

Color tunable persistent luminescence of Ce-Cr co-doped garnet phosphors

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1. Introduction

Ce³⁺ doped garnet phosphors are used for white-LED because Ce³⁺ in a garnet structure $A_3B_2C_3O_{12}$ has blue absorption and efficient visible luminescence due to the 4f-5d allowed transition. The 5d energy level of Ce³⁺ is shifted by crystal field splitting and nephelauxetic effect. In garnet hosts, it is known that the degree of crystal field splitting is large and depends on the size and distortion of dodecahedral *A* site. When *A* site cation becomes larger, the crystal field splitting becomes larger and the Ce³⁺ 4f-5d luminescence shifts to longer side [1].

In our previous work, we reported intense green persistent luminescence after ceasing blue light excitation in $Y_3Al_2Ga_3O_{12}:Ce^{3+}-Cr^{3+}$ [2]. We found that the bottom of conduction band shifts to lower with increasing Ga concentration. Consequently, the trap depth, the energy gap between the bottom of conduction band (CB) and the electron trap was controlled by CB engineering for persistent luminescence at room temperature [3].

In this study, $(GdY)_3(GaAl)_5O_{12}:Ce^{3+}-Cr^{3+}$ (GYAGG: Ce³⁺-Cr³⁺) ceramic phosphors were prepared and there optical properties were investigated systematically.

2. Preparation and Measurement

$(Gd_xY_{3-x})(Ga_yAl_{5-y})O_{12}:Ce^{3+}-Cr^{3+}$ ($x = 1, 2, 3; y = 0, 1, 2, 2.5, 3, 4$) phosphors are fabricated by a solid state reaction method. The samples are identified as a single phase of garnet structure by X-ray powder diffraction. Photoluminescence (PL), persistent luminescence, photoluminescence excitation (PLE) spectra and thermoluminescence (TL) were measured.

3. Result and Discussion

Figure 1 shows the color variation of persistent luminescence. Compared with $SrAl_2O_4:Eu^{2+}-Dy^{3+}$ which shows green luminescence of $Eu^{2+}:5d-4f$, the chromaticity coordinates of the persistent luminescence in GYAGG: Ce³⁺-Cr³⁺ are located in much yellow region. It is found that the persistent luminescence peak shifts to longer wavelength with increasing Gd or decreasing Ga content because the crystal field splitting becomes larger.

Figure 2 shows the trap depth estimated from TL grow peak in the GYAGG: Ce³⁺-Cr³⁺ ceramics. The trap depth tends to be shallower with increasing both Gd and Ga content. The decrease of trap depth above $y = 1$ is caused by lowering the CB bottom. At room temperature, the samples with $y = 3$ are suitable for long persistent luminescence.

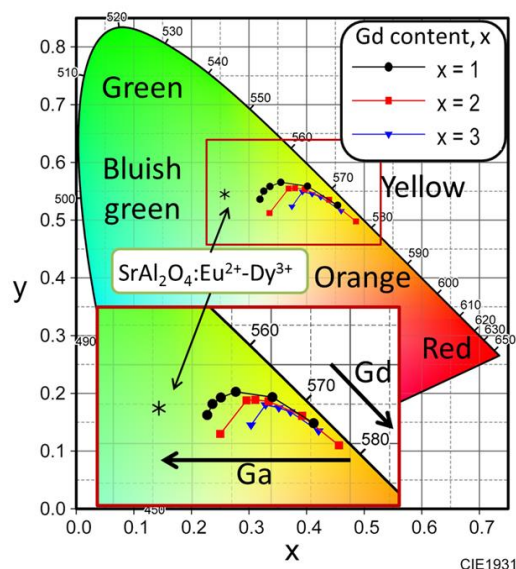


Figure 1: The persistent color variation in GYAGG:Ce³⁺-Cr³⁺.

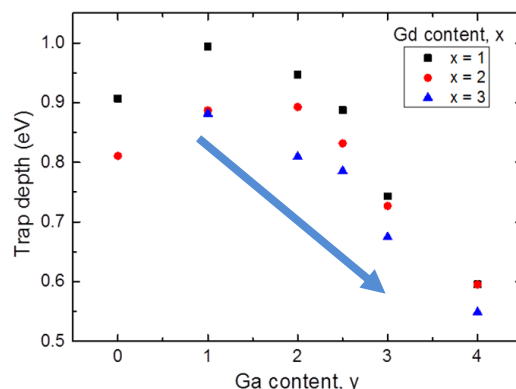


Figure 2: The trap depth estimated from TL in GYAGG:Ce³⁺-Cr³⁺.

4. Conclusion

Color tunable persistent luminescence from yellowish green to orange in Ce³⁺, Cr³⁺ codoped $(GdY)_3(GaAl)_5O_{12}$ phosphors were fabricated. The color coordination of the best persistent phosphor of $y = 3$ was controlled by Gd content x since the trap depth was mainly controlled by Ga content y .

References

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