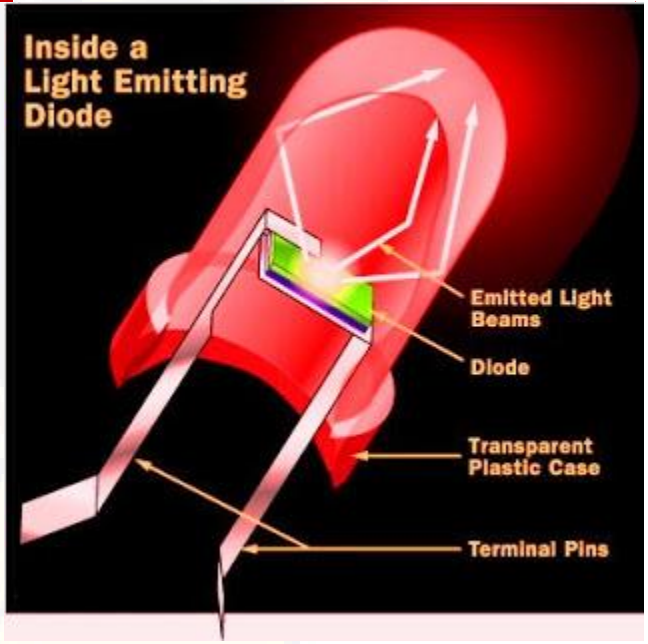
UNIT IV



LIGHT EMITTING DIODES

Light Emitting Diodes

- Introduction
- History
- Construction of LED
- Working
- Colors & Materials
- Types
- Comparison
- Applications
- Advantages & Disadvantages

Introduction

- LED is an acronym for Light Emitting Diode.
- A Light Emitting Diode(LED) is a two LED semiconductor light source.
- It is a *P N Junction* diode.
- Which emits light when activated by a suitable voltage is applied to the leads.

History

Inventors

1907 - **H.J. Round** discovered electroluminescence when using silicon carbide
and a cats whisker.
London, United Kingdom

1920s - **Oleg V. Losev** studied the phenomena of light emitting diodes in radio sets. His first work on 'LEDs' involved a report on light emission from SiC. *Saint Petersburg, Russia*

1961 - **James R. Biard. "Bob" Biard** and **Gary Pittman** developed the Infrared LED at Texas instruments. This was the first modern LED.
Dallas, Texas

Inventor s

1962 - **Nick Holonyack Jr.** develops the red LED, the first LED of visible light. He used GaAsP (Gallium Arsenide Phosphide) on a GaAs substrate. General Electric.
Syracuse, New York

1972 - **Herbert Maruska and Jacques Pankove** develop the violet LED
using Mg-doped GaN films.
RCA Labs , New Jersey

1976 - **Thomas P. Pearsall** develops special high brightness LEDs for fiber
optic use. This improves communications technology worldwide.
Paris, France

Inventors

Nobel Prize Winner

For the invention of efficient blue light emitting diodes which has enabled bright & energy saving white light source.

