iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 6 **Issue:** IV **Month of publication:** April 2018

**DOI:** http://doi.org/10.22214/ijraset.2018.4723

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

# Different Types of in Light Emitting Diodes (LED) Materials and Challenges- A Brief Review

BY Susan John[1]
[1]Dept Of Physics S. F. S College Nagpur 06, Maharashtra State. India

## I. INTRODUCTION

***LEDs are semiconductor devices, which produce light when current flows through them. It is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable current is applied electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light is determined by the energy band gap of the semiconductor. LEDs are typically very small. In order to improve the efficiency many researches in LEDs and its phosphor has been taking place. However still many technical challenges such as conversion losses, color control, current efficiency droop, color shift, system reliability as well as in light distribution, dimming, thermal management and driver power supply performances etc need to be met in order to achieve low cost and high efficiency. [1]***
***Keywords: Glare, blue hazard and semiconductor.***

## I. DIFFERENT TYPES OF LEDS MATERIALS USED:

*A.* Gallium Arsenide (GaAs) emits infra-red light
*B.* Gallium Arsenide Phosphide (GaAsP) emits red to infra-red, orange light
*C.* Gallium Phosphide (GaP) emits red, yellow and green light
*D.* Aluminium Gallium Phosphide (AlGaP) emits green light
*E.* Gallium Nitride (GaN) emits green, emerald green light
*F.* Gallium Indium Nitride (GaInN) emits near ultraviolet, bluish-green and blue light
*G.* Aluminium gallium indium phosphide
*H.* Silicon carbide(SiC)
*I.* Zinc Selenide (ZnSe):light-yellow light

## II. REVIEW ON LED MATERIALS

*A.* Gallium arsenide (GaAs) is a compound of the elements gallium and arsenic. It is a III-V direct band gap semiconductor with a Zinc blende crystal structure. Gallium arsenide is used in the manufacture of devices such as microwave frequency integrated circuits, monolithic microwave integrated circuits, infrared light-emitting diodes, laser diodes, solar cells and optical windows [2]. GaAs is often used as a substrate material for the epitaxial growth of other III-V semiconductors including indium gallium arsenide, aluminum gallium arsenide and others.

*B.* *Gallium Arsenide Phosphide (GaAsP :* Gallium arsenide phosphide ($Ga\ As_{1-x}\ P_x$ ) is a semiconductor material, an alloy of gallium arsenide and gallium phosphide. It exists in various composition ratios indicated in its formula by the fraction x. It is factor X which decides the color of LED .Gallium arsenide phosphide is used for manufacturing red, orange and yellow light-emitting diodes. It is often grown on gallium phosphide substrates to form a GaP/GaAsP heterostructure. In order to tune its electronic properties, it may be doped with nitrogen (GaAsP:N).[3]

*C.* *Gallium Phosphide (GaP):* It is a phosphide of gallium, is a compound semiconductor material with an indirect band gap of 2.26 eV (300K). The polycrystalline material has the appearance of pale orange pieces. Undoped single crystal wafers appear clear orange, but strongly doped wafers appear darker due to free-carrier absorption. It is odorless and insoluble in water. Sulfur or tellurium is used as dopants to produce n-type semiconductors. Zinc is used as a dopant for the p-type semiconductor. Gallium phosphide has applications in optical systems. Its refractive index is between 4.30 at 262 nm (UV), 3.45 at 550 nm (green) and 3.19 at 840 nm (IR) [ 4], which is higher than in most known materials, including diamond (2.4).Gallium phosphide is transparent for yellow and red light, therefore GaAsP-on-GaP LEDs are more efficient than GaAsP-on-GaAs. At temperatures above ~900 °C, gallium phosphide dissociates and the phosphorus escapes as a gas. In crystal growth from a 1500

°C melt (for LED wafers), this must be prevented by holding the phosphorus in with a blanket of molten boric oxide in inert gas pressure of 10-100 atmospheres. Pure GaP LEDs emit green light at a wavelength of 555 nm. Nitrogen-doped GaP emits yellow-green (565 nm) light, zinc oxide doped GaP emits red (700 nm).Gallium phosphide (GaP) is a polycrystalline compound semiconductor that appears pale orange and has an indirect band gap of 2.26 eV. It does not dissolve in water and is odorless. The dopants used to obtain n-type semiconductors are tellurium or sulfur. For the p-type semiconductor, zinc is used.[5]

D. *AluminiumGallium Phosphide (AlGaP):* It is a phosphide of aluminium and gallium, is a semiconductor material. It is an alloy of aluminium phosphide and gallium phosphide.[6]

E. *Gallium Nitride (GaN):* GaN is a very hard mechanically stable wide bandgap semiconductor material with high heat capacity and thermal conductivity.[7 ] In its pure form it resists cracking and can be deposited in thin film on sapphire or silicon carbide, despite the mismatch in their lattice constants.[7] GaN can be doped with silicon (Si) or with oxygen [8] to n-type and with magnesium (Mg) [9].

