Correlation of the simulated light pattern on manufacturer-based LED rayfiles with goniophotometric measurements

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This article shows a comparison of the simulated light pattern based on the data from LED manufacturers to the light pattern measured on the goniophotometer. The optical measurement setup consists of LED light source and a simulated reference reflector using computer aided lighting (CAL) program.

1 Introduction

The developing process of optical systems such as lamps on the LED basis requires three basic steps: design, prototyping, and validation. In the design phase, optical simulations of the system are performed based on rayfile's provided by light source manufacturers. Ideally, these simulations lead to a set of parameters and requirements which can later be easily validated. When using rayfile's for lamp simulation, the results in the validation phase are likely to differ since the emission characteristics of light sources vary due to production tolerances. In addition to the rayfile's exact luminous flux value, electrical and thermal specifications are also needed.

2 LED experiment

An Osram-LED was used in the experiment with a nominal power of 1 W. Five LEDs were measured in independent experiments. All samples were preassembled on printed circuit board (PCB). According to the data sheet, the range of luminous flux of the LEDs is between 76 and 121 lm at a nominal current of 350 mA, depending on the LED type and group. The color temperature is in the range of 2700-4500 K. The data sheet of the tested LEDs includes 8 types of LEDs, 6 brightness groups, 4 voltage groups, and 54 color chromaticity groups. However, only one electrical and thermal characteristic diagram, and only one rayfile for all LED types and groups are included. The development of a lighting system requires an exact definition for the group and type of the applied LED.

Table 1 shows the results of the luminous flux for 5 LEDs measured in the integrating sphere at normal current I_N= 350 and maximum current I_{MAX}=800 mA. To get representative results the same LEDs were ordered at two different times and divided into two groups: LED 1-2 (group1) and LED 3-5 (group 2). The difference in luminous flux is as much as 11 %. The measured values are slightly higher than the limits of the binning groups specified on the data sheet.

Table 1: Luminous flux of Osram Oslon SSL 80 LCW CR7P.CC at different currents

	sample number	luminous flux at 350 mA	luminous flux at 800 mA
group 1	LED 1	73 lm	136 lm
group 1	LED 2	75 lm	139 lm
group 2	LED 3	79 lm	148 lm
group 2	LED 4	80 lm	149 lm
group 2	LED 5	81 lm	150 lm

The manufacturer rayfile for the LEDs was necessary for this study. Fig. 1 shows a normalized horizontal cut of an LED measured at 350 mA (black curve) and simulated with a rayfile (broken curve). The deviation of the characteristics in the rayfile curve from the real LED curve may be a result of the difference in simulated and measured light patterns.

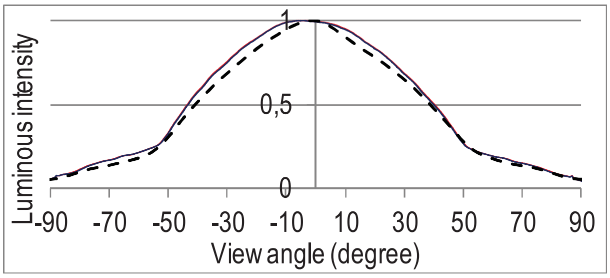

Fig. 1: Normalized horizontal cut of LED measured at 350 mA (black curve) and simulated with rayfile (broken curve)

3 Simulation of reference reflector and test setup

In this paper, ray data of manufacturer LEDs were evaluated first. The aim of the light simulation is a homogenous light pattern with a narrow view angle. The angle of the imitated beam in Fig. 1 is ± 90 and should be reduced to ± 10 degrees. This is realized by the use of a reference reflector. This was simulated with the CAL program LucidShape using a rayfile provided by Osram. Fig. 2 shows the experimental setup. It is comprised of a refer-

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ence reflector, aluminum plate, heatsink, cooling fan, and test LED.

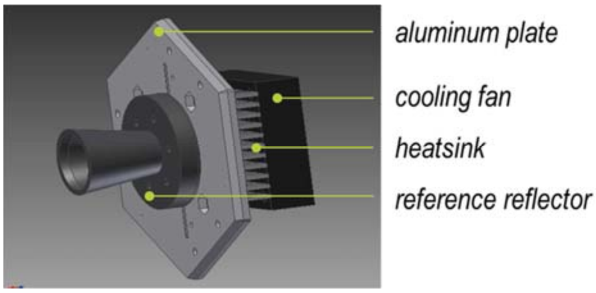

Fig. 2: Experimental setup with reference reflector designed in LucidShape

Fig. 3 shows a cross-section along the H-axis of the modified light pattern. It was simulated within the experimental setup.

