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Energy-Saving Lighting Lamps and Their Parameters

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Abstract

This article provides information on the structure, working principles, history of creation, and economic indicators of energy-saving lighting devices- LED lamps. Energy transitions in LED lamps, recombination processes, energy brightness of sources and the parameters of these lamps were analyzed in comparison with the parameters of incandescent lamps.

Key words: semiconductor, light-emitting diode, p-n junction, electron, hole, quantum, spectrum, recombination, lumen, power, optical radiation, luminescence.

Introduction: A revolutionary change has occurred in lighting technology due to the use of the phenomenon of luminescence, which occurs during the r-n transition in semiconductors, as a light source. A light-emitting diode is a semiconductor diode that converts electrical energy into incoherent light radiation. When direct current passes through a semiconductor diode, charge-carrying electrons and holes are created. The excess energy generated in the base region of the diode during the p-n transition, i.e., the mutual recombination of electrons and holes, is released as light quantum radiation. Radiation in light-emitting diode lamps is generated from the recombination energy of electrons and holes in the process of energetic r-n transition [1-3]. In order for the outgoing quantum energy - photons separated during the recombination process - to be in the visible range of the spectrum, the bandgap of the semiconductor should be relatively large (Yeg >1.8eV). Therefore, the following semiconductor materials are used in the manufacture of LEDs: gallium phosphide (GaP), silicon carbide (SiC), solid compounds: gallium-arsenic-phosphorus (GaAsP) and gallium-arsenic-aluminum (GaAsAl), as well as gallium nitride (GaN), is equal to the enhanced zone (E_g > 3.4 eV). As a result, up to violet radiation can be produced in the short wavelength part of the visible spectrum. A light-emitting diode (SD, SID, LED) is a semiconductor material with an electron-hole transition, which produces optical radiation when a current is passed through it. Radiated light lies in a very narrow spectral region. Its spectral characteristics depend on the chemical composition of the semiconductor materials used in the manufacture of the LED, and the chemical elements used. In 1907, Henry Joseph Round was the first to observe the phenomenon of electroluminescence, which occurs when current is passed through the metal-carbide silicon (carborundum SiC) vapors, and he witnessed that this radiation is yellow, green, and violet in color [3,4]. These experiments were later returned by O. V. Losev in 1923, independently of Round. The first visible light emitting diode was created in 1962 by a group of scientists working under the leadership of Nick Holoniak at the University of Illinois. When a current passes through the p-n transition zone in semiconductors in the right direction, the charge carriers emit their excess energy as luminescence in the visible region when electrons and holes move and recombine.

By selecting the semiconductor composition, it is possible to create LEDs that emit from ultraviolet (GaN) to mid-infrared (PbS) regions. Crystals with a proper transition, such as silicon, germanium or silicon carbide, practically do not radiate. The original silicon-based yellow-emitting diode KL 101 was created in the former Soviet Union in the 70s. But it was extremely low brightness and could only be used as an indicator. In 1961, Robert Bayard and Gary Pittman, employees of the Texas Instruments company, created a light emitting diode in the infrared region and received a patent. The world's first practical red light-emitting diodes were created in 1962 by General Electric employees led by Nick Holoniak. Therefore, Kholonyak is considered the "father of modern light-emitting diodes". His former student, George Crawford, created the world's first yellow light-emitting diode in 1972 and increased the brightness of red and yellow light-emitting diodes tenfold. In 1976, T. Pirsol was the first to create light-emitting diodes capable of transmitting information through optical fibers used in high-efficiency telecommunications. Until 1968, LEDs were very expensive ($200 per unit), and their use was limited. Monsanto Company was the first to start mass production of light-emitting diodes. Initially, these LEDs were used as indicators in pocket calculators. Until the beginning of 1970, American scientists called LEDs "Losev Light" and "Losev sveti". The lighting power of LEDs is extremely high, with a value of 200 lumens/watt. Cree Company has produced a new LED lamp, XLamp MK-R, which has a light output of 200 lumens/watt, and an 8-watt LED bulb produces the same amount of light as a 100-watt incandescent lamp, i.e. 1550-1630 lumens. 200 lumens/watt (lpw) is considered to be the highest rating for light bulbs.

In incandescent lamps, this indicator is from 4 to 15 lpw, in halogen lamps - about 27 lpw, in fluorescent lamps from 50 to 100 lpw, in gas discharge lamps (xenon lamps of cars, etc.) it has a value of 100 lpw and more. Therefore, a light output of more than 200 lpw is considered the highest. The LED lamp created by

Cree company has a value of 208 lpw, which reaches its maximum value at 25°C, room temperature, but during operation, the LED heats up to 85°C, and in this case the light output is reduced to 106.7 l pw [4.5- 8]. Usually, the radiation of LEDs is monochromatic and can deviate slightly from the maximum of the wavelength. The main technological method for obtaining light-emitting diodes is the epitaxial growth method. One of the main parameters of LEDs is the brightness of radiation, that is, the ratio of light power to the surface of the illuminated area. This ratio is measured in square meters where the candela is distributed. The spectral characteristic of the LED is caused by the dependence of the radiation intensity on the wavelength of the radiation. The wavelength of the radiation spectrum is determined by the difference between the two energy levels of electrons during the recombination process. Below are technical and economic indicators of LED lamps created in CD-LM 3 w and LM-LBL 5-7 w models [4].

Operating voltage	160-240 v	130-265 v	130-265 v
Current strength	0.01-0.02 A	0.03-0.04 A	0.03-0.04 A
The flow of light	200-210 lm	595-630 lm	595-630 lm
Efficiency	85-90 lm/w	85-90 lm/w	85-90 lm/w
Power	3 w	5 w	7 w
Duration of work	25000 соат	10000 соат	10000 соат
Power factor	0.5-0.6	0.5-0.6	0.5-0.6

Conclusion: The life of LEDs is 6-8 times longer than the life of fluorescent lamps. The LED lamp has a resource of 100,000 hours of operation, which means 10-12 years of continuous operation. Neon and fluorescent lamps can work for 10 thousand hours. If fluorescent lamps are used at this time, they will have to be replaced 8-10 times. If we use incandescent lamps, it will be necessary to change the lamps up to 40 times. When we use LED lamps, energy consumption is reduced up to 87%. The operating temperature also has a wide range, and it is the most modern energy-efficient device.

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