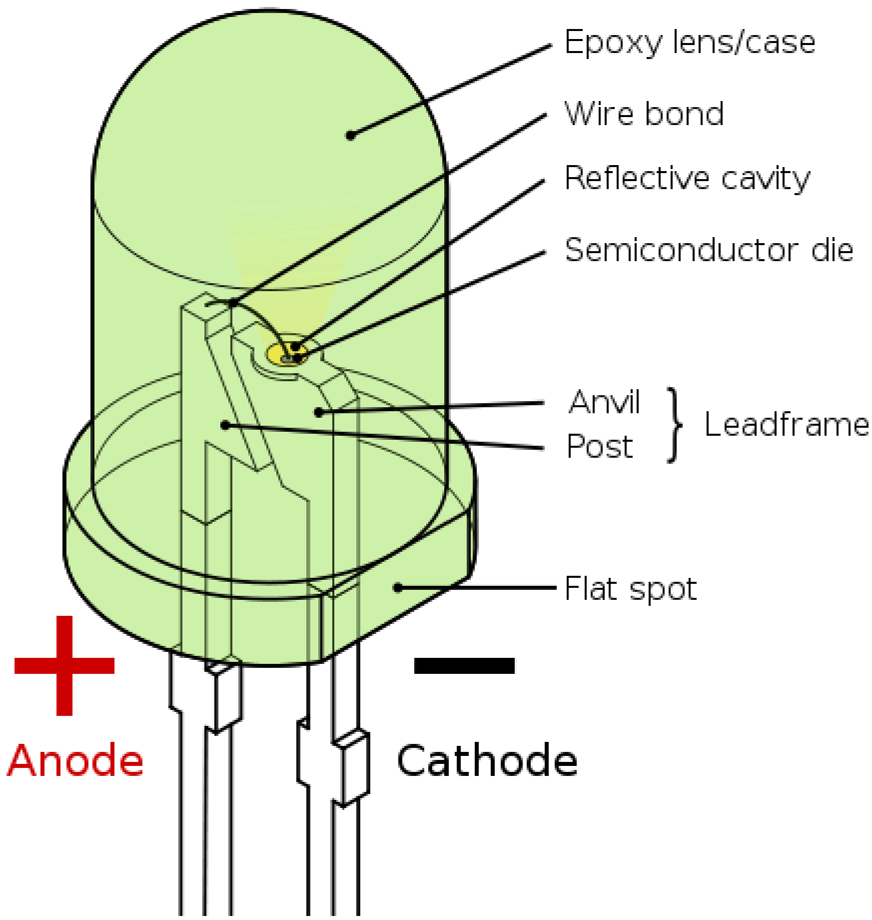
ALL THAT YOU WANT TO KNOW ABOUT THE LIGHT EMITTING DIODES OR LEDS

LED=LIGHT EMITTING DIODE IS A SEMICONDUCTOR DEVICE WHICH EMITS LIGHT WHEN PROPERLY BIASED. LIKE THE BASIC SEMICONDUCTOR DIODE IN FORWARD BIAS, THE ELECTRONS AND THE HOLES IN THE LED COMBINE TO RELEASE ENERGY BY A PROCESS CALLED ELECTROLUMINESCENCE. THE COLOUR OF THE LIGHT IS DETERMINED BY THE ENERGY GAP OF THE SEMICONDUCTOR.

A LIGHT EMITTING DIODE CONSISTS OF MULTIPLE LAYERS OF SEMI-CONDUCTING MATERIAL. WHEN THE DIODE IS BEING USED WITH DIRECT CURRENT, LIGHT IS PRODUCED IN THE ACTIVE LAYER. THE LIGHT PRODUCED IS DECOUPLED DIRECTLY OR BY REFLECTIONS. IN CONTRAST TO INCANDESCENT REFLECTOR LAMPS, WHICH EMIT A CONTINUOUS SPECTRUM, AN LED EMITS LIGHT IN A PARTICULAR COLOR. THE LIGHT'S COLOR DEPENDS ON THE SEMICONDUCTOR MATERIAL USED. TWO MATERIAL SYSTEMS ARE MAINLY USED, IN ORDER TO PRODUCE LEDS WITH A HIGH DEGREE OF BRIGHTNESS IN ALL COLORS FROM BLUE TO RED AND, BY MEANS OF LUMINESCENCE CONVERSION, ALSO IN WHITE. DIFFERENT VOLTAGES ARE NECESSARY, TO OPERATE THE DIODE IN FORWARD BIAS.

