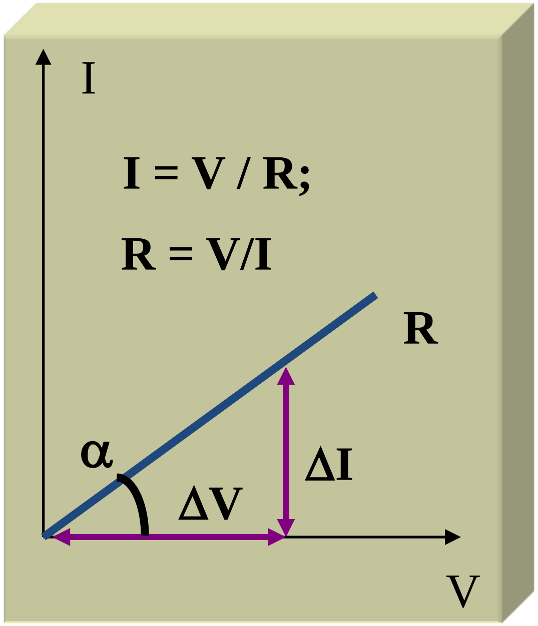
Lecture-2

I-V characteristics of the Electronic Components

The I-V plot represents the dependence of the current I, through the component, on the voltage V across it.

Resistor $V = I \times R; \;\; => I = \left(\frac{1}{R}\right) \times V$



The I-V Characteristic of the Resistor

Opto-Electronic Diodes:

- Many of these diodes involve semiconductors other than Si.

- Use ***direct band gap*** semiconductors.

- Devices that convert ***optical energy*** to electrical energy are:
  - **Photodetectors: generate electrical signal**
  - **Solar cells: generate electrical power**

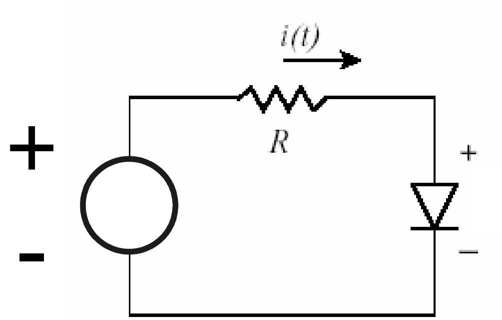
- Devices that convert ***electrical energy*** to optical energy are:
  - **Light emitting diodes (LEDs)**
  - **Laser diodes**

Light Emitting Diodes:

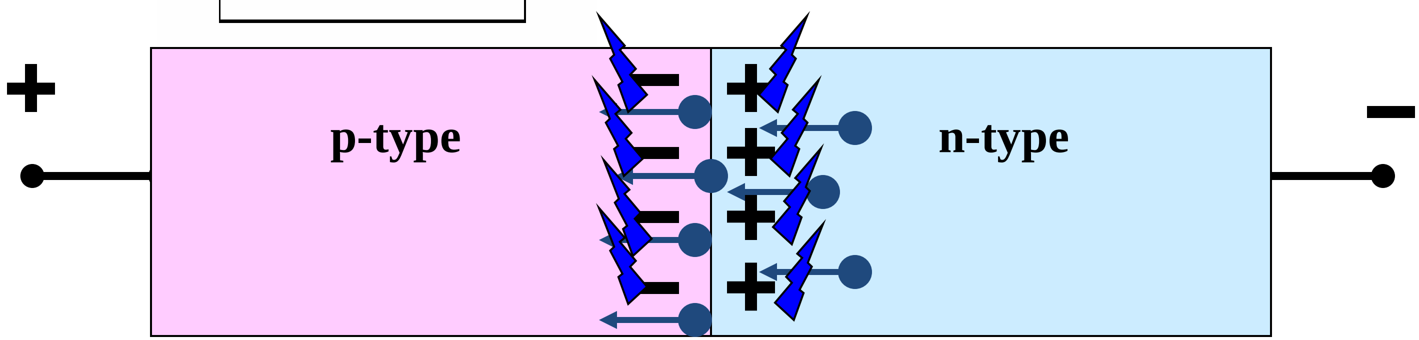
- **When p n junction is forward biased, large number of carriers are injected across the junctions. These carriers recombine and emit light if the semiconductor has a direct bandgap.**

- **For visible light output, the bandgap should be between 1.8 and 3.1 eV.**

Light Emitting Diodes – LED's:



P-N Junction can emit light when *forward biased.*



Electrons drift into p-material and find plenty of holes there. They "RECOMBINE" by filling up the "empty" positions.

