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A MULTIFUNTCIONAL SETUP FOR MEASUREMENT OF LED LUMINOUS FLUX BASED ON INTEGRATING SPHERE METHOD

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A setup for measuring luminous flux of light emitting diodes (LEDs) was constructed and characterized. The measurement setup (see Fig. 1) is based on the CIE 127 standard [1]. It consists of a 30-cm integrating sphere, a standard photometer with a good cosine response, temperature stabilizers for both low power LEDs and high power LEDs[2] and a temperature controller unit. The total luminous flux and the partial LED flux of low and high power LEDs can be measured using the same integrating sphere. In our knowledge, this kind of a multifunctional setup for LED luminous flux measurement has not been published before.

In the total luminous flux measurement mode of low power LEDs ("Total flux A"), the LED is placed at the center of the sphere by using a lamp holder. By doing so, also the backward emission of the LED is taken into account in the measurement. The total luminous flux of high power LEDs is measured using a 21-mm aperture and by operating the test LED with a temperature stabilizer on the edge of the sphere ("Total flux B").

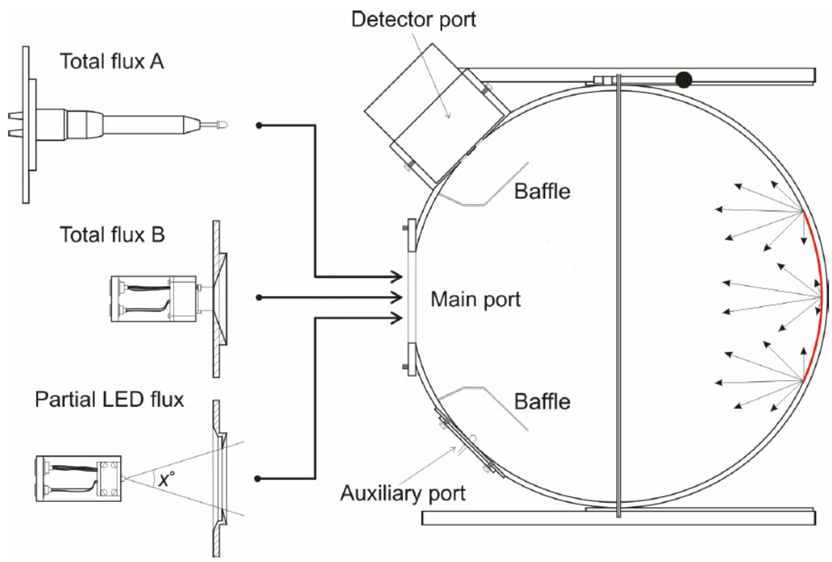

Figure 1. Functional diagram of the integrating sphere and the parts used in different measurement modes. Total flux A: Lamp holder. Total flux B: Temperature stabilizer for high power LEDs & 21-mm aperture. Partial flux: Temperature stabilizer for low power LEDs & 50-mm aperture.

[2] Low power LEDs are herein considered as lamp type LEDs with a nominal current of 20 mA. High power LEDs are considered as surface mounted LEDs in connection with a printed circuit board.

A 50-mm precision aperture is used for the partial LED flux measurement mode, in which the LED is also operated outside of the sphere. Depending on the measurement distance, the flux entering the sphere forms a measurement angle x [1]. In every measurement mode, the self-absorption or reflection of the test LED is measured by comparing the signal levels of the auxiliary LED with and without the test LED being in the measurement position.

In addition to a detector port and an auxiliary LED port, the integrating sphere has only one entrance port, in contrast to other designs which typically have an additional port for the lamp holder [2,3]. The port design of our sphere allows the light beam to hit the same clear hemisphere area from the same direction in all measurement modes and in the calibration of luminous responsivity of the sphere photometer, thus improving the reliability of the calibration with an external source. The area of the ports and baffle supports is less than 2 % of the total sphere surface. While designing the lamp holder, special attention was paid to minimize the near-field absorption of the backward emission of the LED.

The integrating sphere photometer was calibrated for the luminous flux responsivity in the partial flux mode against a reference photometer by producing a known external luminous flux using a luminous intensity standard lamp. The illuminance of the external source was first measured with the reference photometer. It was then replaced by the sphere photometer so that the 50-mm precision aperture was at the same distance from the source and the photocurrent was measured with the standard photometer of the sphere. A white auxiliary LED was used for transferring the luminous flux responsivity from the partial flux mode to the two total luminous flux modes. This was done by measuring the signal levels of the auxiliary LED in the sphere, while the lamp holder or one of the two apertures was installed in the main port of the sphere. This measurement method is faster and easier to carry out than using incandescent lamps for calibrating all measurement modes.

Spectral throughput of the integrating sphere was measured using a spectroradiometer whereas the relative spectral responsivity of the standard photometer was measured using our spectral responsivity measurement facility [4]. Spectral power distributions of the LEDs under test were measured in the corresponding measurement mode. The spectral measurements of phosphor-converted white LEDs are vital to be carried out in the convenient geometry because their spectra depend on the direction of observation. The spectral mismatch correction factor for the photocurrent signal of the standard photometer was calculated with the measured relative spectral responsivity of the sphere photometer and the LED spectrum.

The expanded uncertainties (k = 2) for the measurement setup vary between 2.5 % and 5.0 % depending on the measurement mode and the color of the test LED. The most significant uncertainty component is related to the measurement of the relative spectral responsivity of the integrating sphere photometer. The ability to measure both low and high power LEDs with the same integrating sphere and the opportunity to avoid characterization efforts of incident angle and spatial nonuniformity of the sphere make the measurement setup a very cost effective solution for luminous flux measurement of LEDs.

REFERENCES

[1] Commission Internationale de l'Eclairage, CIE Publ. No 127, 38p (2007).

[2] J. Hovila, P. Toivanen, and E. Ikonen, Metrologia 41, 407–413 (2004).

[3] C. C. Miller and Y. Ohno, Proc. 2nd CIE Expert Symposium on LED Measurement, 45 (2001).

[4] F. Manoocheri, P. Kärhä, L. Palva, P. Toivanen, A. Haapalinna, and E. Ikonen, Anal. Chim. Acta 380, 327–37 (1999).