The light emitting diodes engineering essay

History of lighting devices starts with low efficient incandescent lamps, then next came the CFL lamp. In the history of lighting devices, invention of LED was a turning point Light Emitting Diode or simply LED is an electronic device, which emits light when electricity passes through it. LED has a number of different uses in day to day life. Its uses varies from a simple power on indicator to indicator to traffic signals. LED uses about 10% of the energy traditional light bulb uses and they can last about thirty times longer. LED lights are highly efficient and cost effective.

Nano technology has its own role to play in lighting devices history. Invention of quantum dots and ionic liquids changed the face of lighting industry. Quantum Dots LEDs were manufactured using quantum dots particles. QLEDs offer better luminescence than normal LED lights. Introduction of Ionic Liquids (IL) was another turning point. Still in the beginning stage, Ionic Liquids offer a better solution to the world of lighting devices.

2. Light Emitting Diodes (LED)

A Light Emitting Diode or LED is a semi-conductor device which can be used as a light-source. Semiconductors are neither a good conductor nor an insulator. Semiconductors are made up of semiconducting materials like Silicon or Germanium.

A diode (also called as a PN junction diode) has two terminals, anode(a) and cathode (k), anode is a positive terminal and cathode is negative terminal- which allows electric current to pass only in one direction. A semiconductor diode can be compared to a switch or a one-way valve.

A Light Emitting Diode emits light when electric current passes through it.

The colour emitted by an LED depends on the type of semiconductor material used for its construction. Common colours available for LEDs are green, red, orange, blue, yellow and white. Aluminium gallium indium phosphide (AlGaInp) alloy is used for obtaining red, yellow and orange lights. Indium gallium nitride (IaGaN) is used for getting blue, green and white lights. White and Blue LEDs are more expensive than other colours. Apart from the above colours, Infra Red LEDS (also called IREDs-Infra Red Emitting Diodes) and Ultra Violet LEDs are also available. Staring into an Ultra Violet LEDS is harmful to the eyes.

3. Quantum dot LEDs (QLEDs)

Quantum Dots are very small crystals, in nanotechnology terminology, they are nano particles of semiconductor materials, usually its diameter varies between 2 and 10 nano meters. Quantum dot particles were discovered in early 80s by Louis Brus at Bell Laboratories. A Quantum Dot can contain either a single electron or thousands of electrons. Generally quantum dots are made from the sulphides or selenides of semi conductor materials like Zinc or Cadmium.

Quantum dots' electronic and optical characters are related to the size and shape of each particles. When energy is applied (under excitation), electrons get energized and moved to higher bands, and when electrons get back to the stable state, the additional energy is emitted as light corresponding to a certain frequency. It's narrow emission spectrum is directly proportional to the size of the crystal. Smaller particles give a blue shifted emission and larger particles give a red shifted emission. Using a technique called ' size quantization effect', quantum dots can be ' tuned' to produce any colour during manufacturing.

Quantum dot LEDs (QLED or QD LED) are devices which use quantum dots as their light emitting material. These dots are excited when electricity is applied and emits light according to the size of the dots. Larger dots produce more energy levels and darker colours and smaller dots create smaller energy levels and emits lighter colour shades.

Gold or silver nano particles are very versatile materials whose diameter varies from 1nm to 100nm. Gold nano particles are comparatively smaller that of Silicon Quantum Dots. And it s experimentally proven that, smaller particles generate better fluorescence than that of larger particles. So, Quantum Dot LEDs manufactured from gold or silver nano particles increases the luminescence.

4. Ionic liquids (IL)

Ionic liquid is the salt form of any material in liquid state. Ionic liquids are liquid salts. Ionic liquids are made up of, ions (charged atoms) or ion pairs. These ions or ion pairs are poorly coordinated in the liquid. This poor coordination of ions results in the liquid from below 100°C. Ionic liquids are also known as liquid electrolytes or ionic fluids. When a salt melts without decomposing, it results to an Ionic Liquid. Ionic bond is much more stronger than the bond between the normal Van der Waals forces in the molecules. Ionic liquid changes its form to ionic solid when it gets cooled. Ionic solids are seen in two forms, crystalline and glassy. At low temperature, ionic liquids acts like ionic solutions, which is a combination of both ions and neutral molecules. Ionic liquids are also called designer solvents, because they are manufacturing in the lab for specific purpose.

