Development of illuminance meter calibration system with LED spectrally tunable light source

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Calibration of an illuminance meter is usually done using a photometric bench and a luminous intensity standard lamp. To replace standard lamp method, we constructed an illuminance meter calibration system based on an LED based spectrally tunable light source (LSTL). CIE Illuminant A approximate spectra realized by the LSTL was controlled at various illuminance values. A test illuminance meter was calibrated by comparison against a reference photometer with the realized Illuminant A approximate spectra.

INTORODUCTION

Illuminance meters are normally used to measure the degree to which incident light from indoor lighting and sunlight illuminates a surface. Calibration of an illuminance meter is usually done using a photometric bench and a luminous intensity standard lamp[1]. The luminous intensity standard lamp is an incandescent lamp that realizes a spectrum of the CIE standard illuminant A (Illuminant A), i.e., its relative spectral distribution is that of Planck radiation at a temperature of about 2856 K[2].

In recent years, by increasing replacement of incandescent lamps with white LED lamps, it has become difficult to obtain the standard lamps. Although LED lighting is used widely, it is important to measure illuminance from sunlight. Therefore, the calibration of illuminance meter based on an Illuminant A approximate spectrum is continued to need for industrial and testing laboratory too.

As a candidate calibration source to take the place of traditional lamp sources, including incandescent lamps, an LED-based spectrally tunable light source (LSTL) has been investigated in several fields[3-5]. The main benefit of LSTLs is that it allows realization of different spectral and various optical intensities with only one lighting system without exchange of several light sources.

In this study, we constructed an illuminance meter calibration system based on LSTL as a pilot study. In the system, test illuminance meters are calibrated by comparison against a reference photometer using an Illuminant A approximate spectrum realized by the LSTL.

CALIBRATION SYSTEM DEVELOPMENT

The calibration system was constructed by modifying an LSTL developed for a solar simulator in the photovoltaic field. An overview of our constructed calibration system is depicted in Figure 1. Overall dimensions of the calibration system are about 1.5 m (H) × 0.8 m (W) × 0.8 m (D). The calibration system consists of the LSTL, two CCD cameras for ascertaining the measurement position, a reference photometer, and a spectroradiometer. In addition, the measurement instruments including a test photometer are installed on a two-axis automatic movement stage (travel length of both axes: 300 mm), which enables accurate comparison measurement at the same position. The measurement distance from the LSTL to the measurement plane is 400 – 450 mm. The measurement distance is limited by the based solar simulator system.

The LSTL was constructed from 21 types of monochromatic HP-LEDs and two quasi-green yellow LEDs based on white HP-LED at wavelengths

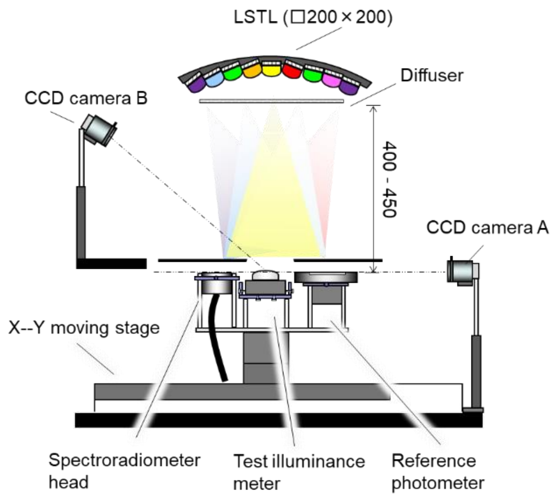

Figure 1. Schematic drawing of the illuminance meter calibration system based on LSTL.

Figure 2. Photograph of LSTL (21 types of monochromatic HP-LEDs and two quasi-green yellow LEDs based on white HP-LED).

of 340 – 800 nm for covering the UV–visible range. Two or four of the same type HP-LEDs were used in one wavelength band. A total of 54 LEDs was used in LSTL. Figure 2 shows a photograph of the LSTL. Their maximum operated current depends on the LED type (500 – 3,000 mA maximum rated current). The optical power can be changed by individual constant current control of each LED from 10 mA to 3000 mA. The overall LSTL shape is a dome-shaped frame. HP-LEDs of the same type were placed diagonally on the LSTL dome frame, with total emission area of the 54 mounted LEDs as 200 mm square.

To improve illuminance power and illuminance uniformity on the measurement plane, individual HP-LEDs have compact magnifier optics. The magnifier optics was constructed with a light pipe (10 mm square, 135 mm length) and a condensing lens ($f = 25$ mm). It was designed to form a uniform illuminance plane of 200 mm square at the measurement plane with individual HP-LEDs.

Test illuminance meters were calibrated by comparison against the reference photometer using an Illuminant A approximate spectrum realized by the LSTL: the illuminance value of Illuminant A approximate spectrum is determined using the reference photometer. The test illuminance meter is calibrated from that value. This method is generally called as the detector-based method[1]. Using this method, the illuminance scale is provided using a reference photometer, not by a standard lamp.

Figure 3 shows a spectral distribution of an Illuminant A approximate spectrum realized by the LSTL. The chromaticity coordinate of the approximate spectrum is (u',v')=(0.239, 0.538). The illuminance is about 10,000 lx. Above condition,

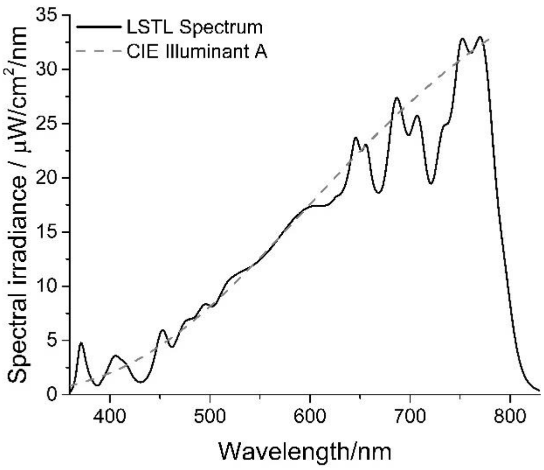

Figure 3. Spectral distribution of an Illuminant A approximate spectrum realized by the LSTL.

diffuser was not inserted for the maximum illuminance. The Illuminant A approximate spectrum in Figure 3 achieves very high illuminance that are difficult to achieve using traditional standard lamps. The Illuminant A approximate spectrum can achieve various illuminance values (800 lx to 10,000 lx) and diffuse characteristics by controlling the current value and inserting a diffuser.

CONCLUSION

In this study, the illuminance meter calibration system based on the LSTL was constructed to replace standard lamp methods. To construct the LSTL to cover wavelengths of 340–800 nm, 23 types were used. The Illuminant A approximate spectrum realized by the LSTL was controlled at various illuminance values from 800 lx to 10,000 lx

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