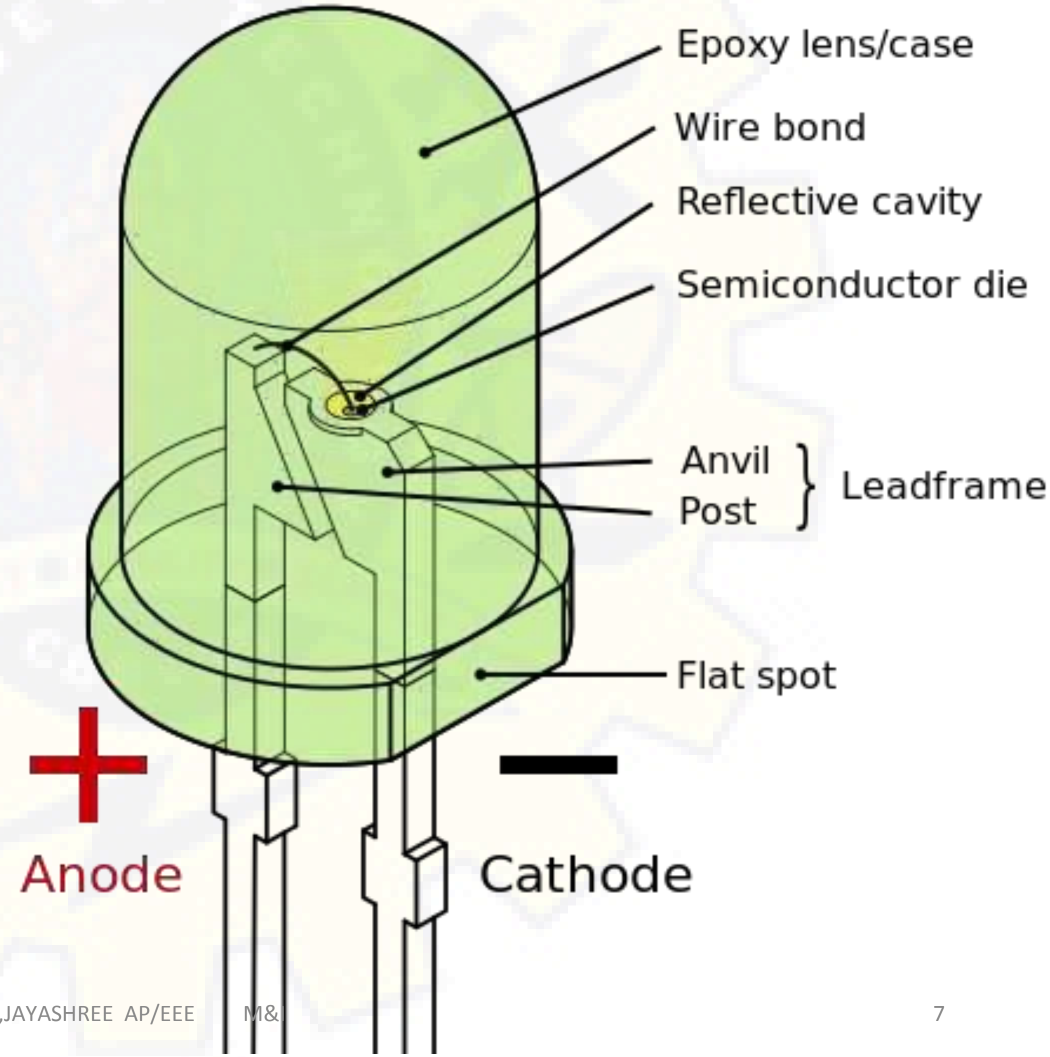
Isamu Akasaki
Nagoya University, Japan

Hiroshi Amano
Nagoya University, Japan

Shuji Nakamura
University of California Santa Barbara, USA

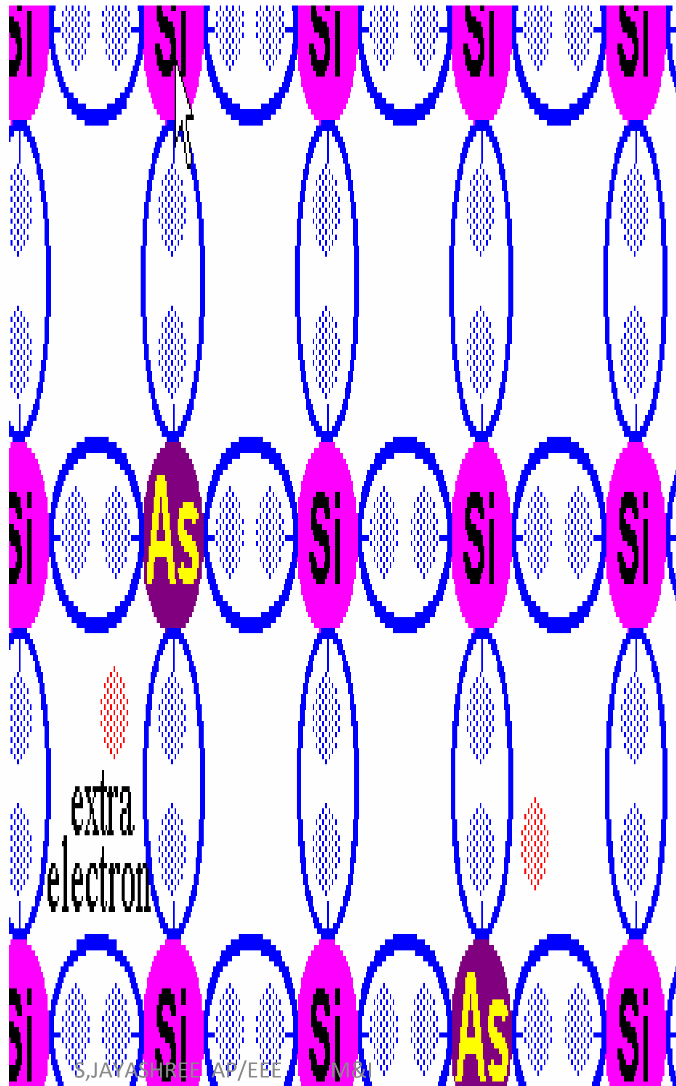
Construction of LED

- The LED consist of a chip of semiconductor material doped with impurities to create a *P N junction.*
- The chips are mounted in a reflecting tray in order to increase the light output.
- The contacts are made on the cathode side by means of conductive adhesive and on the anode side via gold wire to the lead frame.
- The plastic case encloses the chip
area of the lead frame.



N Type

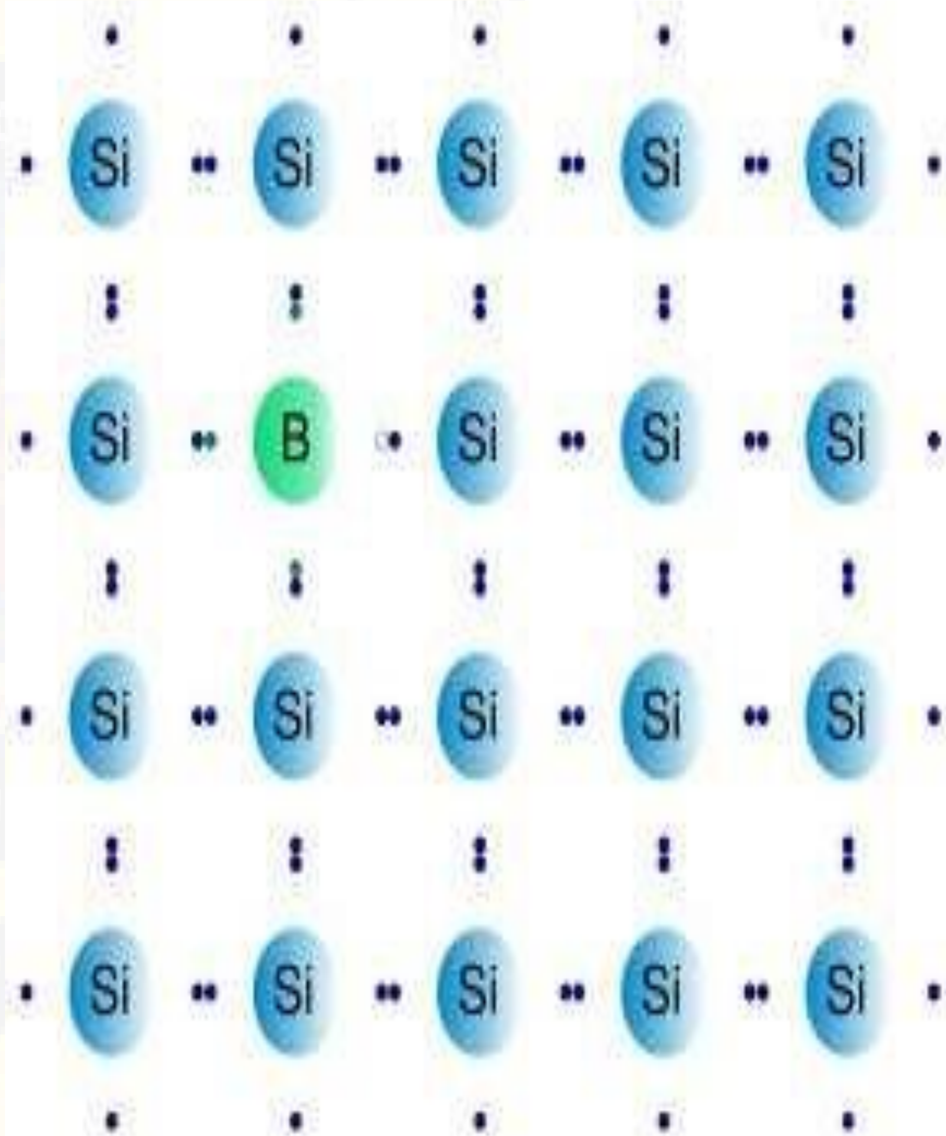
- This type of semiconductor is obtained when a Pentavalent material like Arsenic(as)is added to pure silicon crystal.
- Each Arsenic(As) atom forms covalent bonds with the surrounding four germanium atoms with the help of four of its five electrons.
- The fifth electron is superfluous and is loosely bound to the Arsenic(As) atom



boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007
aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974
gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922
indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76

