Improving color gamut of white LED for LCD B/L application

H.J. Lee*, J.S. Yoo
School of Chemical Engineering and Materials Science, ChungAng University, 221, Huksuk-Dong, Dongjak-Ku, Seoul 156-756, Korea
Phone: 82-2-820-5274, E-mail: jsyoo@cau.ac.kr

Abstract

A three-band white LED was fabricated by combining a blue LED with SrGa2S4:Eu (green) and CaS:Eu (red) phosphors for improving the color gamut, which is favorable to full color image.

1. Introduction

The use of a blue-emitting chip in combination with a yellow phosphor is the most widely used approach for producing white light with LED. There have been some detailed studies on the integration of the InGaN blue-emitting LED and yellow Y3Al5O12 garnet (YAG) doped with cerium (Ce3+) ion, because it produces white light from a combination of blue LED emission (450~470nm) and broadband of yellow YAG phosphor. The YAG phosphors were considered as an innovation for solid-state lighting due to light weight and long lifetime. The luminous efficiency of the commercialized white LED is 30 lm/W at 20 mA, and higher than that of incandescent lamps (15lm/W), but lower than that of fluorescent tube (75lm/W). Therefore, it is important to improve the efficiency of white LED.[1] Besides, white LED based on a blue chip and YAG phosphor show color rendering index (CRI) of 80% due to lack of red emission color. For general illumination, more than 90% CRI are required, and the low correlated color temperature of white LED such as warm lights is required. [4]

To overcome these problems, ultraviolet (UV) LED excited white phosphor based on a mixture of red, green, blue phosphors were proposed for general lighting applications. By mixing of three converters, it is possible to render any color in the CIE diagram and to approach the high CRI of fluorescent tubes. However, there exists a poor blue emission color and the low luminescent efficiency in this system due to the strong reabsorption of the blue light by the red and yellow phosphors.[2]

To complementary solution of these problems, we fabricated a three color white LED by using a blue LED with green and red phosphor coating. This method is possible to obtain the proper white CIE point for realizing full color images as well as high efficiency. Moreover, the white color coordinate is very sensitive to the emission spectrum from the phosphors in case of the phosphor-converted LED. Therefore, various color temperature are obtainable by controlling the amounts and ratios of the green and red phosphors. [4]

For this work, a three-band white LED was obtained by combining a blue LED with SrGa2S4:Eu (green) and CaS:Eu (red) phosphors. Furthermore, to improve luminance intensity SrGa2S4:Eu (yellow) phosphors were successfully added .

2. Experimental

In the first, it mixes the Epoxy and the Hardener with 1:1 mass ratio. During 20 minutes, it mixes the Epoxy and the phosphor at the fixed ratio. It puts in the vaccum chamber during 30 minutes and it removes the bubble. It takes mixture with the syring and it puts above the Blue LED Chip. The samples were heated in a furnace at 160°C. Photolumicescence (PL) and chromaticity of the three-band white LED were measured using a 10 cm diameter integration sphere capable of measuring PL. A commercial white LED with blue GaN Chip and YAG:Ce phosphor is used as a reference sample to compare with our fabricated white LEDs : (x,y)=(0.3076, 0.2943), Tc=7250K, CRI=80%, forward-bias current=20 mA

3. Results

To improve CRI of the white LED, SrGa2S4:Eu (green) and CaS:Eu (red) phosphors were coated on a blue LED. SrGa2S4:Eu and CaS:Eu have strong absorptions at 460nm, which is an emission

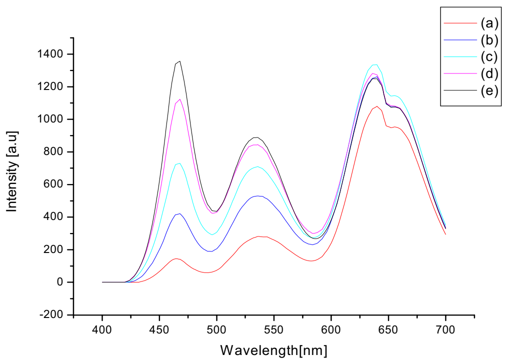

Figure 1. Photoluminescence spectra of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu . The ratio of phosphors to epoxy is (a) 0.167 (b) 0.143 (c) 0.125 (d) 0.111 (e) 0.1

wavelength of the blue LED used in this work. The three band white LED can be obtained from SrGa2S4:Eu and CaS:Eu phosphors emission under the excitation of a blue LED and blue emission in itself.

