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Novel recommendation for enhancing optical properties of CP-WLEDs by $Ba_2Si_5N_8Eu^{2+}$ phosphor

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ABSTRACT

In this paper, the $Ba_2Si_5N_8Eu^{2+}$ phosphor is proposed as the novel recommendation for enhancing the optical properties in terms of D-CCT, CRI, CQS, and LO of the CP-WLEDs. Firstly, we conducted the physical model of the CP-WLEDs in the LightTools software with the main parameters like the real LEDs. Furthermore, the scattering process in LEDs compound of the CP-WLEDs is simulated and investigated by the Matlab software. Then the influence of the $Ba_2Si_5N_8Eu^{2+}$ concentration on the D-CCT, CRI, CQS, and LO of the CP-WLEDs is investigated. Finally, the research results showed that the Ba2Si5N8Eu2+ concentration has a considerable effect on the D-CCT, CRI, CQS, and LO of the CP-WLEDs. From the results, we can state that the $Ba_2Si_5N_8Eu^{2+}$ phosphor can be considered as the novel recommendation for enhancing the optical properties of the CP-WLEDs.

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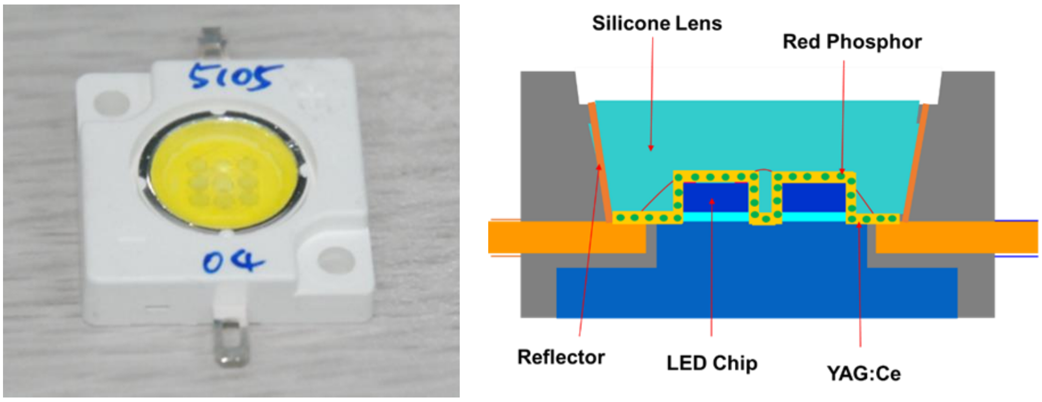
1. INTRODUCTION

In the lighting revolution trend for improving civilian everyday life in over the world, the InGaN-based white-light-emitting diodes (LEDs) can be considered as the primary solution in comparison with the conventional lighting method based on the excellent advantages such as environment-friendly, energy efficiency, compactness, long lifetime, and designable features [1-3]. Nowadays, phosphor-converted LEDs (pcLED) combines a blue LEDs chip, and the yellow emitting phosphor is the novel solution for lighting in civil and industrial purposes [4, 5]. In the last few years, authors in many research focused on enhancing the lighting properties of the white LEDs. Authors in [6, 7] proposed and investigated the effect of the phosphor layer thickness and concentration on the optical properties of white LEDs and concluded that the lower phosphor concentration and higher phosphor thickness led to the higher luminous efficacy. Furthermore, the authors in [8] stated that the spatial color distribution (SPD) of white LEDs is significantly affected by the phosphor layer parameter such as thickness, concentration, and size. As studied in [9-12], the blue light and yellow light have a similar radiation pattern that can be lead to improving the SPD by varying the phosphor layer location of the white LEDs. Besides, the green and red phosphor by adding to the phosphor layer can be considered as a novel solution for enhancing the optical properties of the white LEDs as in [13-15].

In this paper, the Ba2Si5N8Eu2+ is proposed as the novel recommendation for enhancing the optical properties in terms of D-CCT, CRI, CQS, and LO of the CP-WLEDs. Firstly, we conducted the physical model of the CP-WLEDs in the LightTools software with the main parameters like the real LEDs. Furthermore, the scattering process in the CP-WLEDs is simulated and investigated by the Matlab software. Then the influence of the Ba2Si5N8Eu2+ phosphor concentration on the D-CCT, CRI, CQS, and LO of the CP-WLEDs is investigated. Finally, the research results showed that the Ba2Si5N8Eu2+ concentration has a considerable effect on the D-CCT, CRI, CQS, and LO of the CP-WLEDs. From the results, we can state that the Ba2Si5N8Eu2+ phosphor can be considered as the novel recommendation for enhancing the optical properties of the CP-WLEDs. The rest of this paper can be formulated as follows. The physical model of CPW-LEDs, optical properties of the red phosphor is proposed in the second section. The third section presented the numerical results and some discussions. The last section concludes the research.