Holes drift into n-material and find plenty of electrons there. They also "RECOMBINE" by filling up the "empty" positions.

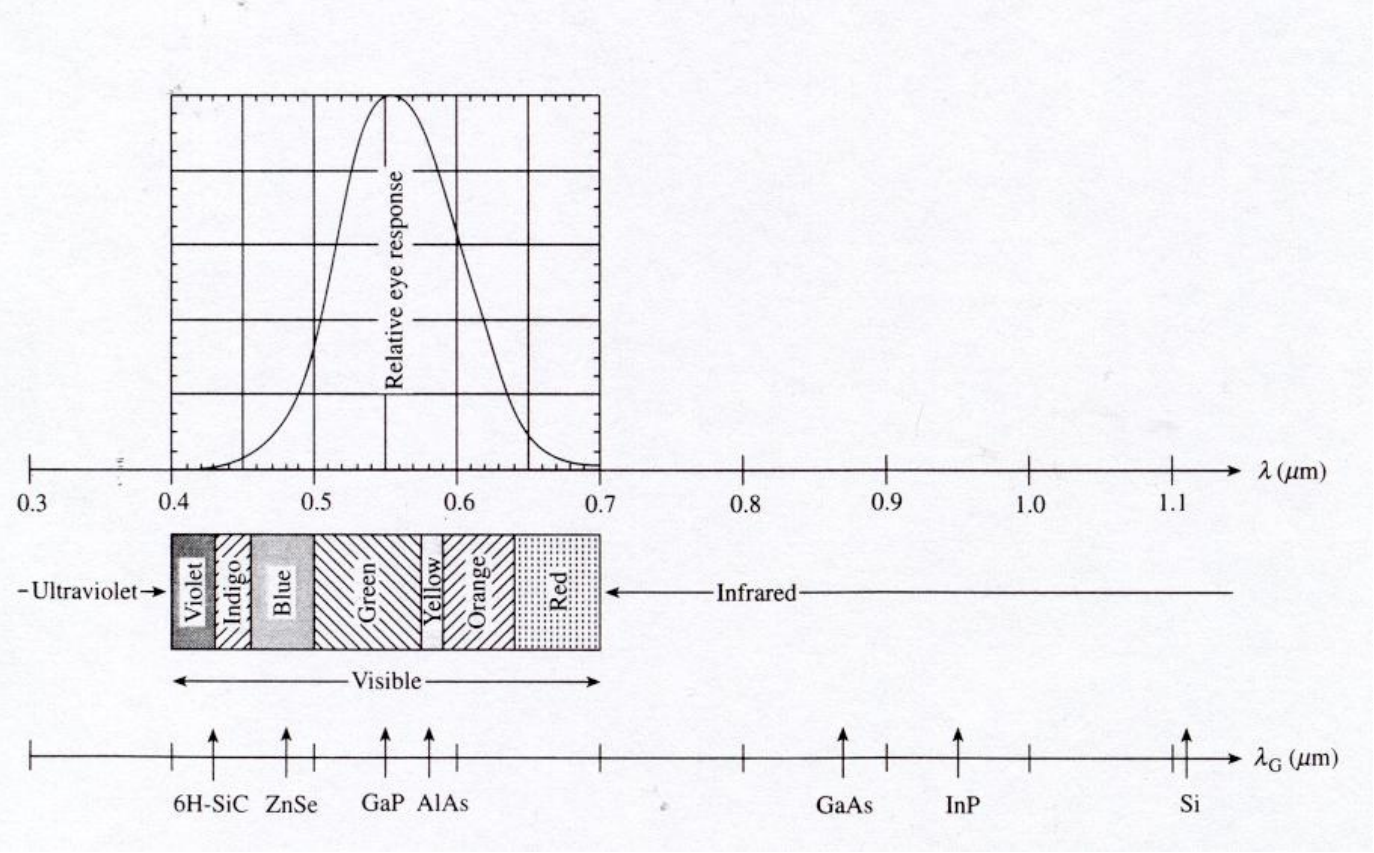
The energy released in the process of "annihilation" produces

