Photoluminescence of Eu^{3+} Doped Rare Earth Molybdates

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Introduction

Light sources based on phosphor converted light emitting diodes (pcLEDs) are going to replace conventional light sources, viz. incandescent and gas discharge lamps within the next decade. The most widely applied phosphor in white pcLEDs is cerium doped yttrium aluminum garnet (YAG:Ce). It possesses high quantum efficiency (>90%), good chemical and photochemical stability, and has a broad emission spectrum peaking at 560 nm. Moreover, the spectral width and position of its absorption band is very suitable to overcome the binning problem of blue-emitting LEDs. However, a combination of yellow phosphor and a blue emitting LED yields an insufficient color rendering index (CRI), i.e. some colors, in particular the red ones, are poorly reproduced under illumination by such a pcLED light source. Another drawback of such combination is the rather high color temperature (CCT > 4500 K) due to the deficiency in the red spectral range. Therefore, the quest of red emitting phosphors that can be pumped by near-UV or blue emitting LEDs gains a lot of attention.

Crystal Structure

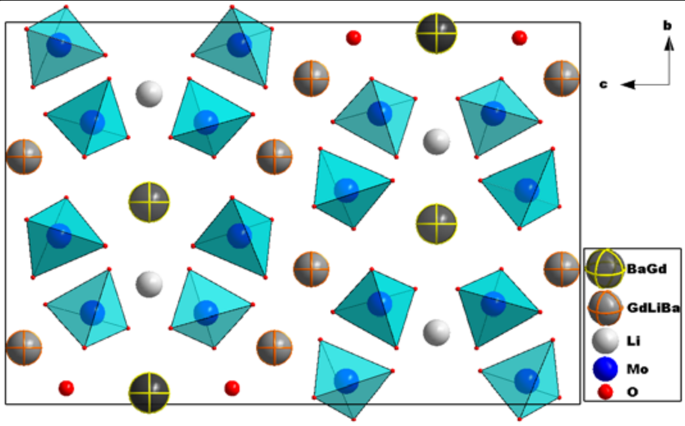

Fig. 1. Crystal structure of $Li_3Ba_2Gd_3(MoO_4)_8$.

Results

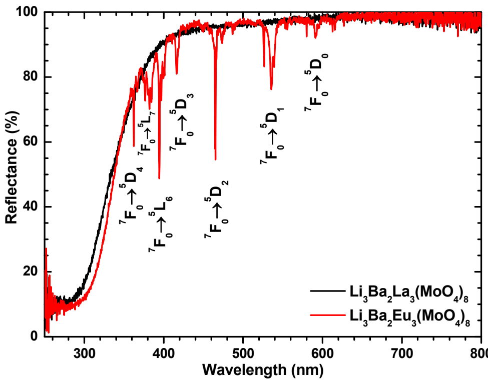

Fig. 2. Reflection spectra of $Li_3Ba_2La_3(MoO_4)_8$ and $Li_3Ba_2Eu_3(MoO_4)_8$.

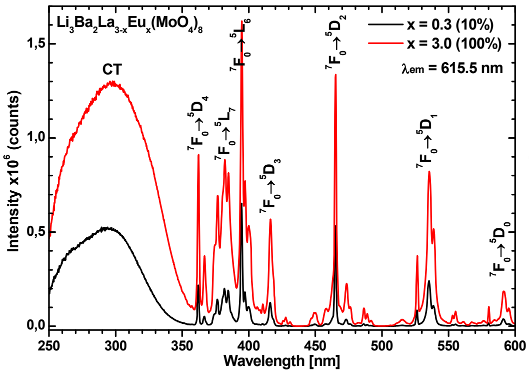

Fig. 3. Excitation spectra of $Li_3Ba_2La_3(MoO_4)_8$ doped with 10 and 100% of Eu^{3+}.

