PARAMETERS OF OPTOELECTRONIC RADIATORS AND SPECTRAL CHARACTERISTICS IN DIFFERENT ENVIRONMENTS

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Annotation. In today's developing world, semiconductor light-emitting diodes are replacing traditional lighting sources. Semiconductor light-emitting diodes differ from other types of light sources due to their energy efficiency, long service life, and environmental friendliness. Semiconductor light-emitting diodes emit beams of light with specific wavelengths. The article presents the measurement parameters, characteristics of optoelectronic semiconductor diodes, their manufacturing technologies, and the laws of propagation of light rays in different environments.

Key words: optoelectronic sensors, optical beam energy, photometric quantities, p-n transition, wavelength, speed of light, illuminance, lux, lumen, temperature.

Intraduction. There are photometric quantities that determine the main characteristics in the research of measurement parameters of optoelectronic sensors. In optoelectronics, the main concept is radiation, which refers to the transfer of energy from a light-emitting body to a receiver. According to physical laws, optical rays are electromagnetic waves, and any body emits electromagnetic waves when its temperature is above zero. During this period, the share of optical rays in the spectrum of electromagnetic waves is very small.

Here, the spectrum of optical rays is divided into the spectrum of ultraviolet, infrared and visible rays. The wavelength of ultraviolet rays ranges from 1 nm to 380 nm. Between 380 nm and 760 nm to visible rays, rays from 760 nm to 1 mm characterize the spectrum of infrared rays [5]. Here we can see that although visible rays are a small part of optical rays, they are important in the way of life of mankind. Detection of matter, perception of colors, physical movement, food products from nature, animal and plant life, natural alternative energy resources are all products of visible optical rays. The field of optical rays surrounds us all the time. The effect of this field is characterized by the energy of optical rays. The energy value of optical light is determined by the following expression.

$$W = \frac{hc}{\lambda} \qquad 1.$$

Here W is the energy of optical rays, unit [J], h is Planck's constant, 6.62*10-34 Js, speed of light s=3*108 m/s, l is wavelength [m],

Using the relationship between the wavelength and the speed of light, we can write the expression 1. – in the following form.

$$W = h\nu \qquad 2.$$

Here n is the beam frequency, unit [Hz].

Usually, the main quantity characterizing optical rays is not the amount of radiation energy, but the amount of radiation current. The amount of optical radiation flow or power is the radiation energy transmitted per unit of time [2].

$$\Phi = \frac{dW}{dt} \qquad 3.$$

The unit of luminous flux is Lumen [Lm].

The spatial density of the radiation flux in a certain direction is called luminous intensity. The magnitude of the light power is determined by the ratio of the light flux to the spatial angle.

$$I = \frac{d\Phi}{d\omega} \qquad 4.$$

The unit of luminous intensity [Cd] is the candela.

Another important quantity is illuminance, which is measured by the ratio of the light flux itself to the incident surface.

$$\mathrm{E} = \frac{\Phi}{\Delta S} \qquad 5.$$

If the light falls on the illuminating surface at an angle, the illumination of the surface is directly proportional to the cosine of the angle of incidence of the light [3].

$$E = E_0 * cos \propto \qquad 6$$

Luminance is a quantity that is equal in quantity to the flux of light radiating from the surface unit of the light source in all directions.

Luminance is a quantity that is numerically equal to the power of light emitted from a unit surface of the source surface in a certain direction and normal to the surface.

$$B = \frac{I}{\Delta S} \qquad 7.$$

The unit of clarity is nit [nt].

The relationship between wavelength, frequency, and speed of light is as follows:

$$\lambda = \frac{c}{\nu} \qquad 8.$$

$$\nu = \frac{c}{\lambda} \qquad 9.$$

$$\vartheta = \lambda\nu \qquad 10.$$

When light travels from one medium to another, the speed and wavelength of light change, but the frequency does not. In a medium with a higher refractive index, the wavelength and speed of light are shorter. The propagation speed and wavelength of light in the medium are determined by the following expressions.

$$\vartheta = \frac{c}{n} \qquad 11.$$

$$\lambda = \frac{\lambda_0}{n} \qquad 12.$$

Here n is the refractive index of the medium, l0 is the wavelength of light in a vacuum.

Extraction technology

We know that there are natural and artificial sources of light, which are important in the way of life of humans and living organisms. The main part of the natural source of light is the sun. Sunlight reaches the earth's surface in the form of radiation. Its composition forms the spectrum of ultraviolet, infrared and visible rays. Rays in each range lie in a certain wavelength, and they have an effect on the environment and functional development and changes of living organisms [11-12]. Light is important not only in the way of life of living organisms, but also in production, techniques and technologies. Artificial light sources mainly include incandescent, halogen, fluorescent and light-emitting diodes [13-15]. They differ from each other in light wavelength, working principle, energy efficiency, shelf life, power and light flux. Among these light sources, light-emitting diodes are preferred in terms of energy efficiency, high illumination, energy efficiency, and long service life [1, 3-5]. Let's consider the principle of operation of the light-emitting diode, the efficiency of lighting and the impact on the environment.

