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LED Revolution: Deep UV LED

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Abstract - *The Deep UV-light emitting diode (DULED) has been attracting attention in the world as a new UV source that can replace conventional mercury gas-filled lamps in water disinfection applications. . We have studied the distinct advantages, fabrication, characteristics and application of DULED.*

Key Words: **LED, DULED, UV source**

1. INTRODUCTION

LED is semiconductor device that emits light due to Electro- luminescence effect [1], PN Junction Diode, which emits light when forward, biased. Light Emitting Diodes are almost everywhere. LEDs can find everywhere e.g. in Cars, Bikes, Street Lights, Home Lighting, Office Lighting, Mobile Phones, Televisions and many more.

Light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. This effect is called electro -luminescence.[1] The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor.[2] White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.[3]

Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared light. [4] Infrared LEDs are used in remote-control circuits, such as those used with a wide variety of consumer electronics. The first visible-light LEDs were of low intensity and limited to red. Modern LEDs are available across the visible, ultraviolet, and infrared wavelengths, with high light output

The reason for such wide range of implementation of LEDs is its advantages over traditional incandescent bulbs and the recent compact fluorescent lamps (CFL).

Advantages of LEDs over incandescent and CFL light sources are mentioned below:

1. Low Power Consumption
2. Small Size
3. Fast Switching
4. Physically Robust
5. Long Lasting

2. Basics of Deep UV-LED (DULED)

The new LED is Deep-UV LED (DULED) which attracted in a whole world and great deal of attention, especially in the hygiene field. This is because the possibilities of expanding Deep-UV light applications to equipment such as water purification devices have further increased.

2.1 Materials of Deep UV LED (DULED):

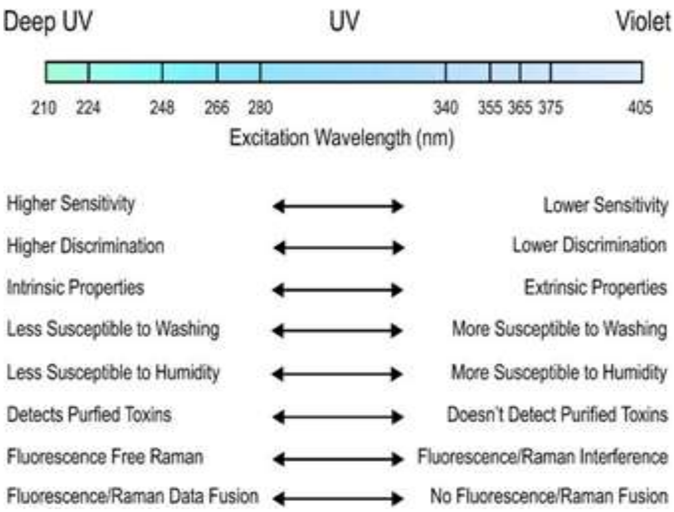
Deep Ultraviolet light-emitting diodes (DUV-LED) made from aluminum gallium nitride (AlGaN) efficiently transfer electrical energy to optical energy due to the growth of one of its bottom layers in a step-like fashion.

$KBe_2BO_3F_2$ (KBBF) is another type of materials practically usable deep ultraviolet (DUV) nonlinear optical (NLO) crystal so far that can generate DUV coherent light by the direct second harmonic generation. Other materials are Fused Silica, CaF_2, MgF_2[5] .

2.1 Application of Deep UV LED (DULED)

The compact size and low power consumption of the UV LEDs help make these instruments practical. Solid state ultraviolet light emitting diodes (UV LEDs) have numerous applications in biomedical industry. LEDs are used for purifying air and water, treating skin diseases, disinfecting surfaces, for industrial (photo-chemical) curing, printing, for forensic investigations and forgery detection [6–10]. Through the years, the UV electromagnetic radiation was primarily based on tube technology first developed in 1901 [11]. Though UV lamps are able to generate high output levels there are several drawbacks of UV lamps: lamps are fragile, can be a biological hazard, since they contain mercury and high voltages resulting in ozone production, require proper disposal techniques, have short lifetimes, and a fixed spectral power distribution. UV lamps cannot be dimmed. High pressure mercury lamps operate at high temperatures and may not be used in processes that require lower temperatures, for example, for photo-chemically curing polymers [12].
Deep-UV LEDs have a superior advantage compared to mercury lamps, such as small size, high efficiency, zero

warm-up time. For this reason, as a general view in the UV light field, mercury lamps will replace LEDs in a natural transition.