PHOTONS – the particles of light

Optical Spectrum Correlated with Relative Eye Sensitivity:

Photon energy $E_{ph} = h\,c\,/\,\lambda$

Inserting numerical values for h and c yields E_{ph} = 1.24 eV μm / λ



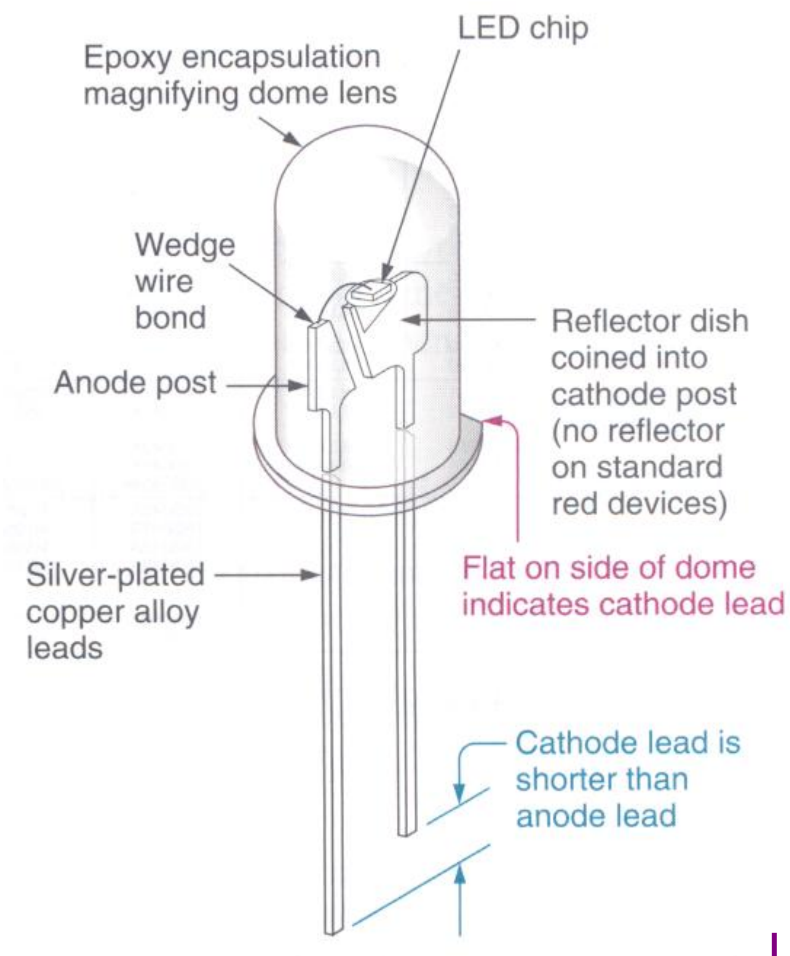
Note: *Our eye is very sensitive to green light*