LEDS ARE SEMICONDUCTOR CRYSTALS. DEPENDING ON THE COMPOSITION OF THE CRYSTAL COMPOUNDS, THEY EMIT LIGHT IN THE COLORS OF RED, GREEN, YELLOW OR BLUE, WHEN CURRENT FLOWS THROUGH THEM. WITH THE THREE RGB COLORS, ANY NUMBER OF COLOR TONES MAY BE MIXED BY VARYING THE PROPORTIONS OF THE INDIVIDUAL COLORS. IN THIS WAY, THE LED LIGHTING CAN CREATE FASCINATING WORLDS OF EXPERIENCE.



HISTORY

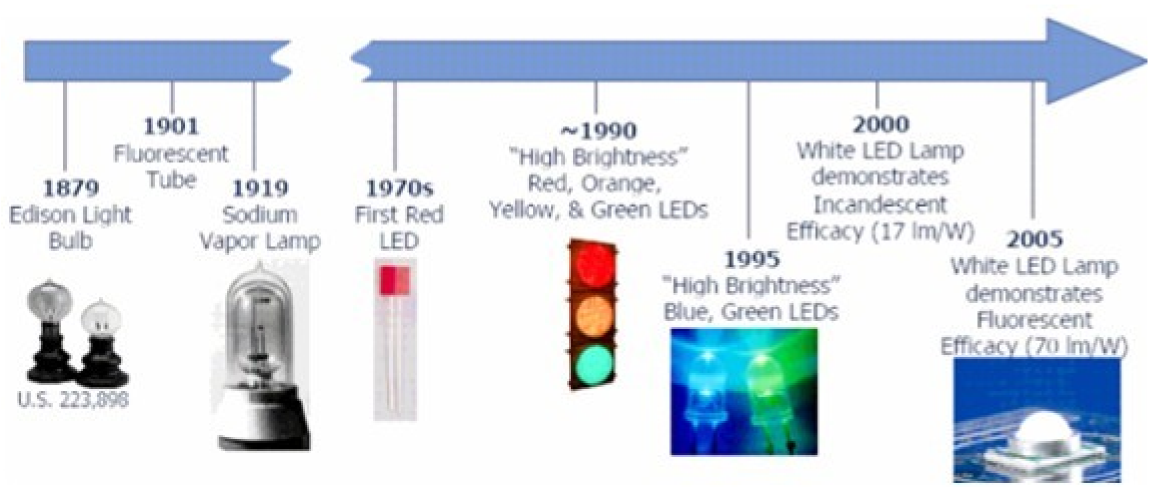
The first LED was invented by Oleg Lose (1927), James R. Biard (1961), Nick Holonyak (1962) separately. Early LEDS emitted low intensity red light, modern ones are available across the visible, ultraviolet and infrared wavelengths with very high brightness. The table below gives the succinct view of the developments in the LED technology over the years.

YEAR	DEVELOPMENT
1907	Electroluminescence discovered as a phenomena by H.J. Round using a crystal of silicon carbide. He was working for Marconi and was undertaking some experiments using crystal detectors. he passed currents through some of his detectors and noted one of them was emitting light when current was passed through it. not understanding the mechanism behind it he published his find in magazine Electrical World.
1927	Oleg Losev created first led. He observed light emissions from zinc oxide

