УДК 621.396.96

HOW LEDS WORK AND WHY IT IS SO HARD TO MAKE A BLUE LED

Zadvornov S.E., student
Skalkovich D.Y., student
Scientific supervisor – Beznis Y.V., senior lecturer
English language department №1
Belarusian National University of Technology
Minsk, Republic of Belarus

Light-emitting diodes (or LEDs how they are usually called for short) are small light bulbs that work on the basis of p- and n-semiconductors, converting electric current into photons of light. Their principle of operation is based on a physical process called electroluminescence, which means that when current passes through the semiconductor materials, they emit photons of light [1].

LEDs always contain p- and n-type semiconductors, which combine to form a stable p-n junction. Recombination of electron carriers occurs when electrons from the n-type semiconductor move to the p-type semiconductor, releasing energy in the form of light of a specific wavelength. When a forward voltage is applied to an LED, the basic principle is that electrons move from the n-region to the p-region. Photons are produced when energy is generated by the recombination of negative electrons and positive holes [2].

The variety of materials that make up the n- and p-regions of an LED determines the color of the LED itself. This is determined by the band gap of the semiconductor, which is inversely proportional to the wavelength of the light. Depending on the color they emit, LEDs can be classified as green, red, yellow or blue. New materials and technologies have made it easier to produce LEDs of different colors. However, creating blue LEDs is still a very difficult task. The need for materials with a wide band gap is one of the main reasons explaining why creating blue LEDs is so difficult.

Researchers developed red and green LEDs in the 1960s and 1970s using gallium arsenide (GaAs) and gallium phosphide (GaP). But to produce blue light, materials with a wide band gap, such as gallium nitride (GaN), were needed. At the time, these materials posed serious structural

and control problems. The inability to grow excellent GaN crystals and control their impurity levels were the main reasons for the difficulty in creating blue LEDs [3].

Japanese scientists Hiroshi Amano and Shujo Nakanishi made significant advances in this field in the 1990s by developing methods for bonding GaN crystals to sapphire substrates. As a result, it was possible to start producing higher quality blue LEDs. Blue LEDs are very demanding in terms of quality and high purity of materials; if these parameters are not controlled, this will lead to defects. Thanks to new technologies such as molecular beam epitaxy and substantial advances in semiconductor technology, it was possible to increase the production of blue LEDs [4].

Combining blue LEDs with phosphorus components allowed to increase the spectrum of possible colors, and the invention of blue LED production technology led to the emergence of white LEDs. Consequently, the efficiency and service life of incandescent and fluorescent lamps also increased.

The production of blue LEDs has become very complex, but at the same time very important for the whole world. For their production, engineers from all over the world have been conducting research and creating new technologies for several decades. They have become an important part of the modern world, from lighting to displays, headlights and complex gadgets.

References

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