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Improving the optical efficiency of white light-emitting diodes based on phosphor-in-glass by a dual-layer remote phosphorus structure with the application of $LiLaO_2:Eu^{3+}$ and $CaSO_4:Ce^{3+},Mn^{2+}$

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ABSTRACT

While the remote phosphor structure is not an appropriate solution for WLED color uniformity, it is more advantageous for the luminous output of WLED than the conformal phosphor or in-cup phosphor structures. Acknowledging the ability of the remote phosphor structure, many studies have been carried out to surmount the color quality disadvantage of this structure. A dual-layer remote phosphor configuration is proposed in this research paper to acquire better color quality for WLEDs through heightening the color rendering index (CRI) and the color quality scale (CQS). The color temperature of the WLED packages this study is 8500 K. By inserting a layer of green $CaSO_4:Ce^{3+},Mn^{2+}$ or red $LiLaO_2:Eu^{3+}$ phosphor on the yellow $YAG:Ce^{3+}$ phosphor layer, the phosphor structure configuration can be constructed. Then, to get the best color quality, the concentration of added phosphor $LiLaO_2:Eu^{3+}$ would be changed. The findings showed the rise of CRI and CQS along with the $LiLaO_2:Eu^{3+}$, which implies the influence of $LiLaO_2:Eu^{3+}$ to the growth of red light components within WLEDs packages. The greater the concentration of $LiLaO_2:Eu^{3+}$ is, the more the CRI and CQS increase. Meanwhile, the luminous flux gains from the green phosphor $CaSO_4:Ce^{3+},Mn^{2+}$. Nevertheless, the luminous flux and color quality would decrease if the concentrations of both red $LiLaO_2:Eu^{3+}$ and green $CaSO_4:Ce^{3+},Mn^{2+}$ phosphors reach a certain corresponding level. Centered on using the Mie-scattering theory and the law of Lambert-Beer, this result is illustrated. The findings in this research are vital references for manufacturing WLEDs with higher white light performance.

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1. INTRODUCTION

As the lighting industry has higher requirements for lighting solution these days, phosphor converted white light emitting diodes (pc-WLEDs) are considered to be the fourth viable light source generation and can be an alternative to the conventional one [1]. In our daily life, the popularity of white light-emitting diodes is undeniable. In several ways, such as architecture, street lighting, backlighting, and more, they are used. However, there are two principal factors that white LEDs require enhancements to widespread their usage: the efficiency in light extraction and the angular uniformity of associated color temperatures [2]. Further