	and silicon carbide rectifiers. He demonstrated the I-V characteristics of the carborundum diode and found that the light emission was not a thermal effect but arising from semiconductor action. He also investigated temperature relationships of the effect, cooling the semiconductors to very low temperatures.
1935	The French physicist Georges Destriau discovers light emission in zinc sulfide. In honor of the Russian physicist, he calls the effect "Lossew light". Today Georges Destriau is credited as the inventor of electroluminescence.
1939	Zoltan Bay together with Gyorgy Szigeti pre-empted LED lighting in Hungry in 1939 by patented a lighting device based on SiC, with an option on boron carbide, that emitted white, yellowish white, or greenish white depending on impurities present
1951	After discovery of transistor (scientific leap in semiconductor physics), Shockly along with Howard Briggs and James Haynes applied for patent on infrared LED in both silicon and germanium.
1952	A research team lead by Kurt Lehovec applied for a patent for silicon carbide diodes that emit light. He appears to have grown n-type SiC doped with arsenic, then locally introducing boron with an electron beam to make p-SiC for the junction.
1955	Rubin Braunstein reports infrared emissions from gallium arsenide, gallium antimonide, indium phosphide and silicon germanium alloys.
1958	Rubin Braunstein and Egnor Loebner, researchers at RCA patented a green led.
1961	James Biar and Gary Pittman found infrared radiation from GaAs When Electric current is applied. Received first us patent for the led.
1962	Nick Holonyak developed first practical visible spectrum (red); regarded as father of led. Robert Keyes and Theodor Quist at MIT, and a group led by Jacques Pankove at RCA, revealed high efficiency infra-red emissions from GaAs p-n junctions infrared LEDs, and combining this with a GaAs photodiode transmitted TV signals optically from a mountain into the MIT laboratory.
1968	Monsanto Company becomes the first organization to mass-produce visible LEDs using gallium arsenide phosphide to produce red LEDs.
1970	Fairchild optoelectronics produce commercially successful LEDs.
1971	jacques Pankove made first blue LEDs using gallium nitride.
1972	M. George Crafoed invented first yellow led, improved brightness of red and red-orange LEDs by factors of ten.
1976	T.P. Pearsall created first high brightness, high efficiency led fro optical fiber transmission wavelengths.

1987	Aluminium galliumarsenide LEDs from HP were bright enough to be used in place of light bulbs in vehicles brake light and traffic lights.
1989	Cree Inc. introduced first commercially available blue LED based on indirect band gap semiconductor , silicon carbide.
1991	Masayuki Senoh, researcher at Nichia succeeded in producing p-type gallium nitride.
1994	Shuji Nakamura of Nichia Corporation demonstrate high brightness blue LED by making first p-n junction GaN LED.
1995	Alberto Barbieri demonstrated a transparent contact LED using indium tin oxide
1999	Philips Lumileds introduce power LEDs capable of continuous use at one watt.
2002	Lumileds make 5 watt LEDs with luminous efficacy of 18-22 lumens per watt. (An incandescent light bulb of 60-100 watt emits around 15 lumens/watt. Efficacy falls sharply with rising currents
2006	The first light-emitting diodes with 100 lumens per watt are produced. This efficiency can be outmatched only by gas discharge ?lamps.
2008	Bilkent university reports 300 lumens of visible light per watt luminous efficacy and warm light using nanocrystals.
2009	Cambridge university reports a process for growing gallium nitride LEDs on silicon.
2010	LEDs of a certain color with a gigantic luminous efficacy of 250 lumens per watt are already being developed under laboratory conditions.

Progress continues to surge ahead. Today, further development towards LED is seen as the technology of the future.



MOVING TOWARDS THE LATEST TRENDS:-

THE ORGANIC LEDS

AN OLED (ORGANIC LIGHT-EMITTING DIODE) IS A LIGHT-EMITTING DIODE (LED) IN WHICH THE EMISSIVE ELECTROLUMINESCENT LAYER IS A FILM OF ORGANIC COMPOUND WHICH EMITS LIGHT IN RESPONSE TO AN ELECTRIC CURRENT. THIS LAYER OF ORGANIC SUBSTANCE IS SITUATED BETWEEN TWO ELECTRODES. GENERALLY IT IS SEEN THAT AT LEAST ONE OF THE ELECTRODES IS TRANSPARENT.

A LITTLE BIT OF HISTORY:-

THE FIRST OBSERVATIONS OF ELECTROLUMINESCENCE IN ORGANIC MATERIALS WERE IN THE EARLY 1950S BY ANDRÉ BERNANOSE AND CO-WORKERS AT THE NANCY-UNIVERSITÉ, FRANCE.

IN 1960, MARTIN POPE AND CO-WORKERS AT NEW YORK UNIVERSITY DEVELOPED OHMIC DARK-INJECTING ELECTRODE CONTACTS TO ORGANIC CRYSTALS. IN ADDITION TO THIS THEY WERE THE FIRST TO OBSERVE DIRECT CURRENT ELECTROLUMINESCENCE UNDER VACCUUM ON A PURE CRYSTAL OF ANTHRACENE AND ON ANTHRACENE CRYSTALS DOPED WITH TETRACENE.