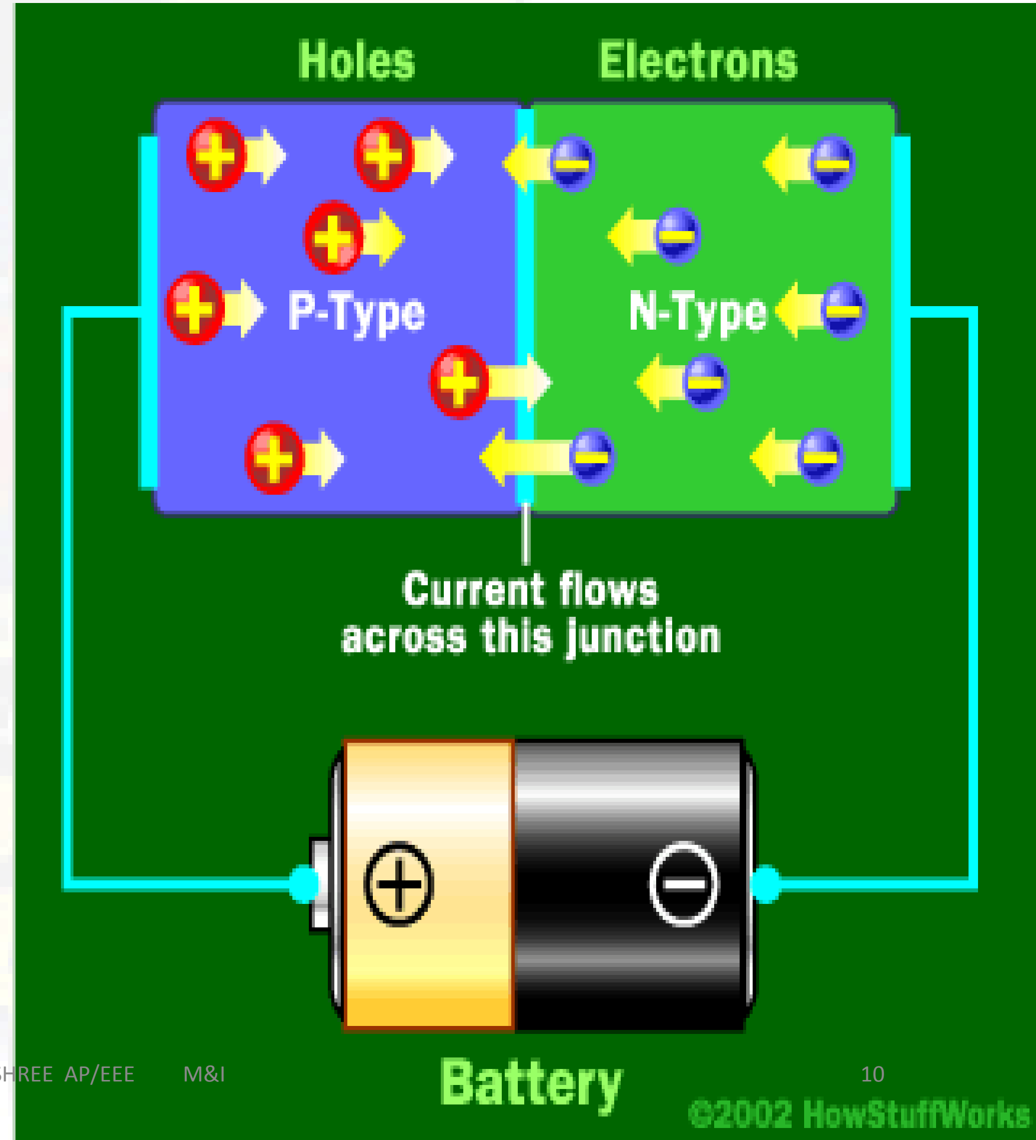
P Type

- This type of semiconductor is obtained when a trivalent material like boron is added to pure silicon crystal.
- The three valence electrons of boron atom form covalent bonds with four surrounding silicon atoms but one bond is left incomplete and gives rise to a hole .
- Thus, boron which is called an acceptor impurity causes as many positive holes in a silicon crystal as there are boron atoms thereby producing a P-type