2. PHYSICAL CPW-LEDS MODEL AND OPTICAL PROPERTIES OF THE RED PHOSPHOR

We use the LightTools software to simulate the real-world model of CPW-LEDs Figure 1(a) with the main parameters, as shown in Figure 1(b) [13-15]. Among these (oxy) nitride phosphors, Ba2Si5N8Eu2+ has high quantum efficiency and very low thermal quenching to improve the color rendering index Figure 2 [16-21].



(a) (b)

Figure 1. (a) The white LEDs, (b) physical model

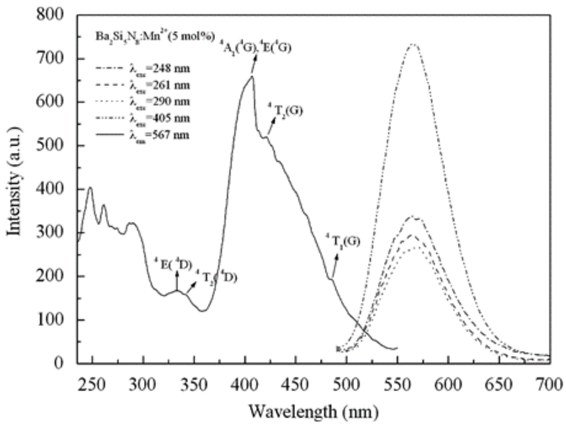


Figure 2. Optical properties of the Ba2Si5N8Eu2+ phosphor

Based on Mie theory [22-30], the scattering coefficients can be calculated as

$$\mu_{sca}(\lambda) = \int N(r)C_{sca}(\lambda,r)dr \qquad (1)$$

$$\mu_{abs}(\lambda) = \int N(r) C_{abs}(\lambda, r) dr \tag{2}$$

$$g(\lambda) = 2\pi \int \int_{-1}^{1} p(\theta, \lambda, r) f(r) \cos\theta d \cos\theta dr \tag{3}$$

$$\delta_{sca} = \mu_{sca}(1-g) \tag{4}$$

$$f(r) = f_{dif}(r) + f_{phos}(r) \tag{5}$$

$$N(r) = N_{dif}(r) + N_{phos}(r) = K_N.[f_{dif}(r) + f_{phos}(r)] \tag{6}$$

$$c = K_N \int M(r) dr \tag{7}$$

$$M(r) = \frac{4}{3}\pi r^3 [\rho_{dif} f_{dif}(r) + \rho_{phos} f_{phos}(r)] \tag{8}$$

3. NEMERICAL RESULTS AND DISCUSSIONS

Based on the Mie Theory, the scattering coefficients (SC) versus Ba2Si5N8Eu2+. concentration are shown in Figure 3 with the red, blue, and yellow lights. From Figure 3, we can see that the (SC) of the yellow light is better than others, and the SC of the red and blue lights are the same. The efficiency of the yellow light in the phosphor layer can cause the enhancing the optical properties of the CPW-LEDs. In another way, the scattering amplitude (SA) is investigated in Figure 4 with red, blue, and yellow lights. As shown in Figure 4, the SA of the blue light is better than others to verify the enhancing the optical properties when we added the red phosphor in the phosphor layer.