ELECTROLUMINESCENCE FROM POLYMER FILMS WAS FIRST OBSERVED BY ROGER PARTRIDGE AT THE NATIONAL PHYSICAL LABORATORY IN THE UNITED KINGDOM.

THE FIRST DIODE DEVICE WAS REPORTED AT EASTMAN KODAK BY CHING W. TANG AND STEVEN VAN SLYKE IN 1987.

THE BASIC PRINCIPLE IS THAT THE ORGANIC MOLECULES ARE ELECTRICALLY CONDUCTIVE AS A RESULT OF DELOCALIZATION OF PI-ELECTRONS CAUSED BY CONJUGATION OVER ALL OR PART OF THE MOLECULE. THE HIGHEST OCCUPIED AND LOWEST UNOCCUPIED MOLECULAR ORBITALS (HOMO AND LUMO) OF ORGANIC SEMICONDUCTORS ARE ANALOGOUS TO THE VALENCE AND CONDUCTION BANDS OF INORGANIC SEMICONDUCTORS.

ORIGINALLY, THE MOST BASIC POLYMER OLEDS CONSISTED OF A SINGLE ORGANIC LAYER. MULTILAYER OLEDS CAN BE FABRICATED WITH TWO OR MORE LAYERS IN ORDER TO IMPROVE DEVICE EFFICIENCY.

PHOSPHORESCENT ORGANIC LIGHT EMITTING DIODES USE THE PRINCIPLE OF ELECTROPHOSPHORESCENCE TO CONVERT ELECTRICAL ENERGY IN AN OLED INTO LIGHT IN A HIGHLY EFFICIENT MANNER, WITH THE INTERNAL QUANTUM EFFICIENCIES OF SUCH DEVICES APPROACHING 100%.

MORE RECENT DEVELOPMENTS IN OLED ARCHITECTURE IMPROVE QUANTUM EFFICIENCY (UP TO 19%) BY USING A GRADED HETEROJUNCTION.

An OLED display works without a backlight. The advantage of this feature is that it can display deep black levels and can be thinner and lighter than a Liquid Crystal Display (LCD). In low ambient light conditions such as a dark room an OLED screen can achieve a higher contrast ratio than an LCD, whether the LCD uses cold cathode fluorescent lamps or LED backlight.

The TWO MAIN FAMILIES or categories of OLEDs-

Those based on small molecules

Those employing polymers

OLED displays can use either passive-matrix (PMOLED) or active-matrix (AMOLED) addressing schemes. Active-matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes.

Applications of OLEDs:- Solid state lighting (require high brightness), Lower cost in the future, Lightweight & flexible plastic substrates, Wider viewing angles and improved brightness, Better power efficiency and thickness, Response time (faster response time than LCD screens), Also used as a fashion trend!!

DISADVANTAGES:- Current costs (still experimental and fabrication process is expensive), Limited lifespan, Color balance issues, Water damage to the organic materials.

OSRAM's PHOSPHORUS LAYERING PROCESS

The "Chip Level Coating" process (CLC), developed and patented by OSRAM, in which phosphorus is applied directly on top of the chip, provides homogeneity in the light output which other processes do not achieve.

SOLID STATE LIGHTING

- Fully integrated to deliver light.

- It delivers a scalable, easily integrable reduction in costs (electrical energy, maintenance, replacement, waste management

Essential parts of led lighting: 1. LED chip/device/package. 2. Driver 3. Optics 4. Heatsink

Advantages:

High light efficacy and long life, have the potential to achieve 95% conversion efficiencies, long life (upto 1,00,000 hours for general application, for special applications 50,000 hours.

IT EMITS LIGHT 2.5 TIMES A COMMON FLUORESCENT AND 100 TIMES THAN OF INCANDESCENT BULB), ROBUSTNESS (RESISTANCE TO VIBRATIONS AND WITHSTAND EXTREME ENVIRONMENT(NO GLASS , NO FILAMENT BREAKS)), VARIABLE AND LOW TEMPERATURE PERFORMANCE (RESISTANCE TO LOW TEMPERATURES AND EXTREME WEATHER FLUCTUATIONS), DIGITAL CONTROL (DIGITAL SIGNALS CAN BE EASILY PROGRAMMED INTO LED DRIER TO CONTROL LIGHTING), COLOUR SATURATION AND SPECTRUM (RGB ARRAY CAN BE PROGRAMMED TO PRODUCE ALMOST ANY COLOUR), OPTICAL CONTROL (OPTICAL SYSTEMS CAN BE DESIGNED TO CONTROL LIGHT BEAM WITH HIGH EFFICIENCY RESULTING IN LESS ENERGY REQUIREMENT), LOW VOLTAGE OPERATION (USE LOW VOLTAGE DC POWER MAKING THEM SAFE ECONOMICAL EASY TO INSTALL AND OPERATE), REDUCE COOLING COSTS.