Properties of ionic liquids are they don’t evaporate, and it is a good conductor of electricity, and it dissolves almost everything. The reason for their non-evaporate property is their non-volatile nature. So, Ionic liquids can replace some acids and organic solvents. Ionic liquids are used for electro polishing, metal plating, extracting metals from rocks. Applications for Ionic liquids are storage for chemical cells, batteries, fuel cells and electro chronic devices for displays, cellulose processing, used as dispersants agents in paints, for gas handling and storage, for natural fuel processing, in food and bio-product industries, in recycling of plastic and synthetic wastes etc.

5. Turn-On Time

Turn on time or rise time is the time required by a signal to change from low state to high state. The time it takes for the output of a system to change from a specified small percentage (usually 5 or 10) of its steady-state increment to a specified large percentage (usually 90 or 95). (www. answers. com)

An LED’s turn-on-time is the time needed by the device to turn from OFF state to ON state. Time needed to emit the light, after applying the electricity. LEDs are very fast devices and its turn-on time is 0. 0001S or 0. 1mS.

Polymer light emitting diodes (PLED) uses an electro luminescent conductive polymer that emits light when connected to a power supply. PLEDs need very small amount of electricity to emit light and therefore they are considered to be very efficient.

A polymer light emitting diode use ionic liquids as one its active material. Usually polymer light emitting diode has fast turn on time.

6. Improved Efficiencies in LED

LED efficiency can be improved by paying attention on packaging, chip structure and positive voltage applying.

White LEDs are usually considered to be more efficient that the other Red, Green, Blue colour LEDs. White light in LED can be produced in two ways. One method is, using three individual LEDs which producing the primary colours and then mixing them to produce the white light. Another method is, using the principle which is using in fluorescent lights, a phosphor material is used to convert light from UV or blue LED to white light. The luminous efficiency of blue/UV chip and the conversion efficiency of phosphorous determine the efficiency of white LED.

Luminous efficiency is highly influenced by temperature and current. Efficiency of LEDs fall with the increasing current. This effect is called droop. When operating temperature increases from 327K to 380K, the luminous efficiency dropped by 20%.

When the temperature is rising, the radiation at the potential decreases which eventually cause a decrease in luminous efficiency. When operating current rises from 0mA to 350mA, the luminous efficiency of LED tend to be decreased by 35%. When current increases, more and more non-stable electrons diffuse out of potential well, thus decreasing the luminous efficiency.

We can improve the luminous efficiency of a LED by improving the heat dissipation efficiency and increasing the width of potential well. Working condition of a LED should be under limited temperature and moderate current. The heat generated in the LED, reduces the efficiency of lighting performance. A good packing technology is the way to solve the heat dissipation problem. But developing a heat dissipation technology for reducing the LED's working temperature is a real challenge. The efficiency and reliability of an LED depends on the thermal dissipation of an LED, because the heat generated in the junction affect the performance and effective operation of LED.

LED efficiency can be improved by LED packaging. But, we need to over come the challenges facing in packaging stage to reach the desired efficiency. The challenges facing in packaging are colour consistency of light emitting, multi-chip packaging etc. Packaging technology used for high power LED are more complex and costly. In addition to packaging, chip structure and positive voltage also play a role in LED efficiency. Efficiency can be achieved if positive voltage can be controlled in a very small range.

7. Studies of radiation damage in solar cells and LEDs

Solar cells

Solar cells or photovoltaic (PV) cells are devices which converts solar light to electricity. Working principle of a solar cell is just opposite to that of LED. A solar cell converts light to electricity while a LED converts electricity to light. In a solar cells, photovoltaic effect generates electricity.

Solar cells are made up of semiconductor materials like silicon. When light hits on a solar cell, some portion of a light is absorbed by silicon material. That means, the energy in the light is shifted to the semi conductor material. This energy excites the electrons and make them to break the covalent bond, Breaking of covalent bonds in an atom results in free electrons. This free electrons start flowing and the flow of free electrons cause a current flow in the solar cell. A group of solar cells are electrically connected to form a frame called solar panels. A solar panels are grouped to form large solar arrays.