Although the working principle of white light-emitting diodes is not complicated, the device's manufacturing technology has a complex structure. The methods of obtaining a white light-emitting diode are as follows:

1. Phosphor layer luminophore coating on blue crystals;
2. Covering a number of phosphor layers of luminophore on the ultraviolet color crystals;
3. Generation of white light by mixing the light of three types of monochromatic red, green and blue diodes.

The white light produced by these methods differs from each other in the level of light scattering and the energy consumption of the light-emitting diode.

In the first method, blue crystal is coated with yellow phosphor. In this process, the phosphor absorbs a certain part of the emitted blue light and emits a yellow color. The unabsorbed blue light is mixed with the yellow light from the phosphor to produce near-white light. The main disadvantage of the white light obtained by this method is the low level of light scattering (Fig. 1).

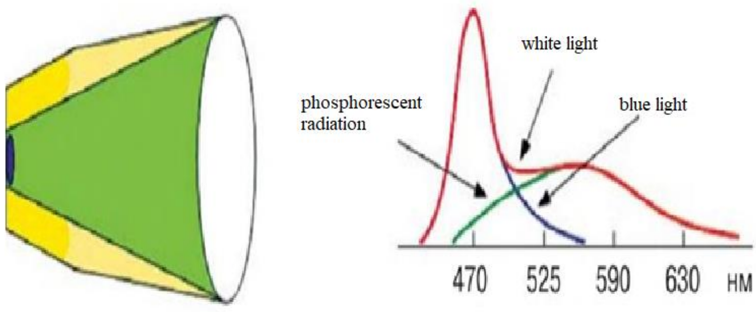

Figure 1. Obtaining white light by coating a blue diode with a yellow phosphor phosphor.

A new technique is to coat UV-emitting crystals with several layers of different phosphor content, which provides excellent color separation, but high energy consumption (Figure 2).

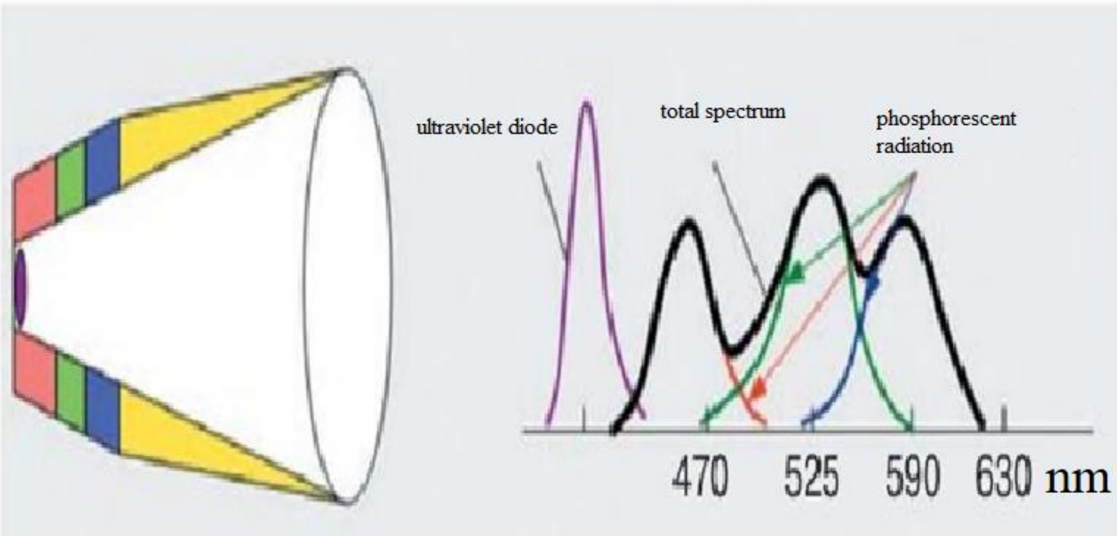

Figure 2. Obtaining white light by coating a red, blue and green phosphor phosphor on an ultraviolet diode.

The white light produced by mixing the light of three types of monochromatic red, green, and blue diodes is distinguished from other methods by its high color index, high light scattering level, and low energy consumption. The disadvantage of this method is that it requires a complex control system to obtain a white light beam (Figure 3).

