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EXTENDED WAVELENGTH LED FOR RADIOMETRICAL AND PHOTOMETRICAL CALIBRATION

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Abstract

Typical white LED has limited energy beyond the band of (420-720) nm, which is not suitable as a transferring standard for spectral radiant flux, spectral irradiance. An extended wavelength LED has enough spectral intensity in the whole visible range has been developed, by six LED dies and RGB phosphor. The spectrum and stability of the developed LED was evaluated and the possibility of it to be used as luminous flux lamp was studied in a 2m integrating sphere-spectroradiometer, the testing result shows it could be worked as a reference standard for transferring spectral radiant flux to calibrate the luminous flux for generally used LED inside the range of uncertainty.

Keywords: Standard Lamp, LED, Total Spectral Radiant Flux, Total luminous flux, Spectral irradiance, Integrating Sphere- Spectroradiometer, Uncertainty

1 Introduction

High quality standard Light source having sufficient intensity in UV and blue range is lack in the field of radiometry. Xenon lamp and halogen lamp with high CCT are widely used as a transferring standard in near UV band, unfortunately, halogen lamp doesn't have sufficient intensity at this band even burning at high CCT, xenon lamp is not stable enough as a standard lamp. As well as, the spectral reflectance of the integrating sphere coating, the responsivity of spectroradiometer and photometry detector are lower in this band, which caused higher measurement uncertainty. The International comparison of APMP.PR-S3 in measuring photometric, colorimetric quantities of a group of colour and white LED chip showed that the deviation of measurement result of blue LED is obviously bigger than white and green, possibly due to the big uncertainty for the spectroradiometer calibration in blue band and imprecise spectral mismatch correction applied for photometer.

Recently, with the remarkable development of LED, the efficiency of LED in blue and UV band is improved. Special spectrum designed LED with sufficient intensity in blue and UV band that be used as a reference light source is becoming possible, as reported NMIJ has been developed a new standard LED covering the full visible light wavelength, for total spectral radiant flux and luminous flux transferring.

2 Development

Most of commercial white LEDs generate white light by mixing the blue emission from the blue LED die and the yellow fluorescence from the phosphor, which has limited energy beyond the band of (420-720) nm. For this reason, typical white LEDs developed to date have not been suitable as standard sources for spectral irradiance or spectral radiant flux. Furthermore, there is a sharp ripple from the blue LED die and a gorge between the blue ripple and the yellow broad ripple, this will cause spectral measurement uncertainty related to the characteristics of spectroradiometer, such as wavelength accuracy, linearity, bandpass. In order to generate sufficient light intensity over the full visible range, without step ripple and gorge of the spectrum. A special spectrum designed LED has been developed, which combined of six types LED dies with different central wavelength from 390nm to 460nm, to excite 2 types red, 2 types of green, 1 types of blue phosphors (RGB phosphor), Figure1is the design of the extended wavelength LED(EWLED).

The developed LED is a COB model composed of 48 LED dies, with a diameter of 9.8mm, the maximum driven current is 200mA, forward voltage is 36V, and typical luminous flux is 250lm. A mechanism heat sink and temperature control system is used to keep it works in a stable temperature 25℃. It could be worked in 2π model or 4π model in an integrating sphere.

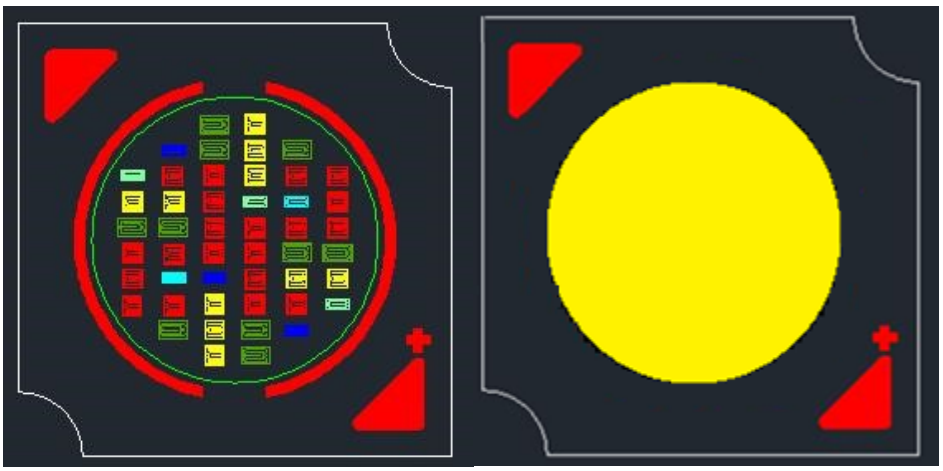

Figure 1 – Design of the extend wavelength LED

3 Characterization and Results

3.1 Spectral characteristics

The spectral characteristics of the EWLED were evaluated in the NIM integrating sphere-spectroradiometer using spectra radiant flux lamp as transferring standard. Figure 2 is the spectrum of the developed EWLED, a typical white LED and source A. The developed EWLED greatly enhanced the intensity in the blue range compared to typical white LED and incandescent lamp, in the range of (380-450) nm is 4 times stronger than source A, in the range of (650-780) nm is stronger than typical LED, when each spectrum normalised at their maximum value individually.