Figure 1 shows the PL spectra of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu phosphors. The fixed ratio of SrGa2S4:Eu to CaS:Eu is 0.33 by weight. Three distinct emission peaks are shown at 460, 530, and 640nm, which represent the blue, green, and red, repectively. As the concentration of both SrGa2S4:Eu and CaS:Eu phosphors are increased, the intensity of blue emission wavelength decreases, while those of green and red emission wavelength increase. Figure 2 shows CIE chromaticity coordinates of 460nm pumped White LEDs with SrGa2S4:Eu, CaS:Eu.

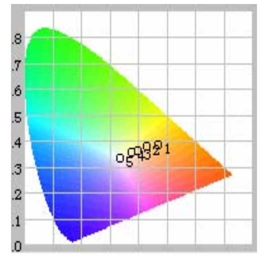

Figure 2. CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu The ratio of phosphors to epoxy is (a) 0.167 (b) 0.143 (c) 0.125 (d) 0.111 (e) 0.1

Near the coordinates of (0.33, 0.33), we can obtain a white LED with three emission bands. When the concentration of both SrGa2S4:Eu and CaS:Eu phosphors are increased, the intensity of blue emission wavelength decreases, while those of green and red emission wavelength increase. Therefore, we can obtain full color emitting LED by simply adjusting both the ratio of SrGa2S4:Eu to CaS:Eu and the concentration of SrGa2S4:Eu and CaS:Eu phosphors. Also, in order to examine the interrelation of the spectrum and color coordinate which it follows in ratio of the phosphor and the epoxy, that of the R, G phosphors, we made an experiment with white LED fabrication.

Figure 3,4,5,6 shows the PL spectra and CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu phosphors. Differential ratio of SrGa2S4:Eu to CaS:Eu is 0.5, 0.6, 0.7, 0.65 by weight. As the concentration of green phosphor is increased, the intensity of green emission wavelength increases and that of red emission wavelength decreases.

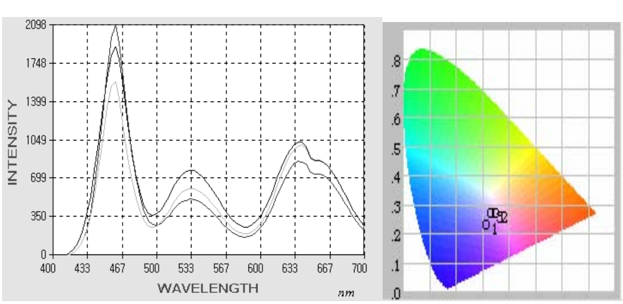

Figure 3. Photoluminescence spectra and CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu . The fixed ratio of phosphors SrGa2S4:Eu to CaS:Eu is 0.5 by weight. The ratio of phosphors to epoxy is (1) 0.1 (2) 0.090 (3) 0.083

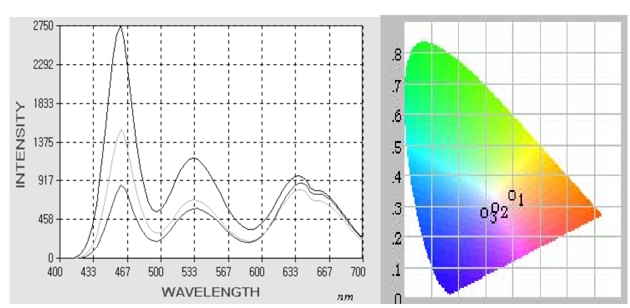

Figure 4. Photoluminescence spectra and CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu . The fixed ratio of phosphors SrGa2S4:Eu to CaS:Eu is 0.6 by weight. The ratio of phosphors to epoxy is (1) 0.1 (2) 0.090 (3) 0.083

Moreover, when the ratio of green phosphor to red phosphor is 6.5, 7 by weight, we obtained the good result of the white point and the CRI.