While LED device manufacturers focus on accelerating the development of Deep-UV LEDs. It is widely recognized that compact, efficient, long-lived, low- power, affordable deep-UV (DUV) sources would dramatically push LIF detection forward. (Here DUV covers wavelengths of 200–250nm.) In comparison to violet, UV-A, and UV-B (see Figure 1), DUV wavelengths offer LIF detection that is more sensitive because of strong fluorescence cross sections from fluorescent amino acids in proteins, and more discriminating because it targets intrinsic biological properties rather than growth-media residues. It is also less susceptible to threat- washing techniques, residual threat moisture, and ambient.

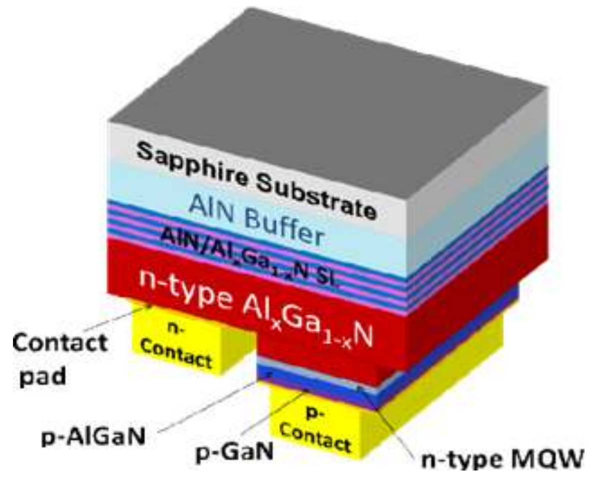
2. Design of Deep UV LED (DUVLED)

Light emitting diodes are very promising efficient light sources. Advanced visible LEDs can deliver more lumens per watt than any other lighting technology [13]. Both red [14] and blue [13] light emitting diodes demonstrated wall plug efficiencies of over 60%. The LED theory [15] and experiments show that LED WPE could, in principle, exceed 100%.

Typical DUV LEDs are considerably less efficient than their visible counterparts. DUV LED's decreased efficiency is due to poor transparency of semiconductor layers to UV light, poor UV light reflectivity of n- and p-contacts, and low conductivity of semiconductor heterostructure. Nevertheless, significant improvement has been achieved by fabricating more transparent semiconductor layers, by improving reflectivity of contacts, by chip encapsulation and by growth of semiconductor layers with low density of threading dislocations. All these improvements allow to predict possibility of achieving 20% wall plug efficiency for DUV LED.

Figure 1 shows the general schematic of the LED flip chip design. The location of different regions is indicated on the figure. The Figure 1 (a) show a traditional device containing p-GaN layer and p contact with low reflectivity, whereas Figure 1 (b) shows an advanced device with p-AlGaN transparent layer and reflective p contact.

(a)



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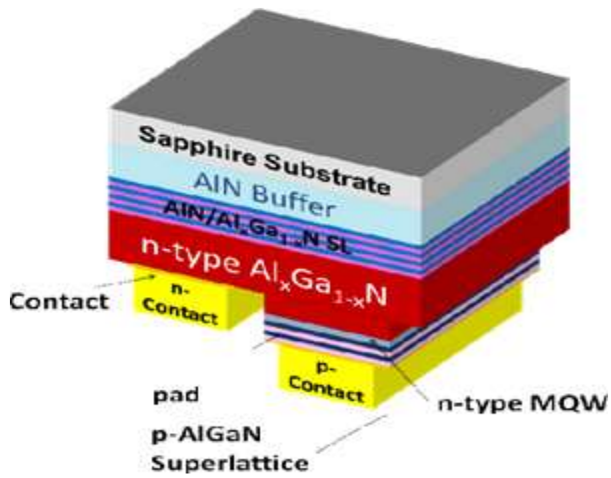

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3. Fabrication of Deep UV LED (DULED):

Kazunobu Kojima of Tohoku University specializes in quantum optoelectronics, which studies the quantum effects of light on solid-state semiconductor materials. He and colleagues in Japan used a variety of specialized microscopic techniques to understand how the structure of AlGaN-based LEDs affects their efficiency. Hey fabricated an AlGaN-based LED by growing a layer of aluminium nitride on top of a sapphire substrate with a very small one degree off-angle. Next, they grew a cladding layer of AlGaN with silicon impurities on top of the aluminium nitride layer. Three AlGaN 'quantum wells' were then grown on top of this. Quantum wells are very thin layers that confine subatomic particles called electrons and holes within the dimension that is perpendicular to the layers' surface, without restricting their movement in the other dimensions. The top quantum well was finally covered with an electron-blocking layer formed of aluminium nitride and AlGaN with magnesium impurities. The microscopic investigations revealed that terraced steps form between the bottom aluminium nitride and AlGaN layers. These steps affect the shapes of the quantum well layers above them. Gallium-rich stripes form that connect the bottom steps to the small distortions they cause in the upper quantum well layers. These stripes represent micropaths of electric current in the AlGaN cladding layer. These micropaths, together with a strong localization of movement of electrons and holes within the quantum well layers, appears to increase the LEDs' efficiency in converting electrical energy to optical energy, the researchers say.