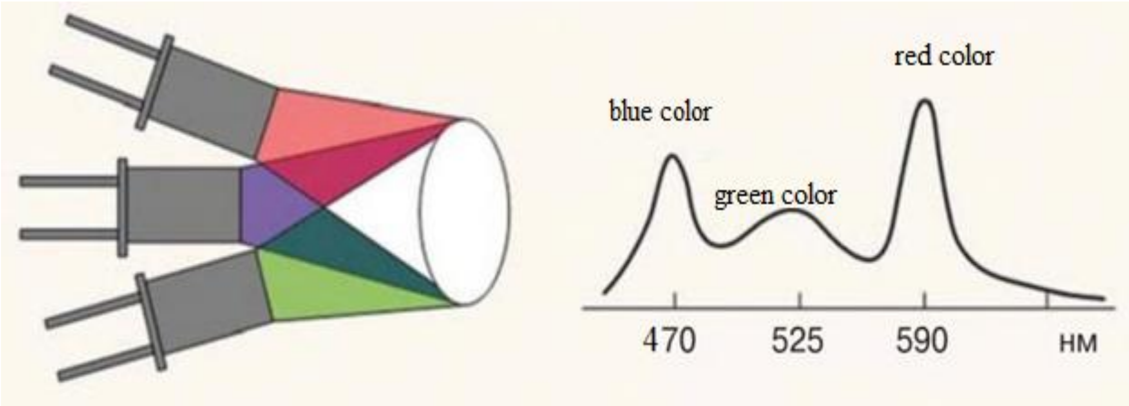

Figure 3. Blue, green and red diodes produce white light by adding light rays.

Semiconductor light-emitting diodes are connected in parallel to the power source through the following scheme (Fig. 4).

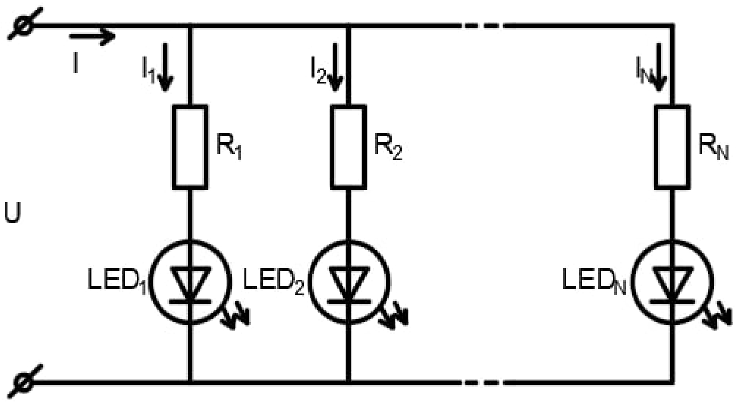

Figure 4. Parallel connection of semiconductor light-emitting diodes.

When the semiconductor is connected in parallel to the energy source of the light-emitting diodes, the current consumed by the energy source is determined as follows (formula 4).

$$I = NI_L = N\frac{U - nU_L}{R} \qquad 13.$$

The volt-ampere characteristic of a semiconductor light-emitting diode corresponds to the characteristic of a conventional semiconductor silicon diode [6-8]. The differential resistance in the direct working part does not exceed a few ohms, so a source with a large internal resistance (current source) is required to drive the light emitting diode. Phototransistors, photodiodes, photoresistors and photothyristors can be used as photoreceivers [9-10].

Materials

Table 1

Wavelength compatibility of emitters made of semiconductor materials [3-8]

Light-emitting diodes are made of materials	Radiation spectrum range, nm
$InGaP_2GaN$, SiC	400 – 860
GaP	600 –700
GaAlAs, GaAs, GaAsP	700 – 950
AlGaAsSb, GaAsSb	1000 –2000
InGaAsP – InP	1000 –2100
InAs, InGaAs, InGaAsSb – InAs, InGaAsSb – GaSb	1800 – 4000

Currently, it is widely used in the preparation of semiconductor light-emitting diode devices, studying various qualitative and quantitative parameters of substances and materials [5]. In these devices, infrared light-emitting diodes made of semiconductor materials with an indium-gallium base are used. Such light-emitting diodes have a high efficiency, strong isolation, and directed radiation flow [4]. However, the external quantum efficiency of these emitters is limited by large radiation losses due to intra-crystal absorption and very small critical angles. If one of the regions of the p-n structure is formed into a Weierstrass sphere or by using chalcogenide glass coatings, these losses can be greatly reduced. The coatings are spherical, and the diameter of the spherical coating is chosen to be 4 times larger than the linear size of the light emitting diode.

Conclusion. Coating of light-emitting diodes does not change their spectral characteristics. At the same time, when using a truncated ellipsoid-shaped coating, the efficiency of the light-emitting diode, that is, the energy efficiency, increases by 3-4 times, and by 1.6% at a temperature of 3000 K. The volt-ampere characteristic of light-emitting diodes is almost linear in the range of 1.5-2.2 V with the initial ignition limit and in the working part [7].

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