DISADVANTAGES: HIGH COST OF GENERAL LIGHTING, LIMITED MARKETING POTENTIAL FOR HIGH QUALITY PRODUCTS.

WHITE LED LIGHTS

EMPLOY A Y3AL5O12: CE OR YAG PHOSPHOR COATING TO MIX DOWN CONVERTED YELLOW LIGHT WITH BLUE LIGHT THAT APPEARS WHITE.

TWO PRIMARY WAYS OF PRODUCING HIGH INTENSITY WHITE LIGHT:

1. USE OF INDIVIDUAL LEDS THAT EMIT THREE PRIMARY COLOURS- RED, GREEN AND BLUE THEN MIX ALL THE COLOURS PROPORTIONATELY TO PRODUCE WHITE LIGHT.

2. USE OF A PHOSPHOR MATERIAL TO CONVERT MONOCHROMATIC LIGHT FROM A BLUE OR UV LED BROAD SPECTRUM WHITE LIGHT (THIS OPTION IS MORE POPULAR BECAUSE OF COST ADVANTAGES).

FIRST LIGHT EMITTING TRANSISTOR

THIS BREAKTHROUGH WAS ACHIEVED BY THE FATHER OF LED, NICK HOLONYAK. THE IDEA BEHIND LETS IS TO CHOOSE MATERIALS CAREFULLY IN ORDER TO CREATE A BAND GAP LARGE ENOUGH TO EMIT VISIBLE LIGHT WHEN ELECTRONS AND HOLES RECOMBINE. HOLONYAK AND FENG CHOSE A COMBINATION OF INDIUM-GALLIUM-PHOSPHIDE AND GALLIUM ARSENIDE FOR THEIR TRANSISTOR.

LEADING COMPANIES IN LED DEVELOPMENT

WHILE NICHIA, OSRAM, LUMILEDS AND CREE REMAIN THE LEADING SUPPLIERS OF PACKAGED LEDS, THEY ARE BEING CHALLENGED BY COMPANIES IN TAIWAN AND KOREA. SEOUL SEMICONDUCTOR IS A RAPIDLY GROWING COMPANY.

ACCORDING TO A REPORT FROM IMS RESEARCH, A MARKET RESEARCH COMPANY BASED IN THE UK, THE TOP THREE COMPANIES IN 2007 IN TERMS OF TOTAL DOLLAR REVENUES FOR PACKAGED LEDS WERE NICHIA (24%

of the market), Osram Opto (10.5%) and Philips Lumileds (6.5%). These three companies have been well established as the top three for several years now. However, these companies now face strong challenges from companies in Taiwan and Korea. Other companies in the top ten in the report include Citizen and Toyoda Gosei from Japan, as well as Everlight and Kingbright, two Taiwanese companies that have also seen good growth. Avago Technologies is also in the top ten by total revenue.

Commercial LED history

The first commercially available LEDs started to appear in the late/mid 1960s. These LEDs early LEDs used a semiconductor made using gallium, arsenic and phosphorus - GaAsP. This produced a red light, and although the efficiency of the devices was low (typically around 1 - 10 mcd at 20mA) they started to be widely used as indicators on equipment.

One of the first companies to manufacture LEDs on any scale was Monsanto. Monsanto was actually a company supplying the raw semiconductor materials. They had aimed at working with Hewlett Packard - then a test equipment company - with Monsanto supplying the semiconductor and Hewlett Packard manufacturing the diodes.

With the original GaAsP devices being manufactured, the next development saw gallium phosphide devices developed. GaP devices were not widely used because the light they produced was at the far end of the red spectrum where the sensitivity of the human eye is low, and even though they produced a high output, the human perception was of a dim light.
High output LED lamps

As LEDs were developed, the light levels increased to the extent that they could be considered for applications outside simple indicator lamps. By 1987 the Hewlett Packard AlGaAs (aluminium gallium arsenide) diodes being produced were bright enough for the first applications within lighting. The first applications for these diodes was within the automotive industry where red LEDs were used for vehicle brake lights, and also for traffic lights.The use of LEDs was of particular interest because of their increased reliability over the incandescent lights that had been previously used.