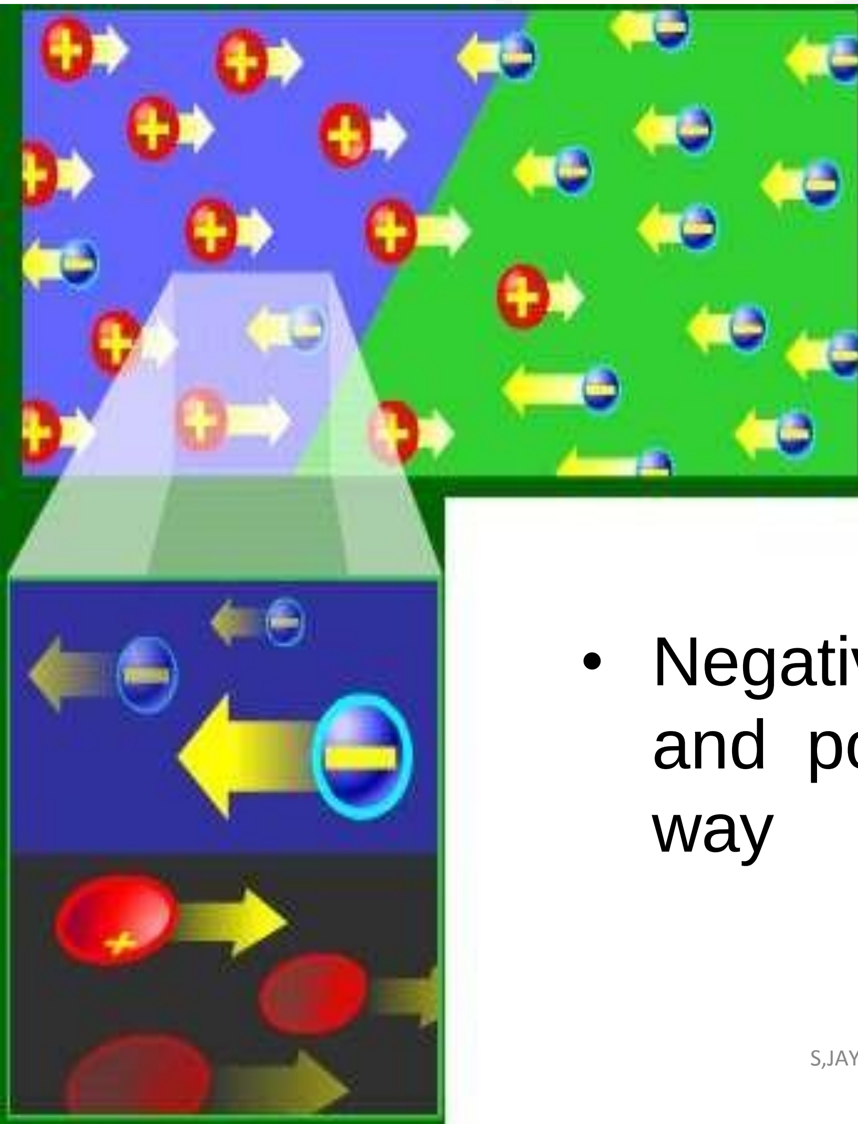


Working

- Wen the negative end of a circuit is hooked up to the N-type layer and the positive end is hooked up with P-type layer than electron and holes start moving.
- If you try to run current the other way, with the P-type side connected to the negative end of the circuit and the N-type side connected to the positive end, current will not flow.
- No current flows across the junction because the holes and the electrons are each moving in the wrong direction.