F. *Gallium Indium Nitride (GaInN)*: Indium gallium nitride (InGaN, InxGa 1−xN) is a semiconductor material made of a mix of gallium nitride (GaN) and indium nitride (InN). It is a ternary group III/group V direct bandgap semiconductor. Its bandgap can be tuned by varying the amount of indium in the alloy. InxGa 1−xN has a direct bandgap span from the infrared (0.69 eV) for InN to the ultraviolet (3.4 eV) of GaN. [10]

G. *Aluminium gallium Indium Phosphide :* It is a semiconductor material that provides a platform for the development of novel multi-junction photovoltaics and optoelectronic devices, as it spans a direct bandgap from deep ultraviolet to infrared.[11] AlGaInP is used in manufacture of light-emitting diodes of high-brightness red, orange, green, and yellow color, to form the heterostructure emitting light. It is also used to make diode lasers.

H. *Silicon Carbide (SiC):* Silicon carbide (SiC), also known as carborundum , is a semiconductor containing silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Synthetic silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. SiC is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both. Large single crystals of silicon carbide can be grown by the Lely method; they can be cut into gems known as synthetic moissanite. Silicon carbide with high surface area can be produced from SiO2 contained in plant material. [12]

I. *Zinc Selenide (ZnSe):* Zinc selenide (ZnSe) is a light-yellow, solid compound comprising zinc (Zn) and selenium (Se). It is an intrinsic semiconductor with a band gap of about 2.70 eV at 25 °C (77 °F). ZnSe rarely occurs in nature, and is found in the mineral that was named after Hans Stille called "stilleite." [13].

## III. CHALLENGES IN LEDS

The main advantages of LEDs includes: its power consumption is less, less maintenance required, total life is more, wider range of working voltage options, it is not omni-directional , dimmable control i.e. when used in applications where dimming is required, LEDs do not change their color tint as the current passing through them is lowered, unlike incandescent lamps, which turn yellow, shock resistance I.E Unlike conventional light sources, LEDs are not subject to sudden failure or burnout as there are no filaments to burn out or break. The light in LEDs emits from encapsulated silicon diodes immersed in phosphor which can be energised from a very low voltage input, light quality. LEDs do not produce ultraviolet light. LEDs can emit light of an intended color without the use of color filters that traditional lighting methods require. LEDs do not contain mercury, unlike compact fluorescent lamps .

But it has serious disadvantages also.

LED performance largely depends on the ambient temperature of the operating environment. Over-driving the LED in high ambient temperatures may result in overheating of the LED package, eventually leading to device failure. Adequate heat-sinking is required to maintain long life . LEDs must be supplied with the correct current. This can involve series resistors or current-regulated power supplies. • LEDs do not approximate a "point source" of light, so they cannot be used in applications needing a highly collimated beam. LEDs are not capable of providing divergence below a few degrees. Many times manufacturers of blue LEDs and White LEDs cross the safe limit which leads to blue light hazard. LEDs have come a long way and currently they are widely used in many applications. [14] [15].

High heat and humidity levels can lower product life spans .As moisture always proves to be the be the enemy of any electrical system, it presents a unique problem for outdoor led-based bulb. When moisture enters into led bulb system it can quickly short it out [16]

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*Volume 6 Issue IV, April 2018- Available at www.ijraset.com*

## IV. CONCLUSIONS

LED has replaced the mercury content in the light emitting bulbs but it has serious disadvantages. Many researchers found that LED contains lead, arsenic and many potentially dangerous substances. For e.g. low-intensity red LEDs, which were found to contain up to eight times the amount of lead, a known neurotoxin. White LEDs contain the least lead, but still make uses of large amounts of nickel, another heavy metal that causes allergic reactions when exposed to it. And the copper found in some LEDs can pose an environmental threat if it accumulates in rivers and lakes where it can poison aquatic life [17] [18].

