KOTEL'NIKOV INSTITUTE
OF RADIO-ENGINEERING AND ELECTRONICS
OF RUSSIAN ACADEMY OF SCIENCES
(ULYANOVSK BRANCH)

The VIII International Conference on
Information Technology and Nanotechnology
May 23 - 27 May, 2022
Samara, Russia

ITNT - 2022

Measurement of the Overheating Temperature Profile of the Surface of the Light-Emitting Heterostructure by the Temperature Droop of the Luminescence Brightness

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The purpose of the investigation. The report presents an experimental approbation of a method for measuring the overheating temperature of local regions of an LED chip by mapping the relative decrease in electroluminescence brightness when the chip is heated by direct current.

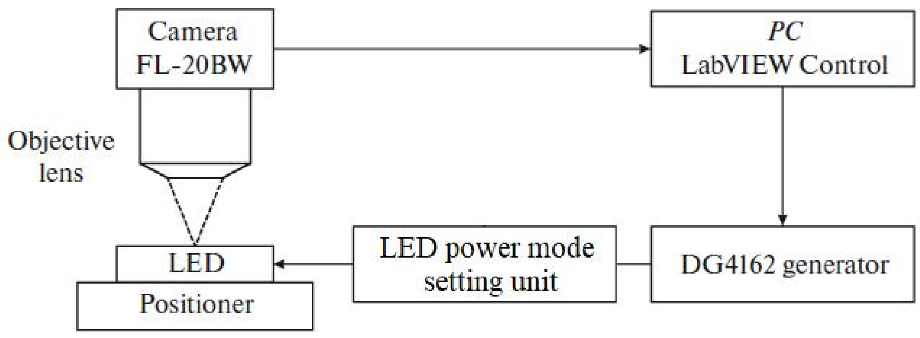


Fig. 1. Block diagram of the hardware-software complex

The hardware-software complex to measure the overheating temperature profile of the surface of the light-emitting heterostructure (fig. 1) includes a DG4162 functional generator, a block for setting the LED power supply mode with a pulsed current, a Levenhuk D320L microscope, and a FL-20BW monochrome CMOS camera with a maximum resolution of 5472x3648 pixels for recording LED chip images.

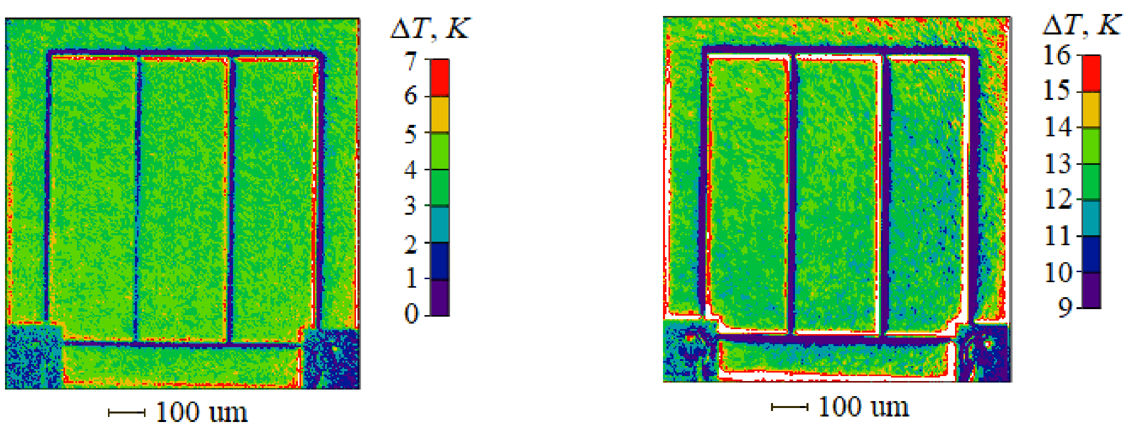
Measurement technique. The LED, fixed on a heat sink, was placed on the microscope stage. A pulsed current with amplitude *I*, pulse duration τ_I = 50 µs, and pulse ratio Q = 100 was passed through the LED. The image from the digital camera with a resolution of 5472x3648 were stored in the computer memory in the .txt format as a 16-bit array of integers. Then, a constant current *I* was passed through the LED and the image was stored in computer memory. Image processing was carried out pixel by pixel in the MathCAD environment. The overheating temperature of the local regions of the chip was determined by the formula

$$\Delta T = \left(\frac{P_2}{P_1 Q} \frac{t_1}{t_2} - 1 \right) \frac{1}{k_T},$$

where P_1 and P_2 are average values of the brightness of the pixels of the local region of the chip, measured in pulsed and continuous modes, respectively; t_1 and t_2 are exposure time of the digital camera when measured in the pulsed and continuous modes, respectively; k_T is temperature coefficient of the decrease in the luminous flux; Q is pulse ratio.

The object of the investigation. We used a commercial green LED XRCGRN-L1-0000-00M01, which has the following parameters: the maximum allowable direct direct current is 500 mA; thermal resistance junction-soldering point 8 K/W; temperature coefficient of the luminous flux droop is -1920 ppm/K; voltage temperature coefficient -4 mV/K.

Experimental results. Fig. 2 shows the overheating temperature profiles of the LED chip surface measured at 100 mA and 400 mA. The temperature distribution over the LED chip is nonuniform: near the metallization, a local temperature increase is observed, which is probably due to an increase in the current density in these regions. Fig. 3 shows the distribution profiles of the chip overheating temperature in the diagonal section of the chip. Local minima on the graphs correspond to the conductive metallization of the chip. Near the metallization, a local increase in temperature relative to the average value is observed: at a current of 100 mA it is about 1 K, and at a current of 400 mA it is about 3 K.



a) b)

Fig. 2. LED chip overheating temperature profile measured at 100mA (a) and 400mA (b)

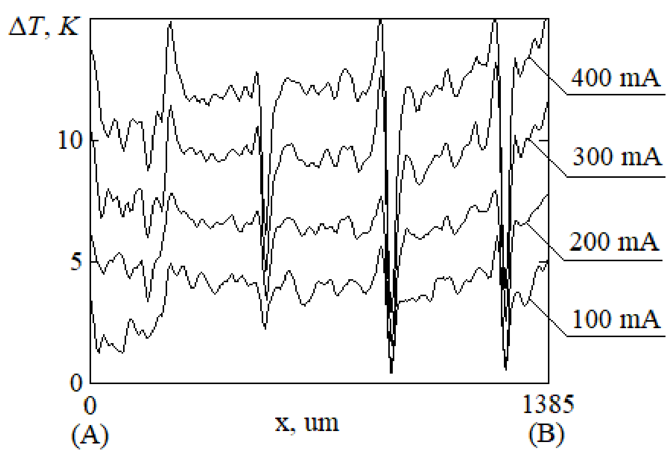


Fig. 3. Chip overheating temperature in the diagonal section of the chip

Conclusions. The method can be used to assess the quality of LEDs by thermal parameters and to diagnose the inhomogeneity of the temperature distribution over the chip area.

The study was supported by a grant from the Russian Science Foundation № 22-29-01134, http://rscf.ru/project/22-29-01134.