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Influence of $Ba[Mg_2Al_2N4]Eu^{2+}$ phosphor particle size on optical properties of the 6000K CPW-LEDs

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ABSTRACT

In this paper, we consider the red phosphor $Ba[Mg_2Al_2N4]Eu^{2+}$ as the novel recommendation for improving the optical properties of the 6000K conformal packaging WLEDs (CPW-LEDs). For this purpose, we investigate the influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle size on the optical properties in terms of CCT, CQS, CRI, and LO using the Light Tools and Mat Lab software. From the research results, it can be observed that the optical properties of the 6000K CPW-LEDs are significantly influenced by the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle. The CRI and CQS increase from 65 to 67 and 64 to 68 while the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle varies from 1 μm to 10 μm, respectively. This research can provide a novel recommendation for LEDs industry at this time.

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1. INTRODUCTION

With the excellent characters such as lifetime, efficiency, and reliability, the light-emitting diodes (LEDs) is the main lighting generation in our time in the comparison with the conventional lighting methods with the huge disadvantages due to the significant energy losses based on high temperatures performance and massive Stokes shifts [1-10]. In the LEDs industry, the white light from the LEDs can be conducted in three ways. Firstly, the white light is generated by mixing blue, green, and red colors LEDs. In a second way, the white light can be conducted by adding the blue, green, and red phosphors in the phosphor layer LEDs. The last way, the white light can be generated by combining ultraviolet (UV) LEDs with blue, green, and red phosphors [11-20]. Commonly, the second way is the best way to conduct the white LEDs in the civil and industrial areas.

In this paper, the red phosphor $Ba[Mg_2Al_2N4]Eu^{2+}$ is considered as the modern solution for improving the optical properties of the 6000K conformal packaging WLEDs (CPW-LEDs). For this purpose, the influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ size on the optical properties in terms of CCT, CQS, CRI and LO is proposed and investigated using the Light Tools and Mat Lab software. From the research results, we can see that the optical properties of the 6000K CPW-LEDs is significantly influenced by the size of

the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle. The CRI and CQS increase from 65 to 67 and 64 to 68 while the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle varies from 1 μm to 10 μm, respectively. Here are the main point of this research:

- Light Tools conduct the physical model of the 6000K CPW-LEDs.
- The scattering processes of CPW-LEDs phosphor layer is investigated by Mat Lab.
- The effect of the $Ba[Mg_2Al_2N4]Eu^{2+}$ size on the D-CCT, CRI, CQS, and LO are investigated and convinced.

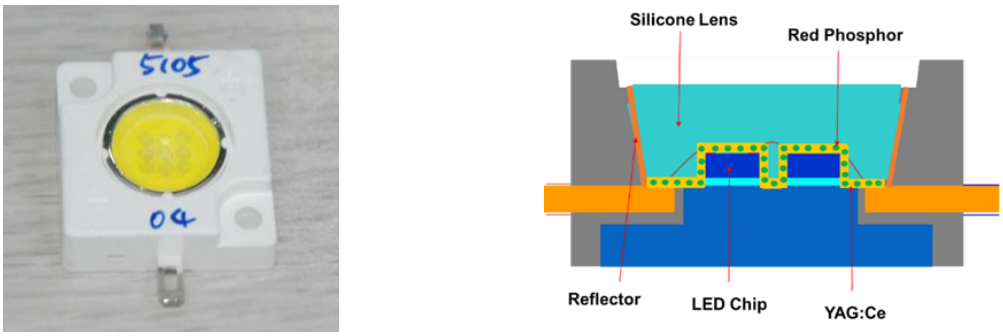
The rest of our paper can be proposed in the following sections. The second section provides the physical model, scattering processes of the 6000 K CPW-LEDs. The third section gives results and some discussions. The last section concludes this manuscript.

2. RESEARCH METHOD

2.1. The CPW-LEDs physical model

In this section, the real WLEDs is shown in Figure 1 (a). As previous researches [13-15] the 6600K CPW-LEDs is simulated by Light Tool software with the primary parameters as:

- We set the depth as 2.07 mm, the inner and outer radius of the reflector as 8 mm and 9.85 mm, respectively.
- LED chips are covered with a fixed thickness of 0.08 mm and 2.07 mm. Each blue chip has a dimension of 1.14 mm by 0.15 mm, the radiant flux of 1.16 W Figure 1 (b) [15-19].



(a) (b)

Figure 1. (a) The real WLEDs, (b) The physical model

2.2. The scattering processes in the phosphor compounding

For investigating the influence of the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle on the optical properties of the 6000K CPW-LEDs, the scattering processes in the phosphor layer of the CPW-LEDs is formulated by using Mie Theory as in [20-25]. The scattering coefficient is formulated as;

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

the reduced scattering coefficient is defined as;

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

The influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle size on the scattering process in the phosphor compounding is investigating using Math Lab software. As shown in Figure 2, the scattering coefficient (SC) increases significantly while the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle varies from 1 μm to 10 μm. We can see that the SC with wavelength 555 nm is the highest values, and with wavelength 680 nm is the lowest values. Furthermore, the effect of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle size on the reduced scattering coefficient (RSC) is plotted in Figure 4 with varying the red phosphor size from 1 μm to 10 μm. As shown in Figure 3, the RSC with the wavelengths 453, 555, 680 nm have the same massive increase in connection with the rising of the $Ba[Mg_2Al_2N4]Eu^{2+}$ size from 1 μm to 10 μm. It can be observed that the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle has a massive impact on the SC in the phosphor layer.