A year after the first AlGaAs LEDs were introduced another variant, AlInGaP (aluminium Indium Gallium Phosphide) were manufactured. These LEDs gave a significant improvement over the previous AlGaAs diodes by doubling the light output.

Later, in 1993 HP started to use GaP (gallium phosphide) to provide high output green LEDs. Also further developments of this technology allowed the production of high output orange lamps. These were ideal for use as car direction indicators - again their reliability in being turned on and off as well as their efficiency proved to be a major improvement.

A visible LED

This first laser kicked off a month of activity in which Robert Rediker at MIT, Holonyak at a different GE lab, and Marshall Nathan at IBM all made lasers. The key was nitrogen doping, the idea for which Craford credits a presentation by a Bell Labs researcher – Bell Labs was working with GaP LEDs, trying both ZnO and N as dopant. Craford moved on to HP in 1969, heading a group that pioneered AlGaAs for bright red LEDs and AlInGaP for bright orange and green.

LED as bulb replacement

By 1987 AlGaAs LEDs from HP were bright enough to replace light bulbs in vehicle brake lights and traffic lights, the first time LEDs displaced incandescent bulbs in a lighting application. AlInGaP followed in 1990, offering at least double the brightness of AlGaAs.

White LEDs

By the end of September 1991, Nichia researcher Naruhito Iwasa discovered a production compatible way to make p-GaN – annealing Mg-doped GaN above 600°C. With the added development of Zn+Si doping by 1993 the firm was shipping blue GaN LEDs that were 100x brighter than Cree's SiC types.

For over 30 years, LEDs have been used in various areas of application, whether for industrial systems, hi-fi equipment, car lights or advertising. LED technical development continues to stride ahead. In the course of recent years, the white LEDs' luminous efficacy has increased to a startling 130 lumens per watt and more. This is a trend that will continue into the future. In addition, the physical effect of electroluminescence was discovered more than 10 years.

BENEFITS OF LED LIGHTNING TECHNOLOGY

Initially the LED lighting industry targeted the commercial and military aerospace industries where the benefits of applying LED lighting technology have already achieved substantial acceptance. The energy savings produced are compounded by massive reductions in maintenance costs and the application of LED lighting is now commonplace in both retrofit and new build aircraft as the commercial benefits of this technology are proven beyond doubt.

THE MAIN BENEFITS INCLUDE:

▪ REDUCED POWER CONSUMPTION:

WHEN COMPARED TO CONVENTIONAL MAINS POWERED LIGHTING SOLUTIONS, SAVINGS OF 80% - 85% ARE COMMON IN MANY LED APPLICATIONS WHEN USING LOW VOLTAGE DC POWER CONVERSION FROM MAINS POWER.

▪ INCREASED LIFE AND DECREASED MAINTENANCE:

THE TYPICAL TOTAL LIFE OF 100,000 HOURS (10+ YEARS) PER UNIT WITH MINIMAL DEGRADATION OF LIGHT OUTPUT ELIMINATES THE COST OF LAMP REPLACEMENT AND REGULAR MAINTENANCE.

▪ LOWER TOTAL COST OF OWNERSHIP (TCO):

LEDS OFFER GREATLY REDUCED LONG TERM OUTRIGHT COST OF OWNERSHIP WITH MINIMAL INITIAL SYSTEM OUTLAY IF USED AS A REPLACEMENT LIGHT SUPPLY USING REDUCED VOLTAGE MAINS POWER (110VAC OR 240VAC CONVERTED TO 12VDC OR 24VDC).

▪ WIDER RANGE OF WORKING VOLTAGE OPTIONS:

LEDS ONLY REQUIRE TINY AMOUNTS OF POWER (TYPICALLY IN THE 12VDC â€“ 48VDC RANGE) TO OPERATE EFFICIENTLY WHICH IS IDEAL WHEN CONSIDERING SYSTEMS TO BE RUN FROM SOLAR OR WIND GENERATED POWER. THERE IS ALSO THE OPTION OF RUNNING LED LIGHTING SYSTEMS FROM MAINS GENERATED POWER (110VAC OR 220VAC) VIA CONVENTIONAL TRANSFORMERS AT VASTLY REDUCED RUNNING COSTS.