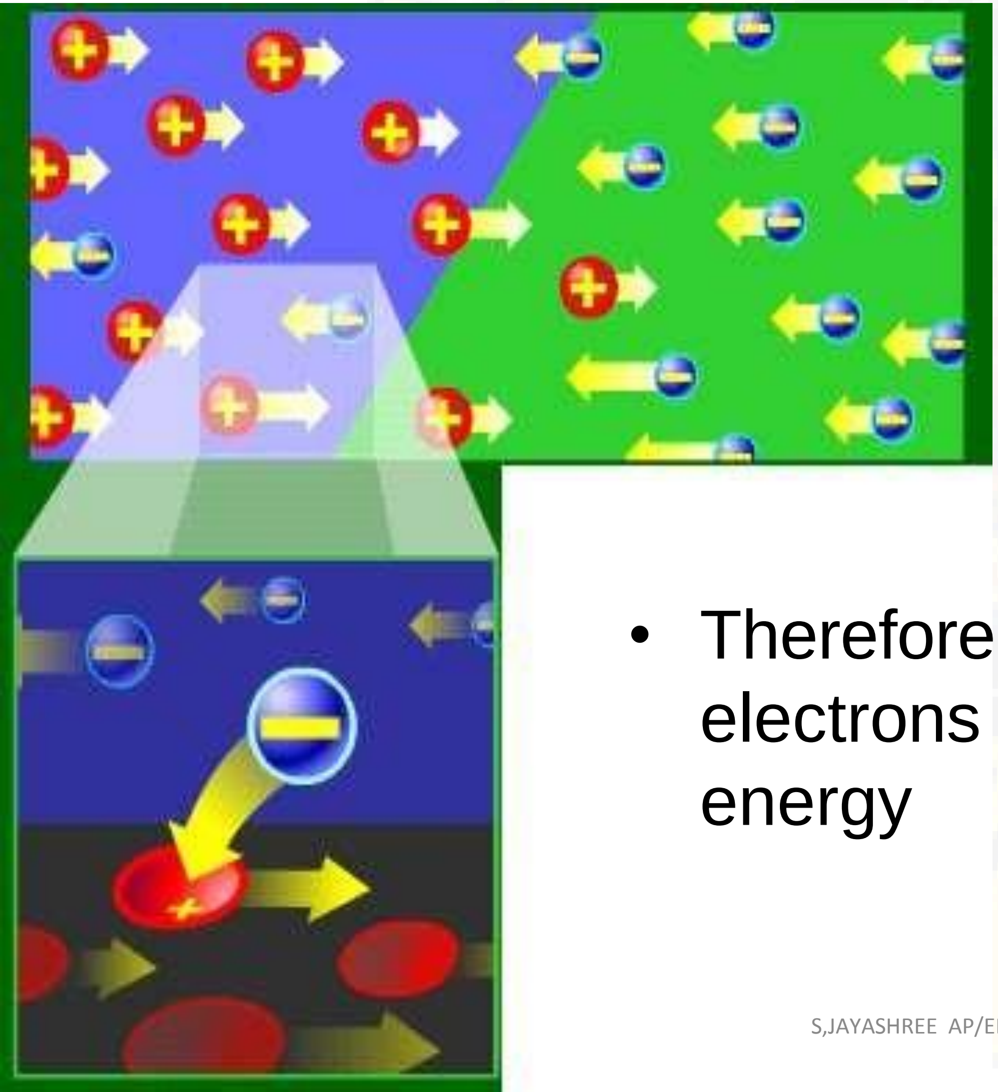
LED: How It Works



- When current flows across a diode

- Negative electrons move one way and positive holes move the other way

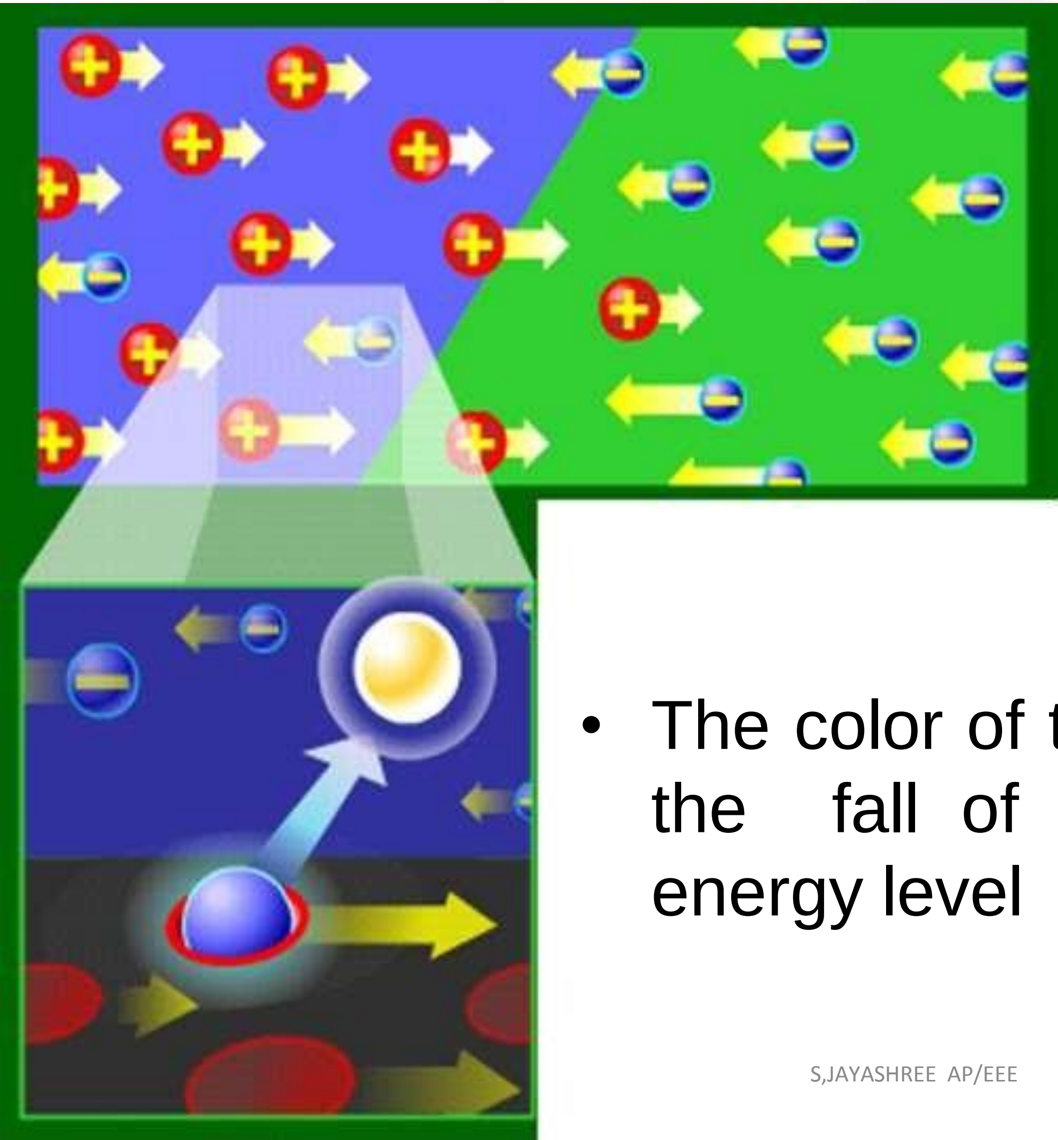
LED: How It Works



- The wholes exist at a lower energy level than the free electrons

- Therefore when a free electrons falls it losses energy

LED: How It Works



- This energy is emitted in a form of a photon, which causes light
- The color of the light is determined by the fall of the electron and hence energy level of the photon

Efficiency & Operational Parameter

Colors	Colors Name	Wavelength Range(nm)	Typical Efficiency(lm/W)
	Red	620 - 645	72
	Red –Orange	610 - 620	98
	Green	520 - 550	93
	Cyan	490 - 520	75
	Blue	460 - 490	37

Types of LEDs

LEDs are produced in a variety of shapes and sizes. The color of the plastic lens is often the same as the actual color of light emitted.

Types of LEDs

Modern high-power LEDs such as those used for lighting and backlighting are generally found in *Surface Mount Technology* (SMT) (not shown here)

Some main types is given below;

- ❖ **Traditional Inorganic LEDs**
- ❖ **Multi Color LED**
- • **Bi-color**
- • **Try-color**
- ❖ **Organic LED**
- ❖ **Miniature**
- ❖ **High power**

Different size of LEDs : 8 mm, 5 mm and 3 mm.

Traditional Inorganic LEDs

- This type of LEDs manufactured from *inorganic materials.*

- Some of the more widely used are compound semiconductor such as *Aluminum Gallium Arsenide(AlGaAr)*, *Gallium Arsenide Phosphide(GaArP)*, and many more.

