Dariusz CZYŻEWSKI

Warsaw University of Technology, Institute of Electrical Power Engineering, Lighting Division

Investigation of high power LED luminance

Abstract *LEDs now are the fastest developing light sources. Photometric parameters improvement is closely connected with structure evolution. The increase of luminous efficiency cause increase of LEDs surface luminance also. The increasing current ranges, which can power the LED, cause a significant increase of LED chips luminance. In the paper will be presented the results of measurements how the supply current increase, change LED luminance.*

Streszczenie. *Diody elektroluminescencyjne są obecnie najdynamiczniej rozwijającymi się źródłami światła. Rozwojowi konstrukcji towarzyszy poprawa parametrów fotometrycznych. Wzrost skuteczności świetlnej powoduje wzrost luminancji powierzchni świecącej LED. Coraz szersze zakresy prądowe, którymi można wysterowywać LED, powodują znaczny wzrost luminancji chipów świecących LED. W referacie zostaną przedstawione wyniki badań, określające jak ze wzrostem prądu wysterowującego zmienia się luminancja LED.* ***(Badania luminancji wysokomocowych diod elektroluminescencyjnych).***

Keywords: light sources, LEDs, field lighting.
Słowa kluczowe: źródła światła, diody elektroluminescencyjne, obszar świecący.

Introduction

Light emitting diodes (LED) are still the most dynamically developing light sources. LEDs with very wide range of steering current can be found on the market more and more often. There are ones that can be fed with current ranging from 100mA up to 3A, while the typical operational currents are 350mA or 700mA. Such a wide range of feeding possibilities causes changes in the photometric parameters of the light source. However, the higher the steering current, the lower the LED's luminous efficacy.

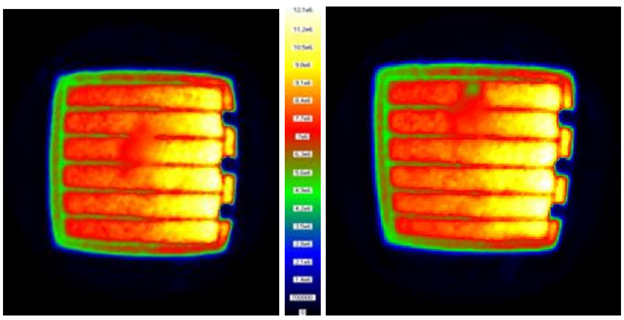
Characteristics of the examined LED

For the reasons stated above high-power diodes by various producers (European and Far-Eastern ones) of good reputation underwent the research. The rated power of particular LEDs was approximately 1W – which means that these LEDS were the most popular in the field of high-power diodes. Moreover, the diodes were characterized by extensive operating current range, at least up to 2A.
The technical parameters of the diode selected for presentation are the following:
- Color: warm white (2600K-3700K);
- Luminous flux: 220lm (700mA);
- Maximum supply current 3000mA;
- Ra ≥ 80
- Viewing angle: 125°
- Low thermal resistance: 2.5 °C / W
- Maximum junction temperature: 150 °C

In order not to forejudge the application value of the described diode, the name of the producer will not be stated.

3. Results of the realized research

The basic stage of the research included checking the luminance distribution at various observation angles. In this case it turned out that the distribution was not uniform. Fig. 1 presents luminance distribution on the surface of the examined diode for various observation directions. The diode was fed with current 700mA during the measurements.



