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# A Review on the Development of Blue Light Emitting Diodes (LEDs)

**Richa Kumar[1] and Somnath Bharech[2]**

*[1]BabuBanarasi Das Northern India Institute of Technology*
*[2]Maulana Azad National Institute of Technology*
*E-mail: [1]er.richakumar@gmail.com, [2]sbharech@gmail.com*

**Abstract—***Revolutionizing lighting with vastly better energy efficiency and brightness with less waste of electrical energy has always been the target to raise the standards of optoelectronics. The blue LEDs helped to overcome such issue. In this article we review the improvements made and required to make blue light emitting diodes even more efficient. The increment usage of blue LEDs in day to day life has also been taken into account.*

## 1. INTRODUCTION

Since the era of Industrial Revolution, the need of lighting the industries with a more promising source than the traditional ones was felt. This led to the invention of incandescent light bulb by Thomas Edison, Hiram Maxim and Joseph Swan [1-3].This invention was the initiation of electric lighting industry.They were used for residential and industrial lighting on a large scale.

Extensive researches were carried out to improve the lighting lamps on the grounds of efficiency. Many lamps such as Arc lamps, Neon lamps, Mercury lamps, Fluorescent lamps were developed over a period of time. Of these, only Compact Fluorescent Lamps (CFLs) developedby Edward E. Hammerof in 1976, could replace the incandescent bulbs [4]. Definitely, CFLs ruled over the lighting industry for many years due to its advantage of efficiency over the incandescent bulbs, but soon issues related to health and environment came forward. It was reported by Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) in 2008 that CFLs emit Ultraviolet (UV) radiation which can act as a potential cause for skin and retinal damage [5]. M.Ivanco and group stated that the use of CFLs would cause a significant increase in levels of $CO_2$ (a greenhouse gas) [6].

Now, the world needed a revolutionary lighting device which should be efficient as well as environment friendly, and that device is LED lamp.

## 2. WHAT IS LED?

A LED, an acronym for Light Emitting Diode, is a two-lead semiconductor light source. It is a p-n junction diode, which emits photons when a suitable voltage is applied to the leads [7]. The lighting effect or electroluminescence is a result of recombination of electrons with the electron holes within the device which releases energy in the form of photons. The color of emitted light is determined by the energy gap of the semiconductor material.

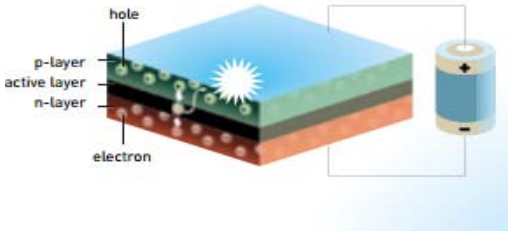


**Fig. 1: Schematic diagram representing a typical LED.**

First visible-spectrum (red) LED was developed by Nick Holonyak, Jr. in 1962 at General Electric Company [8]. M. George Craford created the first yellow LED in 1972 [9]. LEDs were now being used as indicators and signs in traffic lights and automotive applications, but failed to replace the CFLs in residential and industrial lighting.

## 3. WHY BLUE LED?

Residential and Industrial lighting required LEDs that generate high-intensity white light. White illumination from LED or White LEDs can be produced using two ways;one is to use phosphor material to convert monochromatic light from a blue or UV LED to broad-spectrum white light, much similar to the working of fluorescent lamps [10].The other way is to mix the three primary colors namely, Red, Green and Blue. Red and Green LEDs were already invented, thus was the need for the blue one [11].

## 4. ILLUMINATION BREAKTHROUGH

Blue LED was invented by Shuji Nakamura, Hiroshi Amano and Isamu Akasaki for which they were awarded with Nobel Prize in Physics 2014 [12]. Production of Gallium Nitride

(GaN) -based alloys with different compositions and their integration into multilayer structures such as heterojunctions and quantum wells was required for development of efficient blue LEDs. This invention led to efficient white light sources for illumination.

## 5. EFFICIENCY

It has been demonstrated that an LED can emit more optical power than the electrical power it consumes. Although, the results scientifically intriguing, they won't immediately result in ultra-efficient commercial LEDs since the demonstration works only for LEDs with low input power that produce very small amounts of light. A key to achieve a power conversion efficiency above 100%, i.e., "unity efficiency", is to greatly decrease the applied voltage. As per relationship, an LEDs efficiency increases as its output power decreases. ( The inverse of this relationship - that LED efficiency decreases as its output increases - is one of the biggest hurdles in designing bright, efficient LED lights. [15]

## 6. APPLICATIONS

Blue LEDs have changed our lives in many ways. Some of its uses can be summoned up as bellow.[14]

### 6.1. White Energy-Efficient LED lamps

Since LED convert electricity directly into light, rather than the majority of energy on heat, these can be used as more long-lasting and more efficient alternatives to older light sources.

Efficiency of light emitted by traditional light bulbs = 16 lumen/watt

Efficiency of light emitted by fluorescent lights = 70 lumen/watt

Efficiency of light emitted by LED lamps = 300 lumen/watt

As about one-fourth of world electricity consumption is used for lighting purposes, the highly energy-efficient LED lamps contribute to saving the Earth's resources.

### 6.2. TV, Computer, Phone screens

The backlit liquid-crystal display (LCD) in televisions, computers, and phones are built with blue LEDs. They also provide the flash for camera phones.

### 6.3. Providing light to those without electricity

LEDs are far more efficient than traditional light sorces, that means, they require less energy to provide light. In the developing world, more than a billion people live without access to electricity grids, there, the solar-powered LED could replace fuel-powered light, such as kerosene lamps, candles, and open fires, which can be dangerous, polluting, expensive and dim.

Though LEDs are the size of the cherry, they can generate light 100 times brighter than a kerosene lamp at a very low wattage.

### 6.4. Sterilizing polluted water

As Ultraviolet (UV) light destroys the DNA of bacteria, viruses and micro-organisms, the UV LEDs made by blue LEDs, could help sterilize polluted water in the future.

### 6.5. Greenhouse cultivation

Light on different parts of spectrum influences plant growth. As the color of LEDs can be controlled by computers, they can not only provide efficient light in greenhouses, but also more control for growers over their plants.

Plant scientists all over the world are currently studying this phenomenon in an effort to exploit it in future.

## 7. FUTURE

The invention of LED is just 20 years old, but it has already contributed to create white light in an entirely new manner to the benefit all of us. The LEDs produce light with far less waste of electrical energy than with preceding technologies like incandescent and fluoroscent lights. That means a quarter of energy consumption goes to illumination. Hence LEDs are believed to have a big impact on modern civilization. [13]

## 8. CONCLUSION

Though the LEDs are continuing lighting the world since decades, the blue LED added up the spark in the research sector in order to produce more efficient and easy to develop light.

The organic LEDs are one of its such sub-branch that faces difficulties like cost of manufacturing, relatively poor luminosity etc. The improvement is still required in some areas. As LED continues to evolve the world seems to shine even brighter over the years to come.

## 9. ACKNOWLEDGEMENT

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