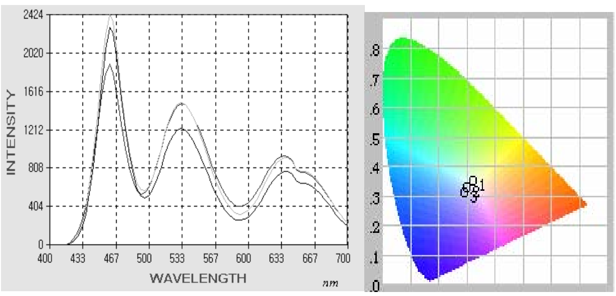

Figure 5. Photoluminescence spectra and CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu. The fixed ratio of phosphors SrGa2S4:Eu to CaS:Eu is 0.7 by weight. The ratio of phosphors to epoxy is (1) 0.1 (2) 0.090 (3) 0.083

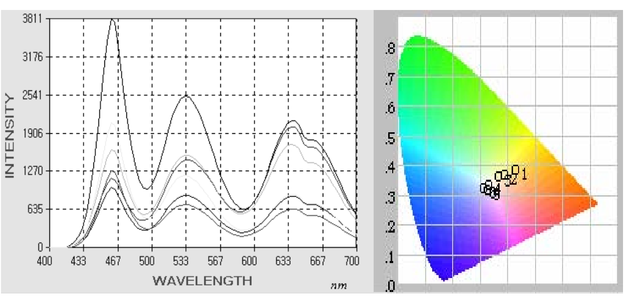

Figure 6. Photoluminescence spectra and CIE chromaticity coordinates of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu . The fixed ratio of phosphors SrGa2S4:Eu to CaS:Eu is 0.65 by weight. The ratio of phosphors to epoxy is (1) 0.11 (2,3) 0.1 (4,5) 0.090 (6) 0.083

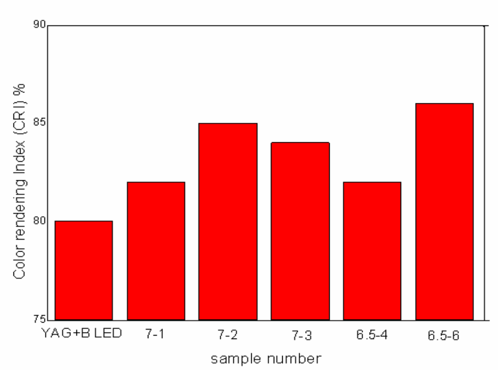

Figure 7. CRIs of 460nm pumped white LEDs with SrGa2S4:Eu, CaS:Eu.

The CRIs of our samples are shown in Figure 7. Most of the samples are higher than the CRI of the commercial white LED with blue GaN chip and YAG:Ce phosphor (CRI=80%). It is because the color gamut is widening by using the combination of three emission colors.

4. Conclusion

We fabricated a three color white LED by using a blue LED with green and red phosphors. This structure makes it possible to obtain the proper white CIE point for realizing full color images as well as high efficiency. The white color coordinate is very sensitive to the emission spectrum from the phosphors in case of the phosphor-converted LED. Therefore, various color temperature are obtainable by controlling the amounts and ratios of the green and red phosphors. Also, serious problem occurred by patent issue can be avoided with this kind of approach with new phosphors. Furthermore, We expect to enhance the luminance intensity of the white LED without payoff in color purity by adding SrGa2S4:Eu (yellow) phosphors.

5. Acknowledgements

The LED chips used in this work were supplied by the Seoul Semiconductor Co., Ltd. Authors greatly appreciate their support.

6. References

[1] J.K. Park, Journal of the electrochemical Society 152(8) H121-H123 (2005)

[2] J.S. Kim, Journal of the electrochemical Society, 152(2) H29-H32 (2005)

[3] Y.D. Huh, Journal of the electrochemical Society, 150(2) H57-H60 (2003)

[4] J.S. Yoo, Journal of the electrochemical Society 152(5) G382-G385 (2005)