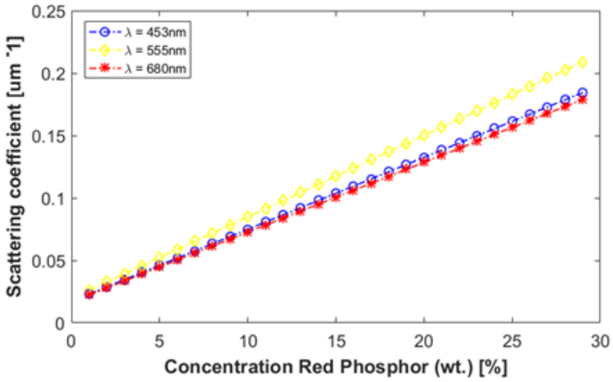


Figure 3. SC

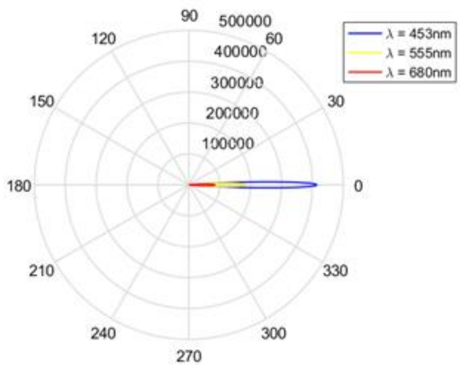


Figure 4. The scattering amplitude

The function of D-CCT of the phosphor concentration is illustrated in Figure 5. In this figure, we varied the phosphor concentration from 0 to 16% and investigated the D-CCT of the CPW-LEDs. As shown in Figure 5, it can be observed that the D-CCT increases massively from 1500 K to 8500 K while we vary the concentration of Ba2Si5N8Eu2+. Furthermore, the effect of the Ba2Si5N8Eu2+ phosphor concentration on the CRI and CQS of the CPW-LEDs is proposed in Figures 6 and 7, respectively. The CRI and CQS increase when the concentration of the Ba2Si5N8Eu2+ phosphor increases from 0% to 10% and then have a huge decrease with rising of the phosphor concentration from 10% to 16%. The maximum values of CRI and CQS are 85 and 79, which can be obtained with 10% concentration of the Ba2Si5N8Eu2+ phosphor. Finally, the LO versus the phosphor concentration is drawn in Figure 8. The LO has a massive fall with the rising of the Ba2Si5N8Eu2+ phosphor. From the results, we can state that the concentration of Ba2Si5N8Eu2+ has a considerable effect on the optical properties (D-CCT, CRI, CQS, and LO).

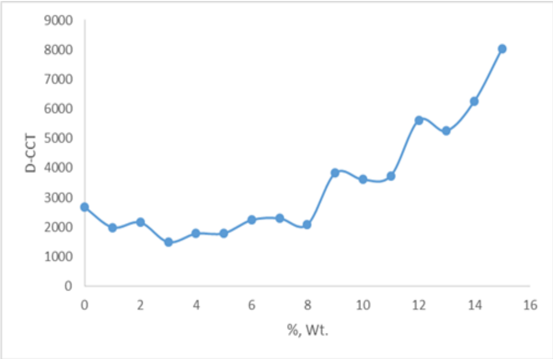


Figure 5. D-CCT

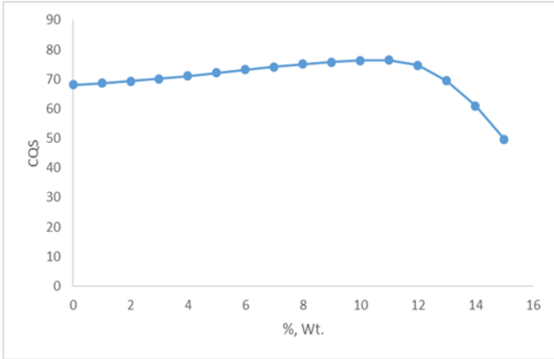


Figure 6. CQS

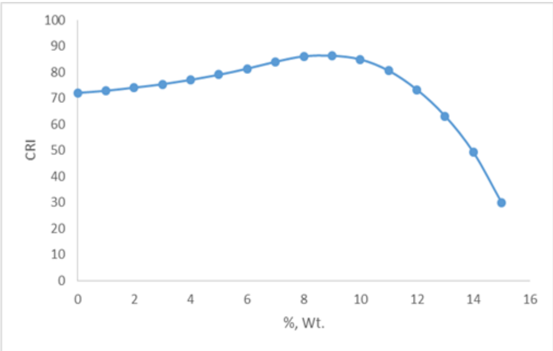


Figure 7. CRI

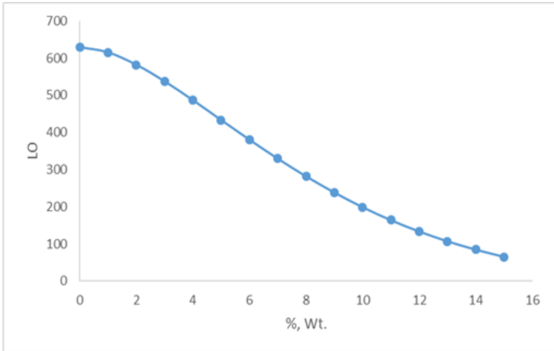


Figure 8. The lumen output LO

4. CONCLUSION

In this paper, Ba2Si5N8Eu2+ is proposed as the novel recommendation for enhancing the optical properties in terms of D-CCT, CRI, CQS, and LO of the CP-WLEDs. Firstly, we conducted the physical model of the CP-WLEDs in the LightTools software with the main parameters like the real LEDs. Furthermore, the scattering process in the CP-WLEDs is simulated and investigated by the Matlab software. Then the influence of Ba2Si5N8Eu2+ concentration on the D-CCT, CRI, CQS, and LO of the CP-WLEDs is investigated. Finally, the research results showed that Ba2Si5N8Eu2+ concentration has a considerable effect on the D-CCT, CRI, CQS, and LO of the CP-WLEDs. From the results, we can state that Ba2Si5N8Eu2+ can be considered as the novel recommendation for enhancing the optical properties of the CP-WLEDs.

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