Multi Color LED

Bi-

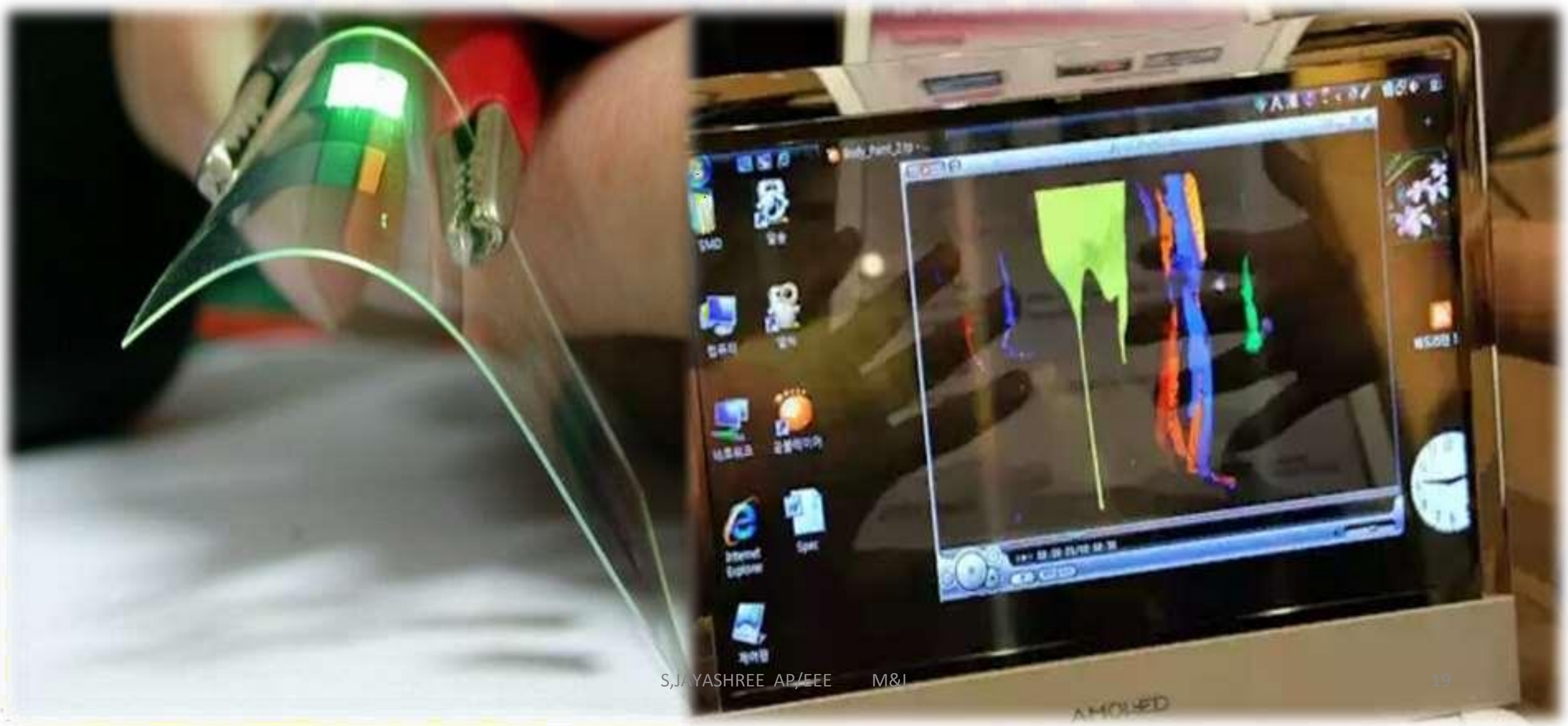
•Two different LED emitters in one case. There are two types of these.

•One type consists of two dies connected to the same two color types of light.

•Current flow in one direction emits one color, and current in the opposite direction emits the other color.

Organic Light Emitting Diode(OLED)

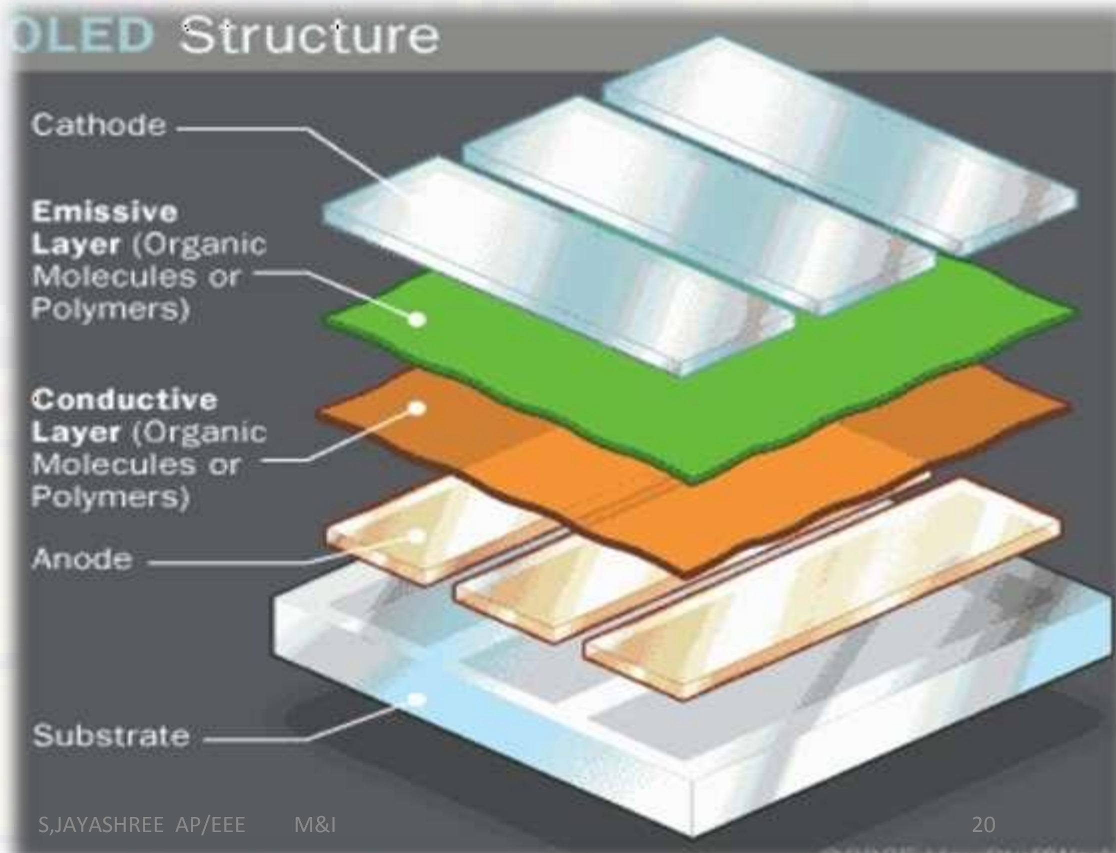
- The OLED mostly used display technology computer monitors, television , mobile phone Screen etc.



