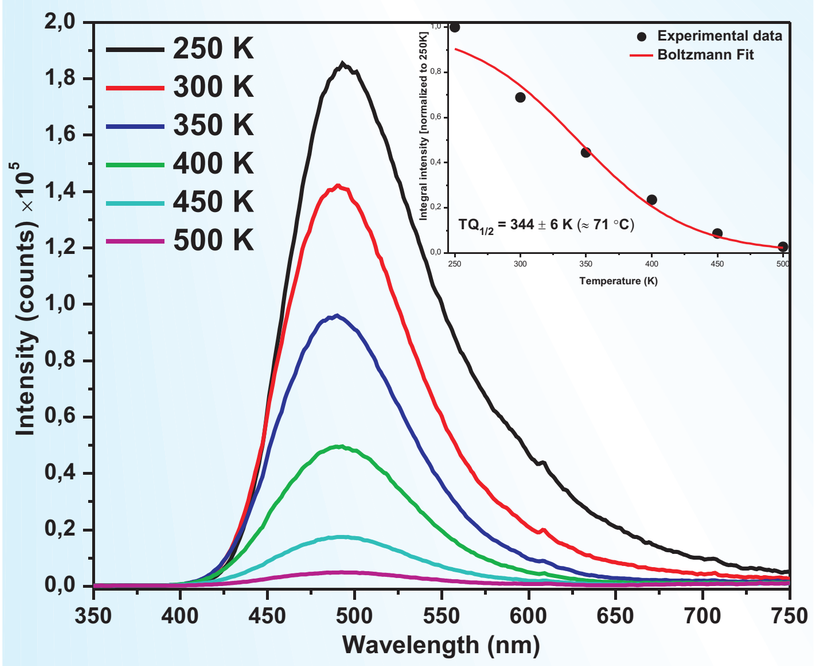

Fig. 4. Temperature dependent emission spectra of $Ba_2Zr_2Si_3O_{12}:2\%Eu^{2+}$.

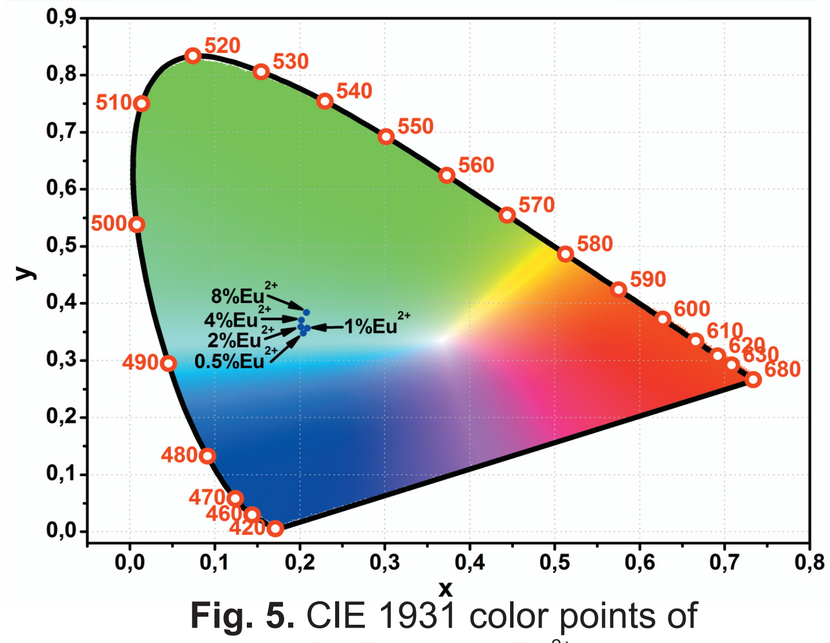

Fig. 5. CIE 1931 color points of $Ba_2Zr_2Si_3O_{12}:Eu^{2+}$.

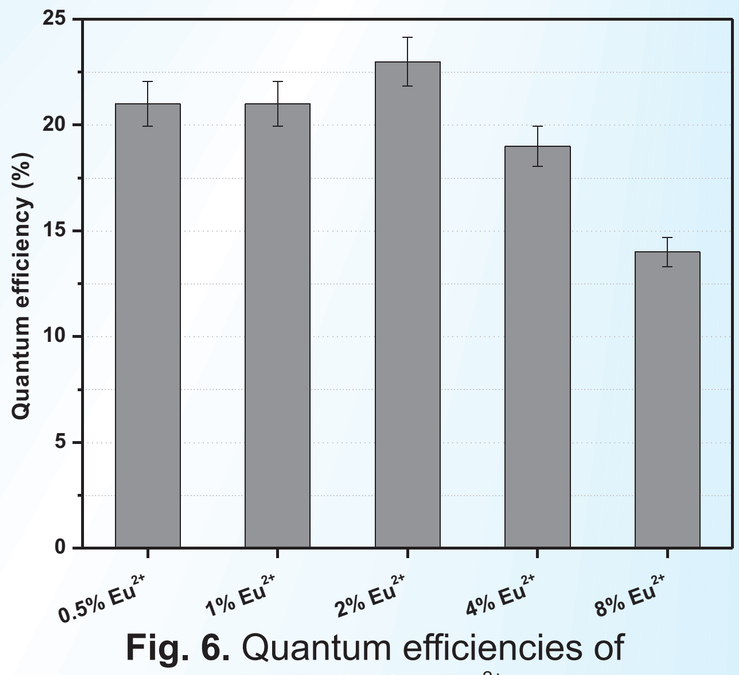

Fig. 6. Quantum efficiencies of $Ba_2Zr_2Si_3O_{12}:Eu^{2+}$.

Results and Discussion

XRD patterns of the synthesized samples are in good agreement with reference data regardless Eu^{2+} concentration (see **Fig. 1**). **Fig. 2** shows reflection spectra of the target samples. As expected an absorption in the near UV region increases with higher Eu^{2+} concentration. The intensity of excitation and emission spectra reaches maximum (495 nm) if samples are doped with 2% Eu^{2+} (see **Fig. 3**). The temperature dependent emission spectra of $Ba_2Zr_2Si_3O_{12}:2\%Eu^{2+}$ sample are depicted in **Fig. 4**. It turned out that emission intensity rapidly decreases with increased temperature. Calculations revealed that phosphor loses half of efficiency already at 71°C. CIE 1931 color points of synthesized phosphors are shown in **Fig. 5**. It is obvious that color points slightly shift towards green spectral region what is in line with emission spectra. Finally, **Fig. 6** depicts quantum efficiencies of the synthesized phosphors as a function of Eu^{2+} concentration. Quantum efficiencies do not exceed 25% and is huge drawback of the phosphor for application in solid state lighting.

Conclusions

In this work we demonstrated that Eu^{2+} doped $Ba_2Zr_2Si_3O_{12}$ phosphor possess emission in cyan-green spectral region. Quantum efficiencies do not exceed 25%, which is likely caused by photoionisation of the excited state. This explanation is in line with the strong thermal quenching of this phosphor.