C = 0°, γ = 0°   scale *L*   *C* = 0°, γ = 15°

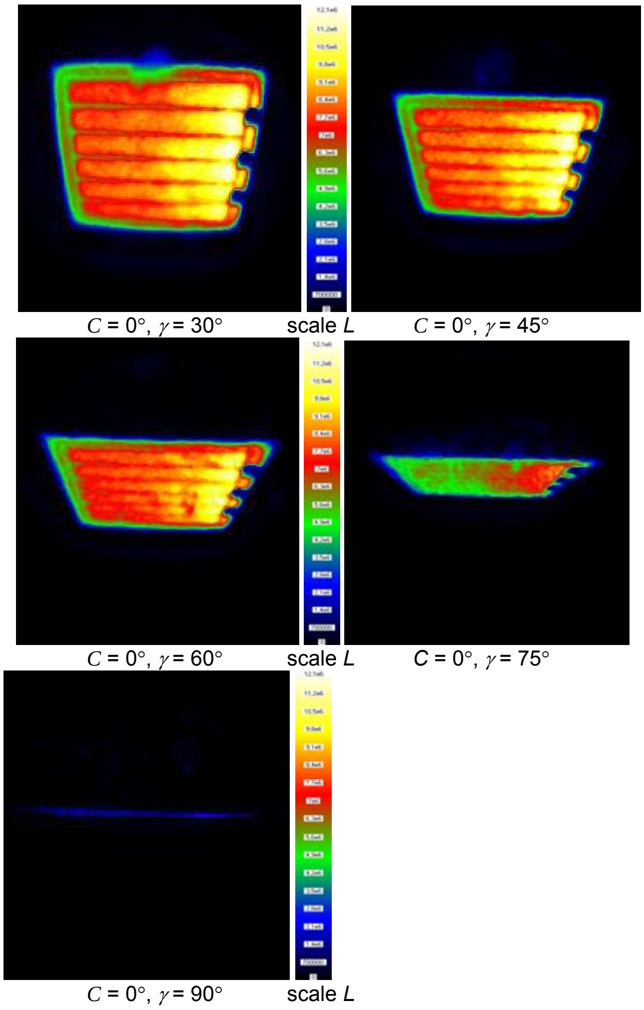


Fig. 1 Luminance distribution on the surface of the examined LED [cd/m^2], for angles γ = 0°÷90° (every 15°)

The next stage of the research was checking the luminance distribution with various diode steering currents. The LED was fed with the following currents: 150mA, 350mA, 700mA, 1000mA, 1500mA, 2000mA and 3000mA. This is when it turned out that the distribution was not even but its nature was similar in all cases. Figure 2 presents luminance distribution on the surface of the examined diode, for various currents. The LED was photometrized in semi-plane *C* = 0° and angle γ = 0°.

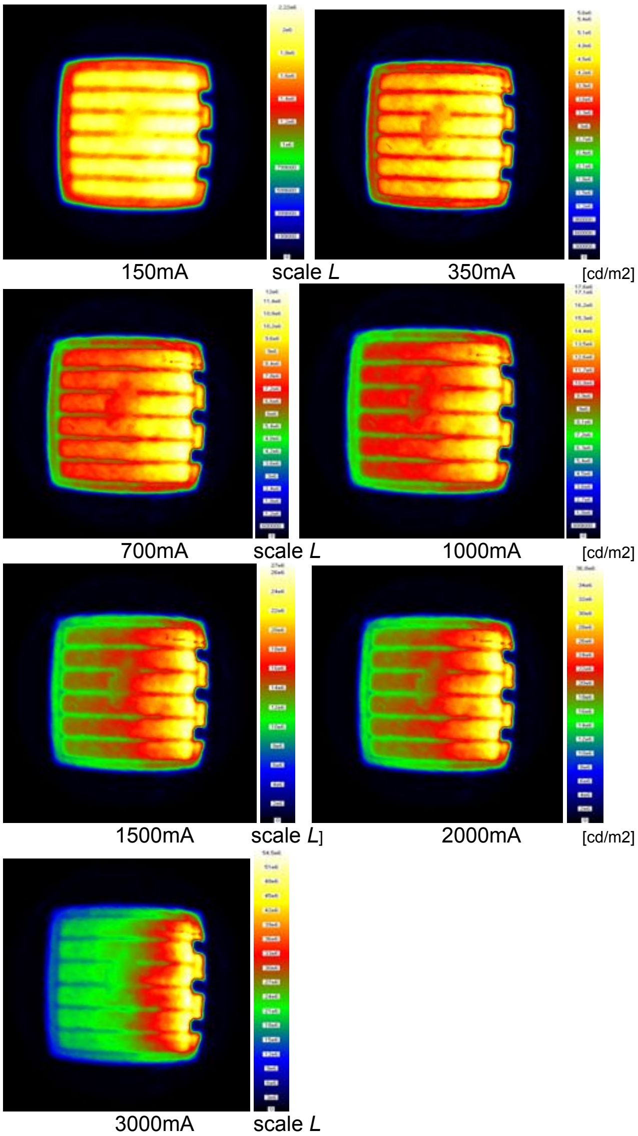


Fig. 2. Luminance distribution on the surface of the examined LED [cd/m^2] for various feeding currents

4. Analysis of the results

The analysis of the results of research concerning luminance constancy for various observation angles (fig. 1) shows that the light emitting area of the LED is changed along with the observation angle and that the changes are particularly well visible for angle γ = 75°. The maximum luminance is then dropped to 50% of maximum luminance for angle *C*0°γ0°.