Organic Light Emitting Diode(OLED)

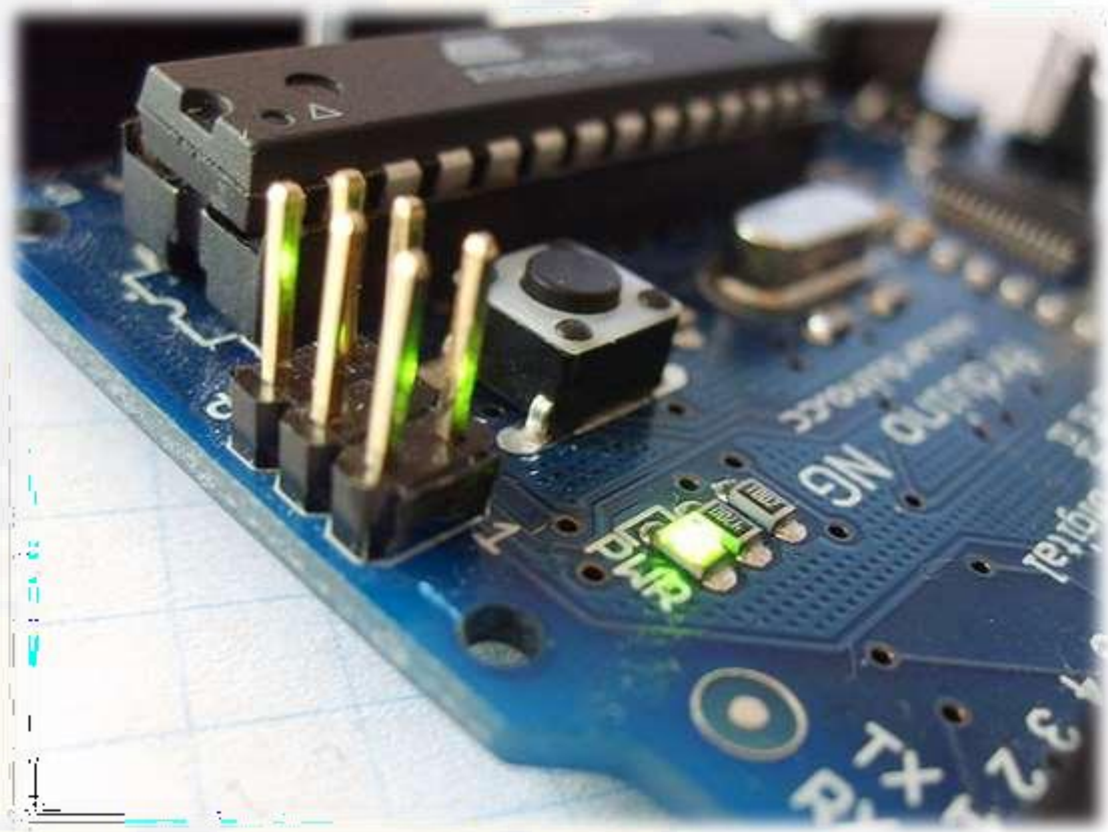
- The semiconductor in an OLED is organic which means it contains *carbon.*

- The OLED uses one of two polymer or small molecule.



Miniature

Miniature surface mount LEDs in most common sizes. They can much smaller than a traditional 5mm lamp Type LED.



- 1.9 to 2.1V for Red, Orange & Yellow.
- 3.0 to 3.4V for Green & Blue.
- 2.9 to 4.2V for Violet, Pink, Purple & White.

High power

For example, the CREE XP-G series LED achieved 105 lm/W in 2009, while Nichia released the 19 series with a typical efficacy of 140 lm/W in 2010.

Comparison *

	LED	CFL	HALOGEN
Life	25,000 Hrs.	10,000 Hrs.	1,000 Hrs.
Watts	7 Watts	13 Watts	43 Watts
Cost per bulb**	$11.98	$4.98	$1.98
KWh used over 25,000	175 KWh	325 KWh	1,075
Bulbs needed for 25,000 Hrs.	1 Bulb	2.5 bulb	25 bulb
25,000 KWh cost***	$21.00	$39.00	$129.00
Total Cost for 25,000 Hrs.	**$32.95**	**$51.45**	**$178.50**

* All information USA Government.
**Cost based on single bulb price at our local Electronic store. Your local prices differ.
***This information 2013 , different from present time.

Compariso
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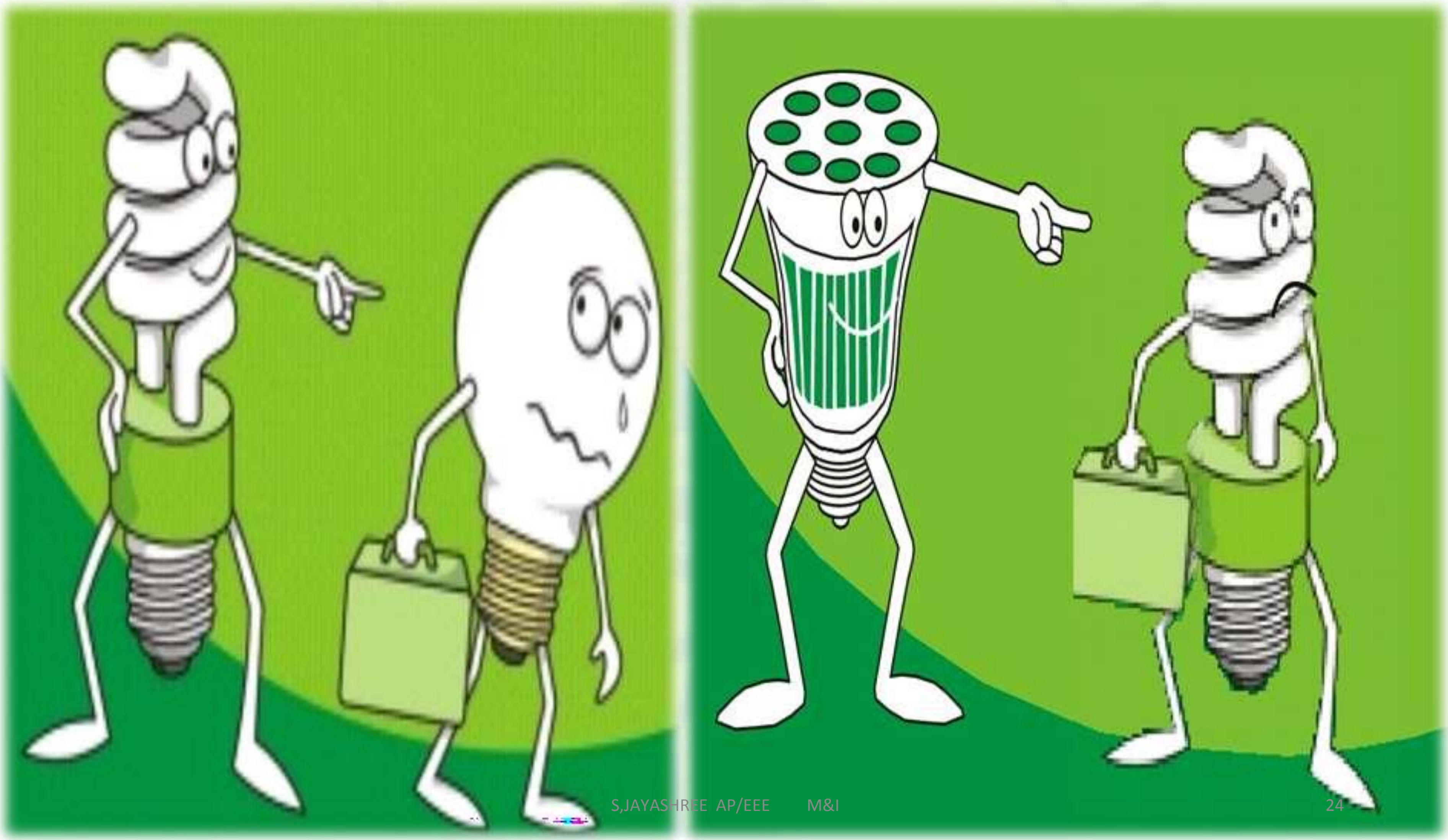


