Development of a total luminous flux measurement facility for LEDs at the National Metrology Institute of Japan

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Abstract. At the National Metrology Institute of Japan (NMIJ), the research of photometric standards for Light Emitting Diodes (LEDs) has been started. In this paper, we have developed the facility for the measurement of the LEDs total luminous flux based on the goniophotometric method and also have evaluated the uncertainty of the measurement of the LEDs total luminous flux.

Introduction

Light Emitting Diodes (LEDs) came into use in various fields and their importances are increasing. Accurate photometric techniques and standards for LEDs measurement are demanded. Therefore, the research on the LEDs measurements is done actively now at many National Metrology Institute (NMI) and Commission International de I'Eclariage (CIE). Also at the National Metrology Institute of Japan (NMIJ), the research of the photometric standards for LEDs has been begun in response to such situation in and outside the country.

In this study, we have developed the facility for the measurements of a LEDs total luminous flux and have evaluated its uncertainty with a calculation and experimental methods.

Goniophotometer for LEDs measurements

The measurement of LEDs total luminous flux at NMIJ is based on the goniophotometric method to cope with strong partially luminous intensity distribution of LEDs. The facility is composed of a rotation stage of LEDs, a photometer and an optical alignment stage. The schematic diagram of the facility is shown in Fig.1. The Photometer is installed on the automatic motion stage and the measurement in arbitrary distance up to 1.2m is possible. The illuminance responsivity (A/lx) and the relative spectral responsivity of the photometer are traceable to the NMIJ luminous intensity scale and the NMIJ spectral responsivity scale, respectively. Furthermore, when measuring the averaged LED intensity, the photometer with aperture area of 100mm^2 for the averaged LED intensity measurement is used instead of the photometer with high-illuminance responsivity for the LEDs total luminous flux measurement. The averaged LED intensity is measured by moving the photometer position to the CIE standard condition (condition A=316mm, condition B=100mm). By measuring the luminous flux measurement and the averaged LED intensity measurement in same geometric arrangement, we can evaluate both the uncertainty related to mechanical axis installation error and optical axis in the averaged LED intensity measurement. The laser beam from the optical alignment stage was designed to pass the azimuth axis (ϕ) and the polar axis (θ) of the rotation stage.

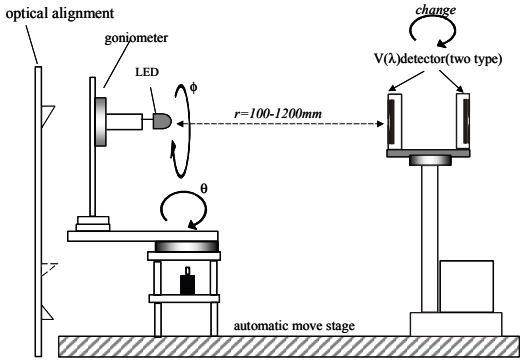

Fig 1. Schematic diagram of the LED goniophotometer

Evaluation of Uncertainty

The uncertainty of the LEDs total luminous flux measurement was evaluated about the twenty factors (for example, the temperature stability of LED, the uncertainty of the measurement distance etc). As a new trial of uncertainty evaluation of LED measurement, the uncertainty related to the geometric conditions between the photometer and a test LEDs was calculated using polar coordinates. Furthermore, the uncertainty of the color correction factor, which is derived from the uncertainty of spectral distribution of LEDs and spectral responsivity of photometer, was calculated using the Monte Carlo methods.

As a result, it turned out that the uncertainty of the illuminance responsivity of photometer (u=0.35%), the temperature stability of a LEDs (u=0.18%) and the installation error of a LEDs to rotations center (u=0.1%) are the largest uncertainty factors. Furthermore, the uncertainty of the measurement distance could almost be disregarded in the total luminous flux measurement that is measured at 1m. However, this uncertainty factor cannot be disregarded in the averaged LED intensity measurement, because of its short measurement distance. The uncertainty of a color correction factor of a white LED, a blue LED and a red LED was calculated to be u=0.02%, u=0.17%, and u=0.16% from the Monte Carlo method respectively. This calculation results clearly showed that there was a large uncertainty in the color correction factor of LED.

Conclusion

We developed the facility for the measurement of the LEDs total luminous flux based on the goniophotometric method and also have evaluated its uncertainty. The result of the uncertainty evaluation showed that the temperature stability of LEDs and the installation error of LEDs to rotations center were the largest uncertainty factors. Furthermore, the result of Monte Carlo calculation showed that the uncertainty of the color correction factor of LEDs couldn't be disregarded.

References

Commission International de I'Eclariage "Measurement of LEDs", CIE Publication 127, 1997.