3.1 Characteristics of DULED:

A Deep-UV LED(DULED) is an LED that emits light in the wavelength range called "UV-C" (100 to 280 nm). Currently, the development of Deep-UV LEDs is becoming particularly active. This is because the demand for Deep-UV LEDs has increased dramatically as an alternative device to replace mercury lamps, which have been the main light sources used for UV light application equipment such as sterilization equipment. Deep-UV LED with an output of 50 mW emitting at 265 nm **(Fig. 2)**; the company has already established mass production technology, and plans to start mass production in 2017.

Item	Specifications
PCB	AlN
Wavelength	265 nm
Light output	50 mW
Forward current	400 mA
External quantum efficiency	2.6 7%
Forward voltage	8. 8V
Light distribution angle	140 °
Package size	3.5 × 3.5 mm

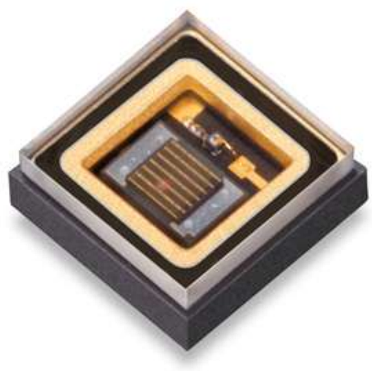

Fig. 2: High-output Deep-UV LED emitting at 265 nm; light output of 50 mW

However, Stanley Electric's Deep-UV LEDs boast the most powerful light output among the 265 nm wavelength products, which currently is the most promising application for water disinfection. "Where chlorine disinfection is ineffective, the wavelength that is effective for sterilization of pathogenic microorganisms ("Cryptosporidium") in water is 265 nm **(Fig. 3)**. Mercury lamp sterilization systems have already been adopted in water purification facilities in Europe and the United States in advance. Recently it has been adopted in water purification plants in Japan. The first Deep-UV LED market is driven by small and medium type water sterilization system applications and — in the future — the replacement of light sources on large scale water sterilization systems (such as water purification facilities).

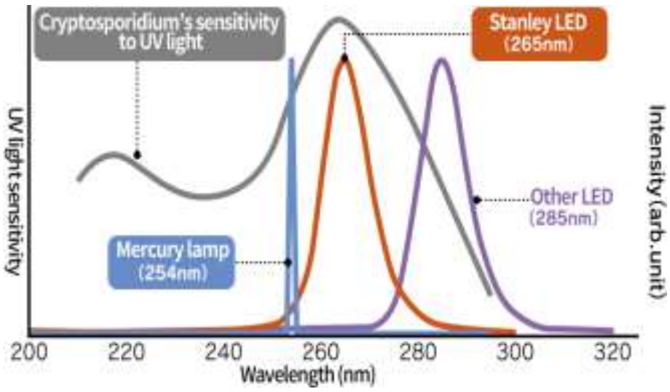

Fig. 3: Deep-UV light emitting at 265 nm, effective for sterilization of the pathogenic microorganism "Cryptosporidium"

Photon Systems offers DUV LEDs with center wavelengths of 280 and 255nm and a choice of a flat window, hemispheric lens or ball lens. Although UV LEDs have a much lower radiance and a much broader line width than a laser, they are useful devices for building compact and lower cost instruments. Due to the spectral line width of 20nm FWHM, the LEDs are useful for fluorescence based detection but not Raman. Here at Photon Systems we use UV LEDs in our TraC trace chemical detector and NaDos personal exposure monitor.

4. CONCLUSION

We have studied the distinct features of advantages of LEDs, DULED, fabrication, characteristics Deep-UV LED with an output of 50 mW emitting at 265 nm ,Stanley Electric's Deep-UV LEDs boast the most powerful light output among the 265 nm wavelength products, which currently is the most promising application for water disinfection. , Where chlorine disinfection is ineffective, the wavelength that is effective for sterilization of pathogenic microorganisms ("Cryptosporidium") in water is 265 nm. Deep-UV LEDs have a superior advantage compared to mercury lamps, such as small size, high efficiency, zero warm-up time. Deep-UV light applications to equipment such as water purification devices have further increased.

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BIOGRAPHIES

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