The spectrum shape of the EWLED is closely related to the driven current and the controlled temperature of the heat sink. The relative intensity at the blue band cannot be effectively enhanced at lower driven current compared to 200mA. Each type LED die has different temperature dependence ratio for radiant intensity and peak wavelength. The spectrum in Figure 2 is obtained at driven current 200mA with the heat sink controlled at 25℃.But, there is a gorge at 430nm～435nm, as we currently lack of LED die with peak wave length at this band.

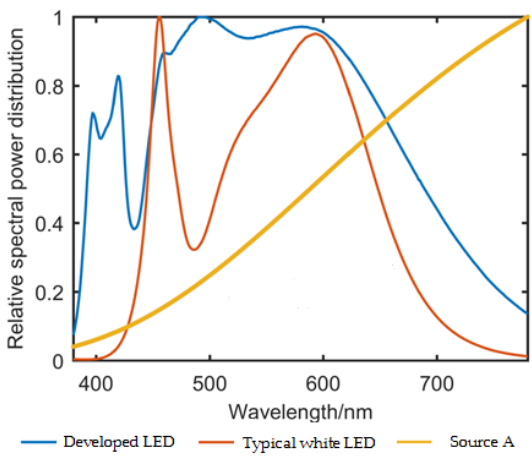

Figure 2 – Normalised spectrum of the developed LED, typical white LED and Source A

3.2 Stability

The short-term stability of luminous flux and spectral radiant flux were evaluated by one hour operation in NIM 2m integrating sphere spectroradiometer with the temperature of the heat sink controlled at 25°C, as shown in Figure3. During one hour period the fluctuation of luminous flux is 0.1% and CCT is 3K. The reproducibility to be tested followed: operating the lamps for 1 hour during consecutive days for 90 days and measurement every 30 days. Table 1 shows the reproducibility of two EWLED driven at 20mA and 100mA individually, which is less than 0.1%, equivalent to incandescent lamp.

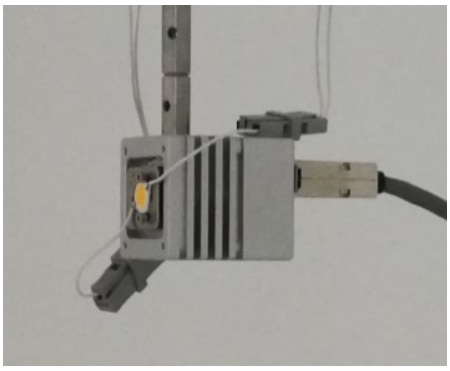

Figure 2 – EWLED with heat sink

Table 1 – Repeatability of the extend wavelength LED

	First Round	Second Round	Third Round
EWLED@20mA	50.85 lm	50.85 lm	50.82 lm
EWLED@100mA	243.5 lm	243.4 lm	243.4 lm

3.3 Testing

In order to investigate the possibility of the developed EWLED been used as transferring standard for photometrical calibration, one EWLED operated in 4π model, was used as a reference spectral radiant flux lamp to calibrate the integrating sphere-spectroradiometer, the luminous flux of a group of LED with colour of red, green, blue, white were measured one by one. Again as the same procedure the reference lamp are substituted by a typical white LED and source A. The measurement result of EWLED reference and typical LED reference were compared to incandescent reference lamp (source A) as shown in Table 2..The deviation of luminous flux using EWLED reference to source A reference is within the measurement uncertainty. Especially for the measurement of blue LED CRHP-B5 the deviation of using EWLED reference is 0.37%, typical LED reference is 0.80%, which shows EWLED has advantage over the typical LED as a reference lamp.

Table 2 – Compared the EWLED and typical LED reference to source A reference

Lamp to be measured	Reference Lamp	Luminous Flux lm	Relative Deviation%
CRHP-R5 Red LED	Source A	54.43	
	EWLED	54.65	0.40
	Typical LED	54.69	0.48
CRHR-G1 Green LED	Source A	81.8	
	EWLED	82.0	0.24
	Typical LED	82.25	0.55
CRHP-B5 Blue LED	Source A	32.54	
	EWLED	32.66	0.37
	Typical LED	32.8	0.80
CRHP-W5 Typical white LED	Source A	93.79	
	EWLED	94.08	0.31
	Typical LED	94.32	0.57
24V/50W-4# Incandescent lamp	Source A	794.0	
	EWLED	796.4	0.30
	Typical LED	798.2	0.53

4 Conclusion

We have developed a kind of extended wavelength LED (EWLED), which has sufficient intensity and relative smooth spectrum in the whole visible band, especially in the blue band compared to typical white LED. The possibility of it to be used as a photometrical standard has been studied, which shows it is a good candidate to instead of high CCT halogen lamp in the field of radiometry and photometry. In the future we will enlarge the band out of the visible range and uniform the spectrum shape furthermore.

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