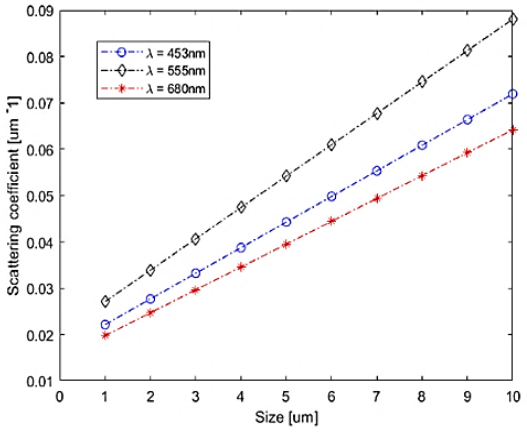


Figure 2. Scattering coefficient (SC)

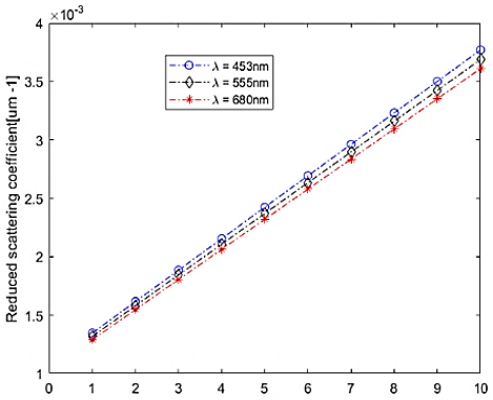


Figure 3. Reduced scattering coefficient (RSC)

3. RESULTS AND DISCUSSION

In this section, the influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle size on the optical properties in terms of D-CCT, CRI, CQS and LO is investigated and discussed by using the Light Tool software. As shown in Figure 4, the D-CCT has a slight increase when we vary the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ phosphor from 1 µm to 10 µm. In Figure 4, the D-CCT increase from 1200K to 1500K with rising the $Ba[Mg_2Al_2N4]Eu^{2+}$ size. Furthermore, the influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ size on the CQS is illustrated in Figure 5. We can see that CQS rises significantly while the size of $Ba[Mg_2Al_2N4]Eu^{2+}$ phosphor rises from 1 to 5 µm, then keep the same values with size from 6 to 10 µm. In the same way, the CRI has a huge increase, and after that has a slight increase when the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ up to 10 µm as plotted in Figure 6. Finally, the LO versus the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ phosphor is showed in Figure 7. The LO has a huge decrease and then keep the same values after that. From the research results, it can be observed that the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle has a huge impact on the optical properties of the 6000K CPW-LEDs.

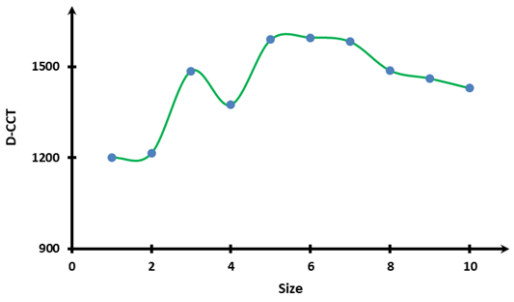


Figure 4. The D-CCT

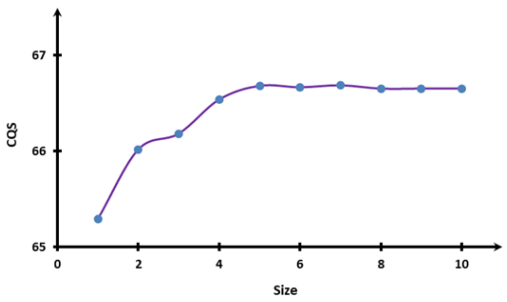


Figure 5. CQS

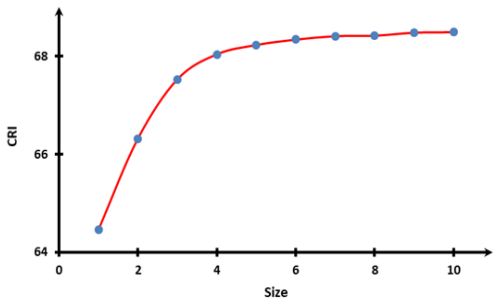


Figure 6. CRI

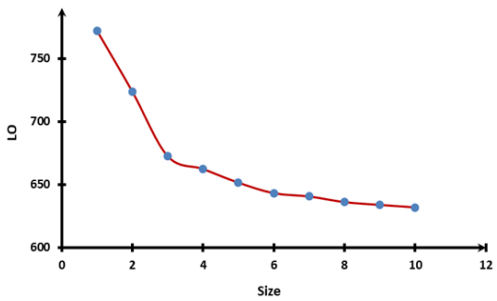


Figure 7. LO

4. CONCLUSION

In this paper, the red phosphor $Ba[Mg_2Al_2N4]Eu^{2+}$ is considered as the novel recommendation for improving the optical properties of the 6000K conformal packaging WLEDs (CPW-LEDs). For this purpose, the influence of the $Ba[Mg_2Al_2N4]Eu^{2+}$ size on the optical properties in terms of CCT, CQS, CRI and LO is proposed and investigated using the Light Tools and Mat Lab software. From the research results, we can see that the optical properties of the 6000K CPW-LEDs is significantly influenced by the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ particle. The CRI and CQS increase from 65 to 67 and 64 to 68 while the size of the $Ba[Mg_2Al_2N4]Eu^{2+}$ phosphor particle vary from 1 μm to 10 μm, respectively.

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