▪ LOWER HEAT OUTPUT:

MAXIMUM LED OPERATING TEMPERATURES ARE TYPICALLY 45Â°C RATHER THAN THE 300Â° - 450Â°C OPERATING TEMPERATURES OF CONVENTIONAL LIGHTING SOLUTIONS. HEAT POLLUTION IS THEREFORE REDUCED OFFERING SAVINGS IN THE OPERATION OF SECONDARY INTERIOR SYSTEMS SUCH AS AIR CONDITIONING.

▪ MINIMISED LIGHT POLLUTION:

LIGHT POLLUTION CAN BE VIRTUALLY ELIMINATED AS LIGHT OUTPUT FROM LEDS IS DIRECTIONAL, ONLY DIRECTING LIGHT WHERE IT IS REQUIRED VIA REFLECTOR OR OPTICAL GUIDANCE. SPECIFIC BEAM SPREADS CAN BE DEFINED TYPICALLY WITHIN A RANGE OF 2Â° - 150Â° FROM LIGHT SOURCE. THIS IS HIGHLY EFFICIENT AS NO LIGHT IS WASTED WHEN COMPARED TO CONVENTIONAL LIGHTING WHERE LIGHT IS TYPICALLY OMNI-DIRECTIONAL FROM BULBS OR TUBES AND INEFFICIENT AS MUCH OF THE LIGHT GENERATED TRAVELS AWAY FROM THE AREA WHERE IT IS REQUIRED.

▪Reduced Carbon Emissions:

LED lighting systems are environmentally and ecologically friendly. Other than the massive reduction in use of conventionally generated energy, there are no poisonous elements used in component manufacture, such as Mercury and other noxious and polluting gases.

▪Dimmable Control:

In addition to Instant On, LED lighting offers fully dimmable illumination from standard leading edge phase control, 0 â€“ 10V / 1 â€“ 10V dimming, DALI automated dimming and DMX software control. The application of highly efficient dimming control systems permits greater energy savings and maintenance reduction especially over any type of fluorescent type lighting which cannot be full range dimmed.

▪Shock Resistance:

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:

The quality of the LED 'white' light can be tailored to suit the human eye, eliminating the eye strain that can have adverse and costly implications in certain working and living environments together with Health and Safety issues. LEDs do not produce ultraviolet light (however there are UV variants) and can be perfectly matched to a specific 'colour rendering index'.

Disadvantages

• High initial price: LEDs are currently more expensive, price per lumen, on an initial capital cost basis, than most

conventional lighting technologies.The additional expense partially stems from the relatively low

lumen output and the drive circuitry and power supplies needed.

• Temperature dependence: LED performance largely depends on the ambient temperature of the operating environment . Over-driving an LED in high ambient temperatures may result in

OVERHEATING THE LED PACKAGE, EVENTUALLY LEADING TO DEVICE FAILURE. AN ADEQUATE HEAT SINK IS NEEDED TO MAINTAIN LONG LIFE.

• VOLTAGE SENSITIVITY: LEDS MUST BE SUPPLIED WITH THE VOLTAGE ABOVE THE THRESHOLD AND A CURRENT BELOW THE RATING. THIS CAN INVOLVE SERIES RESISTORS OR CURRENT-REGULATED POWER SUPPLIES.

• LIGHT QUALITY: MOST COOL-WHITE LEDS HAVE SPECTRA THAT DIFFER SIGNIFICANTLY FROM A BLACK BODY RADIATOR LIKE THE SUN OR AN INCANDESCENT LIGHT. THE SPIKE AT 460 NM AND DIP AT 500 NM CAN CAUSE THE COLOR OF OBJECTS TO BE PERCEIVED DIFFERENTLY UNDER COOL-WHITE LED ILLUMINATION THAN SUNLIGHT OR INCANDESCENT SOURCES, DUE TO METAMERISM, RED SURFACES BEING RENDERED PARTICULARLY BADLY BY TYPICAL PHOSPHOR-BASED COOL-WHITE LEDS. HOWEVER, THE COLOR RENDERING PROPERTIES OF COMMON FLUORESCENT LAMPS ARE OFTEN INFERIOR TO WHAT IS NOW AVAILABLE IN STATE-OF-ART WHITE LEDS.