When sunlight hits the semiconductor, the electrons from P-type semiconductor springs up and is attracted towards the N-type semiconductor. This make negative charges in the N-type semiconductor and more positive charges in P-type semiconductor. Thus electricity is generated due to the flow of electrons. This is called photovoltaic effect.

Radiation damage

Radiation damage is the physical damage occurs to devices (solar cell or LED) in a radiation environment. Visible light, also known as electromagnetic radiation, does not damage soalr cells or LED normally. But exposing to ultra violet (UV) light , which has more energy, can damage the cells overtime. Output parameters of the devices are affected by radiation damage. Radiation damage in solar cells and LEDs occur when highly massive particles like electrons, protons, or ions come in contact with semi conductor materials. The source of the highly massive particles may be nuclear reactions, gamma rays, space radiation etc. The particles having mass and energy can interact with materials in different ways, such as inelastic collision with electrons in a material, inelastic collisions with nucleus and elastic collisions with nucleus.

Ionisation and atomic displacement are the two categories of radiation damage that occur to solar cells and LEDs.

Ionisation : Ionisation is the process when an atom becomes an ion. It happens, when electrons lose from an outer orbit or extra electrons are added to atom structure. High energy radiation cause ionisation in materials.

The use of silicon is solar cells and LEDs cause a range of ionisation related radiation effects such as increased leakage current, decreased gain etc.

Atomic displacement : When a fast particles collide with a crystal, silicon atoms may get displaced from their lattice structure. And this displacement may damage the silicon solar cells.

Silicon Solar cell damage

There are different method to measure silicon solar cell damage. One method is by measuring the irradiation changes occurring in a solar cell and can be explained using basic solar cell equation. This method require data such as series resistance, shunt resistance, current generated by light and diode parameters such as saturation current and quality factor of diode.

Solar cell damage can also be measured by observing the change in minority carrier diffusion length. And this method is widely used because diffusion length is measurable. But there are many disadvantage to this method. One serious disadvantage is damage caused due to low energy protons. Low energy protons do a significant damage to the PN junction of a solar cell. This irregular damage increases the saturation and quality factor of the diode. This damage can cause a significant decrease in voltage. The output parameters of a solar cell can be described using the formula

$Isc = Isc0 - C \log (1 + Phi / Phix)$, where

Isc is the cell short circuit current

Phix is the radiation fluence at which Isc starts to change

C is the Constant indicates the decrease in Isc per decade

The relation between solar cell short circuit current and diffusion length can be represented as $Isc = A \ln L + B$.

Solar cells are more prone to radiation damage in space. The degradation of cover glass material of solar cell in space is more. Ionisation cause more damage to covering material than atom displacement. Ionisation in material are directly depend on the radiation absorbed.

Solar cells are usually made up of Si and GaAs which are more prone to radiation. Replacing these semiconductor material with InP during manufacturing is the best way to reduce damage due to radiation. InP is more resistant to radiation that Si or GaAs. InP substrate constructed with high carrier concentration has superior radiation resistance.

LEDs are also prone to displacement damage. Shorter wave length AlGaAs and GaAs LEDs emitting light in the region 800-900nm are more prone to radiation damage. Manufacturing LEDs with higher wavelength is the answer to this radiation problem.

8. CONCLUSION

LED lights are widely using these days commercially. The main advantage of LED is its reduced power consumption. They are highly efficient, cost effective, durable and long lasting. Inventions like quantum dot and Ionic Liquids in Nano Technology field, bring significant changes in Lighting. Quantum Dot LEDS are more efficient than normal LEDs, QLEDs use nano crystals as their lighting materials. Use of gold or silver nano particles increases the luminescence emitted from the QLEDs. Introduction of Ionic Liquids, changed the appearance of LED lights. Ordinary LED lights produces a harsh white lights. Implementing a layer of ionic liquids to the LED light, produces a warm light. Researches were made to find the ways of improving the efficiencies of LED. When expose to space radiation solar cells and LEDs are more prone to damages. And it reduces the life span of these devices. Researches are still continuing in the field of nano technology, searching for finding new methods to improve the efficiency of lighting devices.