Despite the theoretical rotational symmetry of the photometric block (for such diodes), the shape of the light emitting area and luminance distribution vary for various semi-planes *C*.

The shape of the light emitting area is consistent with the shape of the light emitting chip in the examined diode. In this case it is square shape. It is responsible for luminance with the greatest value. Luminance in the chip area varies within the range of 50-100% of the maximum luminance, for observation from the axial direction. The greatest luminance can be observed near the places where the current lead-in wires were connected. Table 1 depicts how a change in the supply current influences a percentage change of the maximum luminance. Results for the basic current supply, i.e. 700mA were a point of reference.

An analysis of results presented in table 1 shows that a change of the steering voltage is basically proportional to changes of the maximum luminance. Moreover, it was also concluded that luminance of the initial optical system is approximately 1% of the light emitting chip luminance (figure 3).

Table 1. Comparison of the results of maximum luminance for different LED supply currents

Supply current	Percentage change in current	Maximum luminance	Percentage change in luminance
[mA]	[%]	[cd/m^2]	[%]
150mA	21,4	$2{,}22\times10^6$	17,6
350mA	50	$5{,}6\times10^6$	44,4
700mA	100	$12{,}6\times10^6$	100
1000mA	142,9	$17{,}6\times10^6$	139,7
1500mA	214,3	27×10^6	214,3
2000mA	285,7	$36{,}8\times10^6$	292,1
3000mA	428,6	$54{,}5\times10^6$	432,5

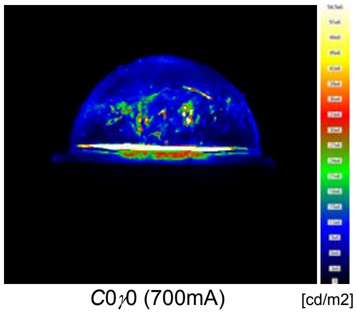


Fig. 3. Luminance distribution on the surface of the examined LED (for angle *C*0*g*0 to supply current 700mA)

5. Summary

The work presents how the luminance distribution changes on the LED surface depending on the observation angle and on the steering current. In both cases it was concluded that the luminance distribution was not perfectly uniform. In case of the axis direction it varied from 50 to 100% of maximum luminance (within the borders of the light emitting chip area). In the second part of the tests it was concluded that a change of the steering voltage was basically proportional to changes of the maximum luminance. Depending on the steering current size, the maximum luminance of the diode varied from $2{,}22\times10^6$cd/m^2 to $54{,}5\times10^6$cd/m^2. This means that by changing the LED steering, an almost 25-time increase in the maximum luminance can be obtained. This information is crucial on the stage of designing optical systems and forecasting their application. On one hand, it makes obtaining greater luminous intensity possible in certain conditions but on the other, it creates the risk of a glare.

LITERATURA

[1] Czyżewski D., Selected problems of defining the luminous area of electroluminescent diodes, *Przegląd Elektrotechniczny*; 84 (2008), n. 8, 125-128
[2] Czyżewski D.: Luminance distribution of LED luminous suffwace, *Przegląd Elektrotechniczny*, 86 (2010), nr 10, 166-169,
[3] Zalewski S., Projektowanie wtórnych układów optycznych do LED-ów, *Przegląd Elektrotechniczny*, 83 (2007), nr 5,
[4] Słomiński S., Mapowanie rozkładu luminancji źródła światła w obliczeniach fotometrycznych odbłyśników zwierciadlanych, doctoral dissertation, Politechnika Warszawska, 2010
[5] Żagan W., Rzetelnie i rozważnie o LED-ach - ocena obecnych i prognoza przyszłych aplikacji oświetleniowych diod elektroluminescencyjnych; *Przegląd Elektrotechnicznych*, 84 (2008), nr 1,.
[6] Wiśniewski A., Diody elektroluminescencyjne (LED) dużej mocy; *Przegląd Elektrotechniczny*, 83 (2007), nr 5
[7] Kotowicz A.: *Leuchtdichteverteilungen an Hoch-druckbogenentladungslampen für KFZ-Scheinwerfer und optische Parameter von Brennermaterialien*; doctoral dissertation, Politechnika Berlińska, Berlin 2004.

***Author**: dr inż. Dariusz Czyżewski, Politechnika Warszawska, Instytut Elektroenergetyki, E-mail: dariusz.czyzewski@ien.pw.edu.pl;*