Structure and luminescent properties of $KGd_{1-x}Eu_x(MoO_4)_2$ ($0 \le x \le 1$)

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Many Eu^{3+}-containing luminescent materials with various crystal structures, including different molybdate compounds were investigated for their potential as red luminescence materials for WLEDs (white light-emitting diodes).[1] Annealing conditions and Eu^{3+} concentration have the great influence on the structure and luminescent properties of $KGd_{1-x}Eu_x(MoO_4)_2$ ($0 \le x \le 1$). Structures of three types are found for $KGd_{1-x}Eu_x(MoO_4)_2$ ($0 \le x \le 1$): scheelite-type α- and β–modifications and an orthorhombic γ-phase with a $KY(MoO_4)_2$-type structure. The powder X-ray diffraction study shows that the number and the character of the phase transitions for $KGd_{1-x}Eu_x(MoO_4)_2$ depends on the elemental composition. the following four intervals of x can be selected for $KGd_{1-x}Eu_x(MoO_4)_2$ phases for annealing temperature in the range from 923 K to 1223 K followed by slow cooling to the room temperature: 1) $0 \le x \le 0.3$ with the reversible α↔γ phase transition; 2) $x=0.4$ with two non-reversible α→β→γ phase transitions; 3) $0.5 \le x \le 0.7$ with the α→β→α transformations; 4) $0.8 \le x \le 1$ with the irreversible α→β phase transition. The existence of the pure monoclinic incommensurately modulated β-$KGd_{1-x}Eu_x(MoO_4)_2$ phases is found only for $0.6 \le x \le 1$.

The luminescence of all $KGd_{1-x}Eu_x(MoO_4)_2$ samples under near-ultraviolet light was investigated. At 300 nm, the excitation spectra of α-$KGd_{1-x}Eu_x(MoO_4)_2$ show the highest charge transfer band contribution as compared to direct excitation, and thus the most efficient energy transfer between the host matrix and the luminescent ion. All samples' emission spectra exhibit an intense red emission originating from the Eu^{3+} $^5D_0 \rightarrow {}^7F_2$ transition. The maxima of the $^5D_0 \rightarrow {}^7F_2$ integral emission intensities was found for triclinic scheelite-type α-$KGd_{0.6}Eu_{0.4}(MoO_4)_2$ ($\lambda_{ex} = 300$ nm) and monoclinic scheelite-type β-$KGd_{0.4}Eu_{0.6}(MoO_4)_2$ prepared at 1173 K ($\lambda_{ex} = 395$ nm). The phosphor β-$KGd_{0.4}Eu_{0.6}(MoO_4)_2$ prepared at 1173 K shows the brightest red light emission among the $KGd_{1-x}Eu_x(MoO_4)_2$ phosphors after excitation at 395 nm. The maximum and integral emission intensities of β-$KGd_{0.4}Eu_{0.6}(MoO_4)_2$ in the $^5D_0 \rightarrow {}^7F_2$ transition region are higher by ~20% than that of the commercially used red phosphor of $Gd_2O_2S:Eu^{3+}$. This confirms that β-$KGd_{0.4}Eu_{0.6}(MoO_4)_2$ is exceptionally attractive as a near-UV convertible phosphor applied as a red-emitting phosphor for LEDs.

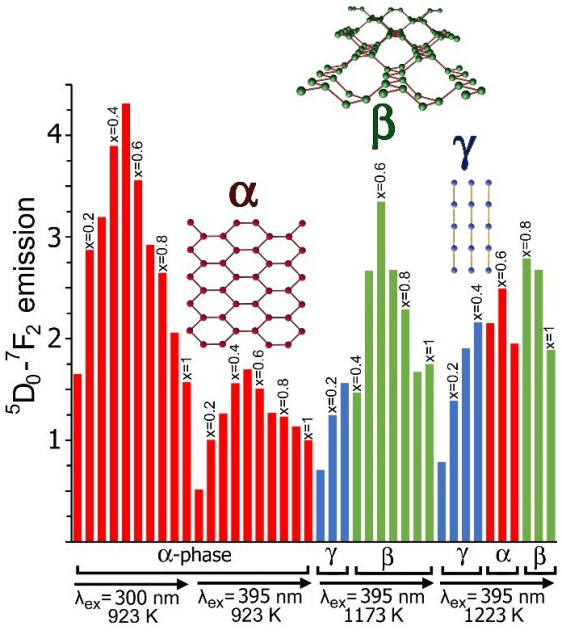

Figure 1. Comparative integral intensity of the 5D0 → 7F2 emission of different Eu3+ concentration for KGd1−xEux(MoO4)2 phases prepared at different annealing temperatures and after different excitations. All intensities are normalized on the integral intensity value of α-KEu(MoO4)2 (Iint).

[1] Li, J.; Yan, J.; Wen, D.; Khan, W.U.; Shi, J.; Wu, M.; Sua, Q.; Tanner, P.A. Advanced red phosphors for white light-emitting diodes. *J. Mater. Chem. C*. **2016**, *4*, 8611-8623

Keywords: structure; phase transitions; molybdate; luminescence; Eu^{3+}; LEDs.

Acta Cryst. (2021), A**77**, C722