• AREA LIGHT SOURCE: SINGLE LEDS DO NOT APPROXIMATE A POINT SOURCE OF LIGHT GIVING A SPHERICAL LIGHT DISTRIBUTION, BUT RATHER A LAMBERTIAN DISTRIBUTION. SO LEDS ARE DIFFICULT TO APPLY TO USES NEEDING A SPHERICAL LIGHT FIELD, HOWEVER DIFFERENT FIELDS OF LIGHT CAN BE MANIPULATED BY THE APPLICATION OF DIFFERENT OPTICS OR "LENSES". LEDS CANNOT PROVIDE DIVERGENCE BELOW A FEW DEGREES. IN CONTRAST, LASERS CAN EMIT BEAMS WITH DIVERGENCES OF 0.2 DEGREES OR LESS.

• ELECTRICAL POLARITY: UNLIKE INCANDESCENT LIGHT BULBS, WHICH ILLUMINATE REGARDLESS OF THE ELECTRICAL POLARITY, LEDS WILL ONLY LIGHT WITH CORRECT ELECTRICAL POLARITY. TO AUTOMATICALLY MATCH SOURCE POLARITY TO LED DEVICES, RECTIFIERS CAN BE USED.

• BLUE HAZARD: THERE IS A CONCERN THAT BLUE LEDS AND COOL-WHITE LEDS ARE NOW CAPABLE OF EXCEEDING SAFE LIMITS OF THE SO-CALLED BLUE-LIGHT HAZARD AS DEFINED IN EYE SAFETY SPECIFICATIONS .

• BLUE POLLUTION: BECAUSE COOL-WHITE LEDS WITH HIGH COLOR TEMPERATURE EMIT PROPORTIONALLY MORE BLUE LIGHT THAN CONVENTIONAL OUTDOOR LIGHT SOURCES SUCH AS HIGH-PRESSURE SODIUM VAPOR LAMPS, THE STRONG WAVELENGTH DEPENDENCE OF RAYLEIGH SCATTERING MEANS THAT COOL-WHITE LEDS CAN CAUSE MORE LIGHT POLLUTION THAN OTHER LIGHT SOURCES.

• DROOP: THE EFFICIENCY OF CONVENTIONAL INGAN BASED LEDS DECREASES AS ONE INCREASES CURRENT ABOVE A GIVEN LEVEL.

IS FUTURE BLEAK FOR THE LED LIGHTING??

DROOP: THE LOSS OF EFFICIENCY AT HIGH POWER—AFFLICTS CONVENTIONAL NITRIDE LED STRUCTURES.

The nitride LEDs feature an active region with gallium indium nitride quantum wells and GaN barriers, and an electron-blocking layer to keep electrons in this region. Researchers at Rensselaer Polytechnic Institute have reduced droop with new active regions, made first by combining GaInN wells and aluminum gallium indium nitride barriers and, more recently, by pairing GaInN wells with GaInN barriers. Meanwhile, Philips Lumileds has also developed a structure that is less prone to droop, thanks to a far thicker quantum well.

LED market developments

The success of the LED industry has to rely on the reliable and credible products that meet customers' need. The outreach training programs are important to establish key market connections from end-users, buyers, product designers and manufactures. The LED market is on the verge of taking off exponentially.

FACTORS DETERMINING GROWTH ARE :

– Technological push: system design

The technological push needs advancements in technology in all of the components selection and design. All of the components need to work together to make color, brightness, efficacy and cost suitable for the right application in the market.

– Manufacturers push: money

Money is the most effective tool to push the manufacturers to the right direction. The government should set up a stringent and transparent standards to stimulate the manufacturers to design and make the right products for the market, this can be done by governmental purchase standards and rebates for high quality and high efficacy LED products.

– Market Pull: Customers

Customers are extremely important to the success of the LED lighting products. The government should support work in surveying world customers in the opinions of current products in the markets and urge the manufacturer to make right adjustment to meet consumers' satisfaction.

– Designers, Architects, Contractors: Direction

Designers, architects and contractors are important in terms of their communication with clients to make the right design and suggestions to the manufacturers. A great design is a key to the product's success.

– Distribution Channel(s)

The LED general light markets are still in development. The right distribution channels are important to make sure the right products get to the market properly.

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