The beams of light emitted by the LEDs cannot be seen directly, to avoid glare. An incandescent bulb has a color temperature (CT) of 2400K, which means it contains far less blue and far more yellow and red wavelengths. Before electric light, we burned wood and candles at night; this artificial light has a CT of about 1800K, quite yellow/red and almost no blue. The new "white" LED street lighting which is rapidly being retrofitted in cities throughout the country has two problems. The first is discomfort and glare. Because LED light is so concentrated and has high blue content, it can cause severe glare, resulting in pupillary constriction in the eyes. Blue light scatters more in the human eye than the longer wavelengths of yellow and red, and sufficient levels can damage the retina. This can cause problems seeing clearly for safe driving or walking at night. The other issue is the impact on human circadian rhythm. The need for energy efficiency is serious but not at the cost of human health.LED technology can optimize and should be properly designed. [19]

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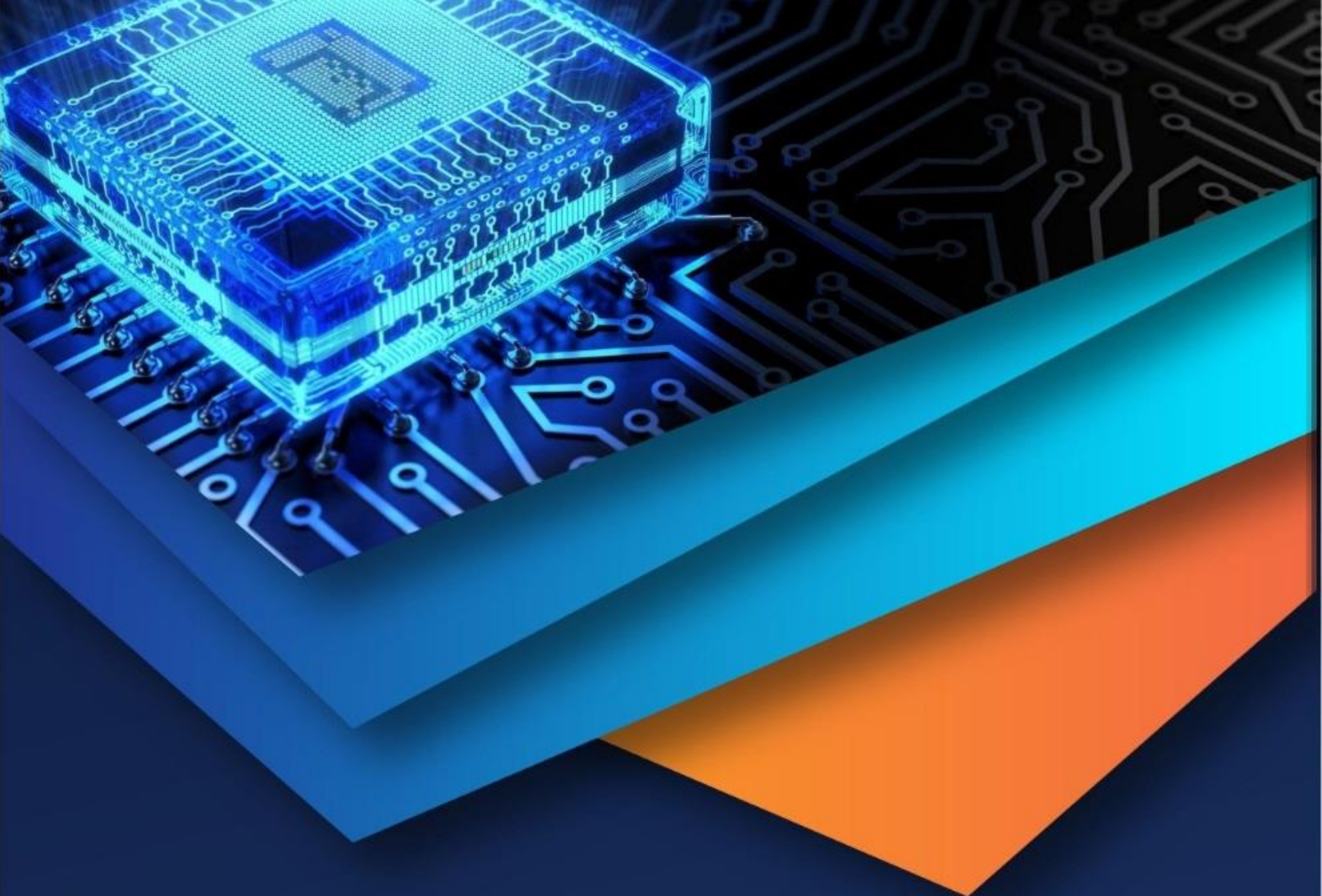

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