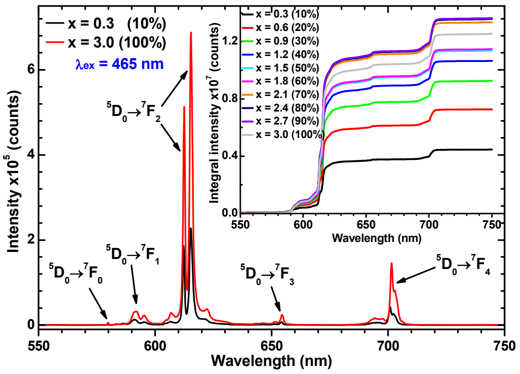

Fig. 4. Emission spectra of $Li_3Ba_2La_3(MoO_4)_8$ doped with 10 and 100% of Eu^{3+}.

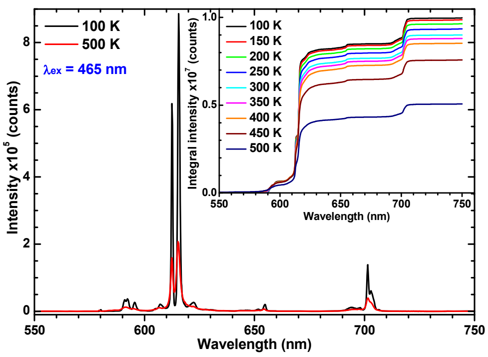

Fig. 5. Thermal quenching of $Li_3Ba_2Eu_3(MoO_4)_8$.

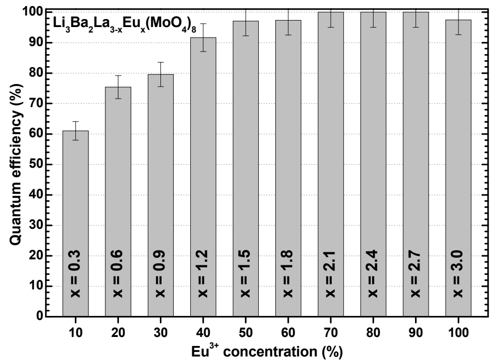

Fig. 6. Quantum efficiencies of $Li_3Ba_2La_{3-x}Eu_x(MoO_4)_8$ phosphors (λ_{ex} = 465 nm).

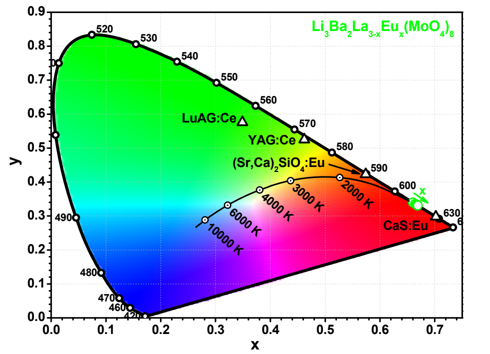

Fig. 7. CIE 1931 chromaticity diagram with colour points of $Li_3Ba_2La_{3-x}Eu_x(MoO_4)_8$ phosphors.

Conclusions

- Single phase target materials can be prepared by annealing the blend of respective oxides and/or carbonates at 800 °C for 10 h in air. Solid solution forms at any La/Eu ratio.
- Optical band gap of $Li_3Ba_2La_3(MoO_4)_8$ and $Li_3Ba_2La_3(MoO_4)_8$ is about 340 nm (≈ 3.65 eV). The phosphors can be efficiently excited in the near-UV and blue spectral regions.
- The dominant emission lines (≈ 615 nm) originates from the $^5D_0 \rightarrow {}^7F_2$ transition. The strongest emission intensity was achieved if samples were doped with about 90% of Eu^{3+}.
- The emission intensity decreases at elevated temperatures. $Li_3Ba_2Eu_3(MoO_4)_8$ looses only about 15% of efficiency at 400 K (127 °C) what makes the investigated phosphors attractive for application in pcLEDs.
- Quantum efficiency of the phosphors increases with increasing Eu^{3+} concentration. Almost 100% efficiency was obtained for the samples doped with 70, 80, and 90% of Eu^{3+}. Sample containing 100% of Eu^{3+} showed a slight decrease in quantum efficiency.
- The colour points of the investigated phosphors are located in the red region of CIE 1931 chromaticity diagram. The increase of Eu^{3+} concentration has led to a slight shift of colour points to the red. The luminous efficacies was 330 and 312 lm/W for 10 and 100% Eu^{3+} doped samples, respectively.