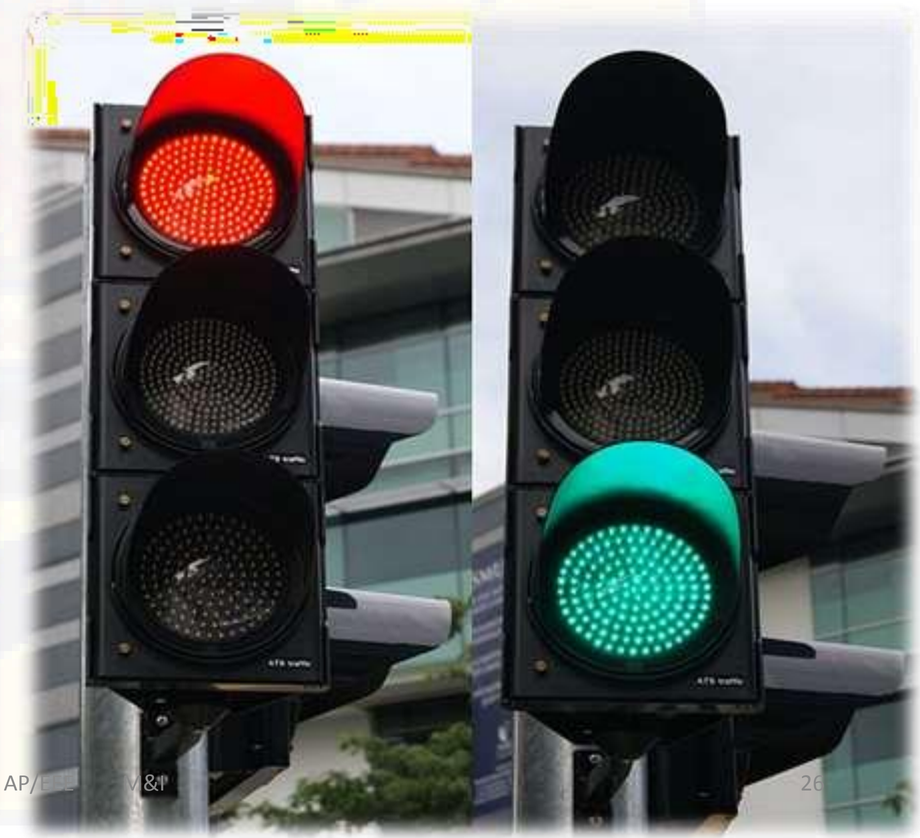
Applications

LED uses fall into Three main categories

- **Indicators and signals**
- **Lighting**
- **Data communication and other signaling**

Indicators and signals

The low energy consumption , low maintenance and small size of LEDs has LED to uses as status indicators and displays on a variety of equipment and installations. the are used as stadium airports and railway stations, trains, buses, trams, and ferries etc.



Lighting

LEDs are now used commonly in all market areas from commercial to home use: standard lighting, stage, theatrical, architectural, and public installations, and wherever artificial light is used.

Lightin
g

Home Light

Home

Data communication and other signaling

- Light can be used to transmit data and analog signals.
- Listening device in many theaters and similar spaces use arrays of infrared LEDs to send sound to listeners receivers.
- Light-emitting diodes are used to send data over many types
  of fiber optics cable, from digital audio the very high bandwidth fiber links that form the internet backbone.

Advantages & Disadvantages

Advantages

- **Efficiency:** LEDs emit more lumens per watt than incandescent light bulbs. The efficiency of LED lighting fixtures is not affected by shape and size, unlike fluorescent light bulbs or tubes.
- **Color:** LEDs can emit light of an intended color without using any color filters as traditional lighting methods need. Easily available many colors.
- **Size:** LEDs can be very small smaller than 2 mm

Advantages

- **On/Off time:** LEDs light up very quickly. A typical red indicator LED will achieve full brightness in under a microsecond
- **Cycling:** LEDs are ideal for uses subject to frequent on-off cycling, unlike incandescent and fluorescent lamps that fail faster when High- intensity discharge lamps that require a long time before restarting.
- **Lifetime:** LEDs can have a relatively long useful life. One report estimates 35,000 to 50,000 hours of useful life, though time to complete failure may be longer.
- **Focus:** The solid package of the LED can be designed to focus its light. Incandescent and fluorescent sources often require an external reflector to collect light and direct it in a usable manner

Disadvantages

- **High initial price** : LEDs are currently more expensive, price per lumen. In 2012, the
  cost per thousand lumens was about $6. The price was expected to reach in 2013
  $2/kilolumen and March 2014 $1.
- **Light Quality:** Most cool-white LEDs have spectra that differ significant from a black body radiator like the sun or an incident light.
- **Temperature dependence:** Driving the LED hard in high ambient temperatures may
  result to overheating of the led package ,eventually leading to device failure.
- **Voltage sensitivity:**
- **Non reparation:**