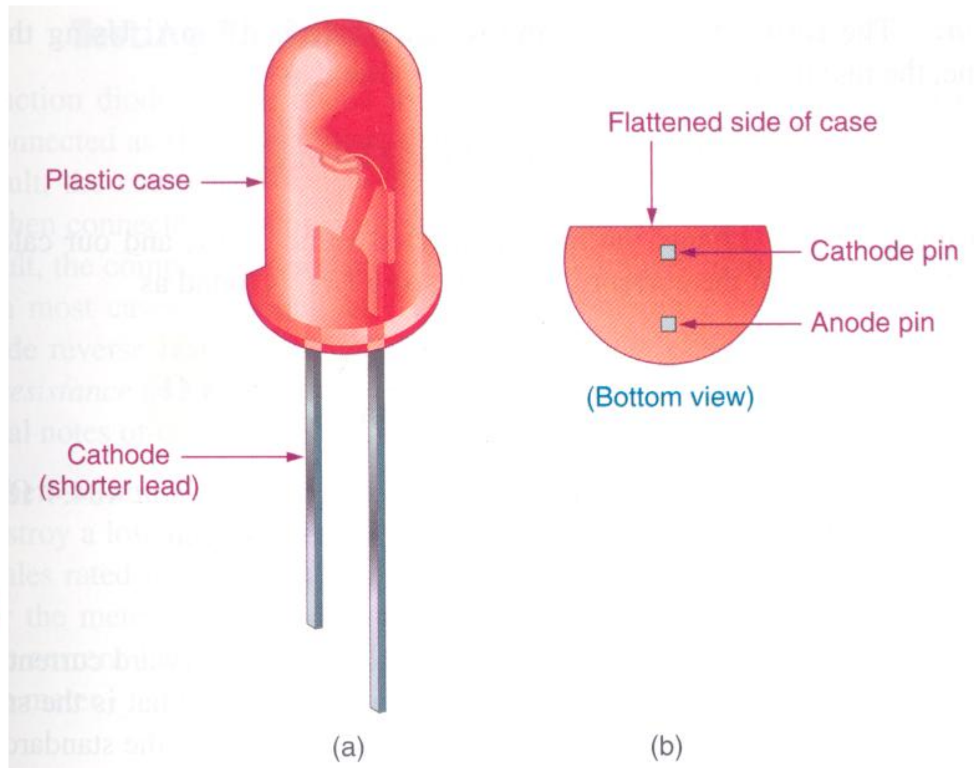
LED

Light emitting diode, made from GaAs

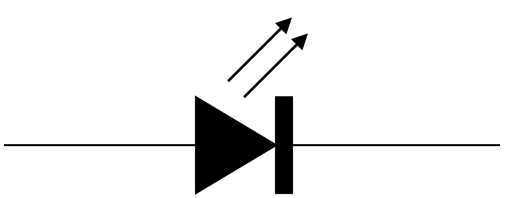
- V_F=1.6 V
- I_F >= 6 mA

Light Emitting Diodes.

