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Realization of warming in LED lighting

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Abstract: *LEDs are semi-conductive p-n diodes emitting light. When current flows in the conduction direction in a p-n junction, the electrons and holes are confronted with each other and recombine in the junction where the p and n semiconductors are combined. The energy that the electrons lose from the free state to the connected state is given either as heat or light to the semiconductor material. In solid-state lighting, 80% of the energy, which is usually caused by photon activity, is heat and 20% is light. In this report, the light and heat emission of the LEDs are investigated.*

Keywords: *LED, Lighting, Warming*

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I. Introduction

Visible light emitting LEDs found in 1962 by N. Holonyak have very low power of 1-10 mW. These LEDs generate low-energy photons and they were diodes emitting red light. Then yellow LED and then in 1994 a LED emitting blue light by using InGaN semiconductor were produced by S. Nakamura, [1-4]. The fact that LEDs can emit blue light also opened the way to use these diodes in lighting [5-8]. One of the developments that led to the use of LEDs in lighting has been to ensure that these diodes can be produced in a way that they can emit light with a very high energy of 20W and above. Nowadays, the ability to make LED chips that produce 150 lumens and more white light from a single 1 W radiation has opened the way for LEDs to be successfully used in building, road and car lighting applications [9-12]. Lamps with LEDs are now increasingly being used in lighting, signalization, communication, automotive lighting. The a typical LED are shown in Figure 1.

Figure 1. A typical LED

II. Working principle of LEDs

Light emitting diodes (LEDs) emit a certain wavelength (λ) of light as a result of driving a semiconductor p-n diode in the direction of transmission. When current is passed through the semiconductor diode in the direction of transmission, holes in the p region and electrons in the n region are driven toward the junction of the p and n type semiconductor materials. The electrons and holes that confront with each other at the joint disappear. In case of junction of electron-hole pair, if the semiconductor material is an energy band material, the extra energy is emitted as one photon. The energy of this photon is seen in Equation 1. h denotes the Planck constant and ν denotes the photon frequency.

$E = h. \nu$ (1)

This energy is approximately equal to the bandwidth of the semiconducting material, which is seen in Equation 2.

$E = Eg.$ (2)

As the bandwidth of the semi-conductor increases, the frequency of the emitted photon increases. The relationship between photon frequency and λ is shown in Equation 3. c denotes light speed.

$N = c/ \lambda$ (3)

The visible light zone starts at purple light ie at 400 nm, ends with red light, i.e. at 700 nm. Direct band-pass semiconductors are used to obtain photons from the combination of electron hole pair at the p-n junction. In direct band-pass semiconductors, a free electron is connected to the last orbit of one of the fixed atoms in the crystal. In other words, when a free electron in the crystal is connected to atom, it loses its energy by emitting a photon equal to the energy difference in between.

The GaAs compound is a semi-conductor with direct band pass and the energy band width is about 1.4 eV. If the equation of 1 is written in equation 3, the energy of the new equation is calculated. When an electron-hole pair is combined in the GaAs p-n junction, an infra-red photon is emitted. When GaN semiconductors are used, the energy of the semiconductors is 3.4 eV, since the band width is sufficiently large. When an electron and hole pair is combined in the p-n junction of this semiconductor diode, this time a blue color photon is emitted. The number of emitted photons determines the energy of the light. The energy of the light is shown in Equation 4 to express the total number of photons n.

$E_p = n.h.\nu$ (4)

Considering that N represents the total number of electron-hole pairs combined at a unit of time, the number of photons emitted per unit of time gives the light flux in watts. In other words, the light flux shows the power of the light emitted by LED. The light flux is seen in Equation 5.

$\Phi = h. \nu N$ (5)

The current of the diode in the direction of transmission. (q unit electric charge) is seen in Equation 6.

$I_f = q. N$ (6)

As the current in the direction of transmission increases, the number of electrons and holes passing through the cross-sectional area of the p-n junction per unit time increases. This increases the number of combined electron-hole pairs, N. The number N is seen in Equation 7.

$N = I_f / q$ (7)

As a result, the number of photons emanating from all these equations, ie the power of the emitted light (Po), is seen in equation 8. η represents the efficiency of the electron-hole pairs to transform into photon.

$P_o = \Phi.\eta = \eta\ h. \nu. I_f / q$ (8)

III. Warm-up story of LEDs

As shown in equation (8), as the diode current in the transmission direction increases, the light flux (Po), in other words power of the emitted light increases. This linear relationship between the emitted light power and the conduction current is broken after the current rises above a certain value, and even if the current rises after this value, the number of emitted photons starts not increase at the same rate. Mechanisms such as the fact that each electron-hole pairs do not necessarily lead to photon release, potential transfer of this energy to the crystal, the impossibility of all of the generated photons to come out of the semi-conductive material affect the photon efficiency and the crystal starts to heat up as the current increases. After a certain level, it becomes a necessity to take this heat away from the diaphragm. The a typical LED hating are shown in Figure 2.

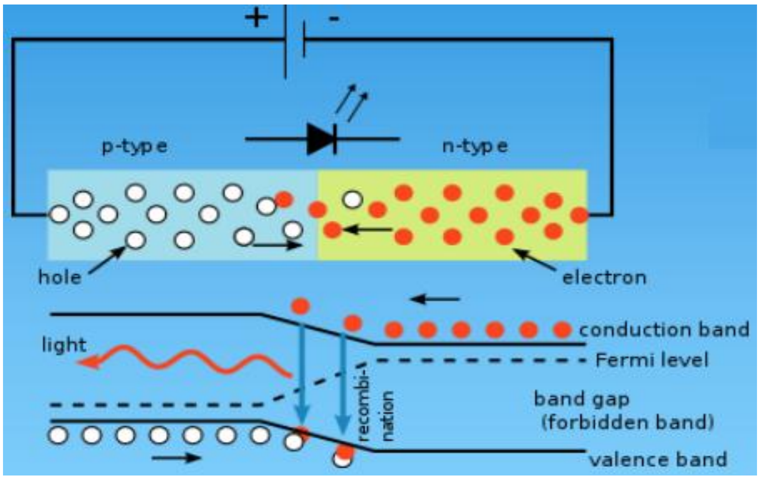

Figure 2. A Typical LED heating

Even if the current increases after a certain level, photon disconnection does not occur on the surface of p-n. Therefore, the crystals in the semiconductor get heated. If the heat is not cooled, the LED is damaged.

IV. Conclusion

In this study, the operation of LEDs has been examined, and it has been seen that the usage of LEDs increases when they provide the desired power levels and color qualities. Due to the lighting consumption that corresponds to 25% of all energy use, it is understood that significant energy savings will be achieved in the World energy consumption for lighting by using energy LEDs. Moreover, as seen in this study, even if the current increases after a certain level, photon disconnection does not occur on the surface of p-n. Therefore, the crystals in the semiconductor get heated. If the heat is not cooled, the LED is damaged. And this affects the visual comfort adversely

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