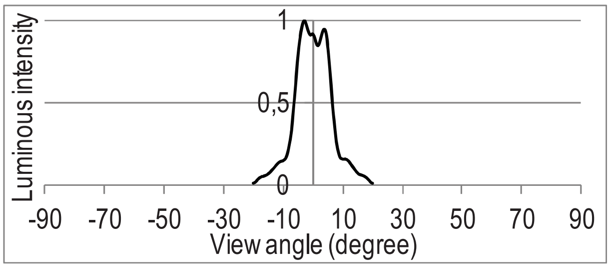

Fig. 3: H-section of light pattern simulated with experiment setup (normalized diagram)

3 Photometrical measurements and results

The light distributions of the samples were measured and evaluated on a far field goniophotometer of the highest accuracy class according to CIE No. 69/70 on a distance of 3162 mm. Fig. 4 shows the simulated distribution on the left and the measured distribution on the right.

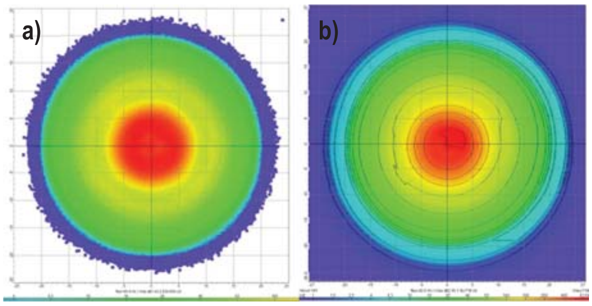

Fig. 4: Simulated a) and measured light pattern b) on 3162 mm plane

The deviation in luminous flux from the measured light pattern to the simulated light pattern in Fig. 4 is about 5 %. These results show the highest light intensity in the H-V range of ± 10 degrees in the simulated and photometrically detected light distribution.

Fig. 5 shows the horizontal cut at V=0° of five measured LEDs at 350 and 800 mA (red and blue curves) within the experimental setup shown in Fig. 2. All photometrical measurements show similar curve characteristics. The black broken curve is simulated and shows a slight difference from the measured results, as the reflector was hand polished. For this reason the simulated geometry was not exactly reproduced.

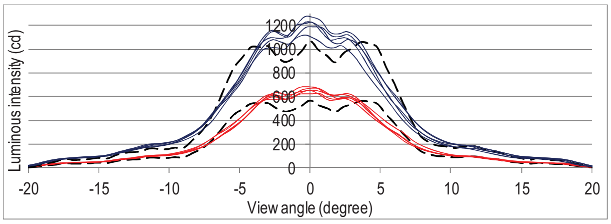

Fig. 5: Horizontal cut at 350 and 800 mA (red and blue curves) and simulated (black broken curve)

In the next step, LED 1 was tested at different currents from 100 mA up to 1300 mA (see Fig. 6). Overpowering is possible because the test setup has a very good active cooling system.

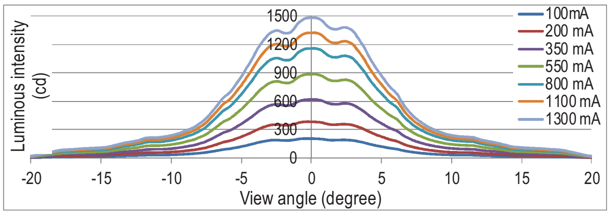

Fig. 6: Horizontal cut at different currents

For the comparison of the luminous intensity at different currents, the curves are normalized to 1. Fig. 7 shows seven normalized curves which have the exact same characteristics. The distribution characteristics of the LED will remain unchanged at different currents.

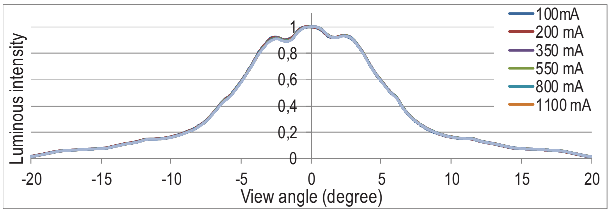

Fig. 7: Normalized horizontal cut at different currents

4 Summary

This paper shows for the first time that the rayfile correlates well to the measured light pattern of the LED. Five measurements of different LEDs within the experimental setup have similar light patterns, and luminous flux may vary by as much as to 11 %. The increase of the LED current from 100 to 1300 mA does not change the characteristics of the light pattern. Luminous flux, assembly, and manufacturing process of the subsystems have a greater influence on the light pattern than the differences in rayfile simulation and measured curve characteristics shown in Fig. 1. By observing the deviation of the measured light pattern from the simulated light pattern, an adjustment analysis of optical components in the setup can be performed.