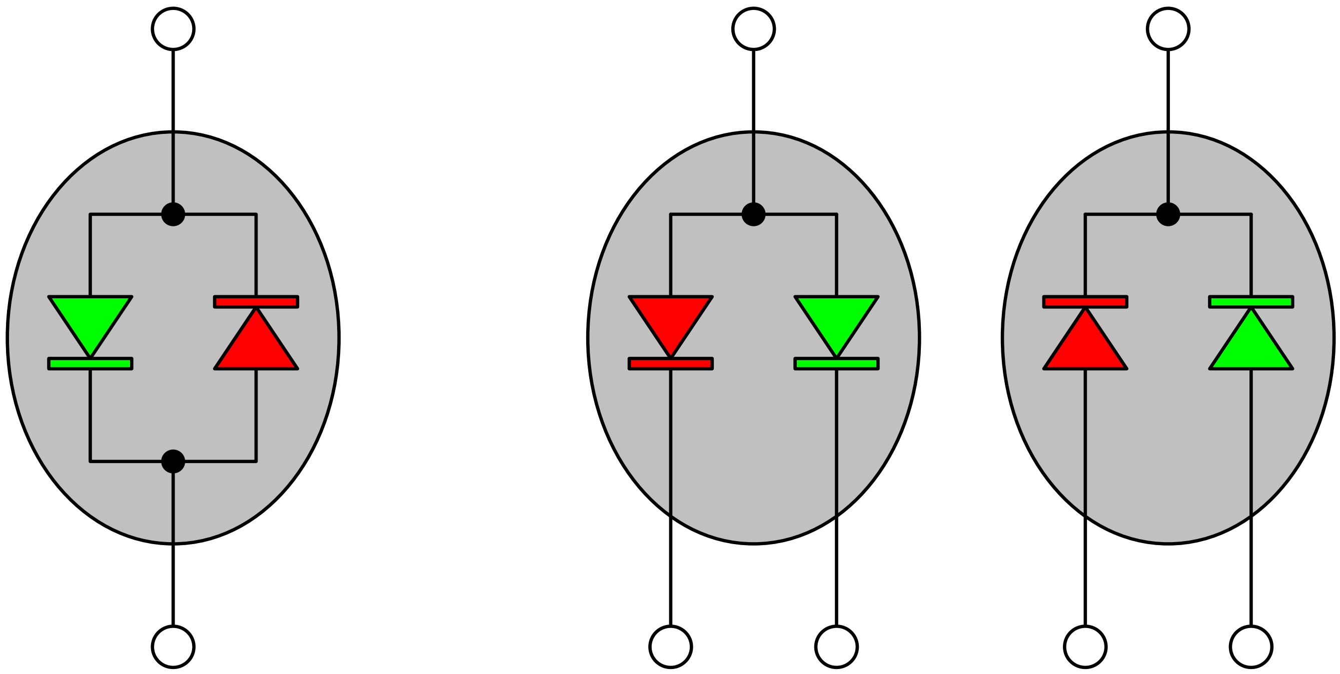




LED symbol

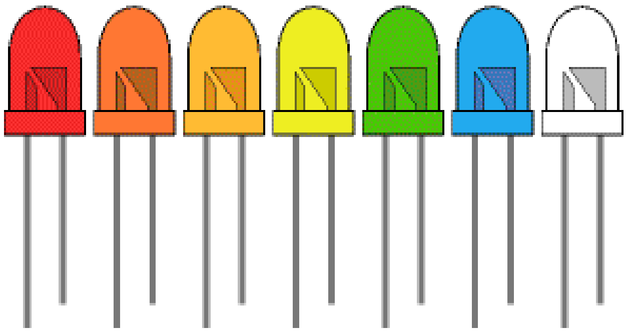


Multicolor LED:



Colours of LEDs:

- LEDs are made from gallium-based crystals that contain one or more additional materials such as phosphorous to produce a distinct color. Different LEDs emit light in specific regions of the visible light spectrum and produce different intensity levels.



- LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours. The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body).

Common LEDs:

Elements	Forward voltage (V_F)	Color Emitted
GaAs	1.5 V @ I_F = 20 mA	Infrared (invisible)
AlGaAs	1.8 V @ I_F = 20 mA	Red
GaP	2.4 V @ I_F = 20 mA	Green
AlGaInP	2.0 V @ I_F = 20 mA	Amber (yellow)
AlGaInN	3.6 V @ I_F = 20 mA	Blue

Characteristics of Commercial LEDs

Semiconductor	*Color*	*Peak $\lambda(\mu m)$*	*External Efficiency η (%)*	*Performance (lumens/watt)*[†]
		Established Materials		
$GaAs_{0.6}P_{0.4}$	Red	0.650	0.2	0.15
$GaAs_{0.35}P_{0.65}$:N	Orange-Red	0.630	0.7	1
$GaAs_{0.14}P_{0.86}$:N	Yellow	0.585	0.2	1
GaP:N	Green	0.565	0.4	2.5
GaP:Zn-O	Red	0.700	2	0.40
		Recent Additions		
AlGaAs	Red	0.650	4–16	2–8
AlInGaP	Orange	0.620	6	20
AlInGaP	Yellow	0.585	5	20
AlInGaP	Green	0.570	1	6
SiC	Blue	0.470	0.02	0.04
GaN	Blue	0.450	2	0.6