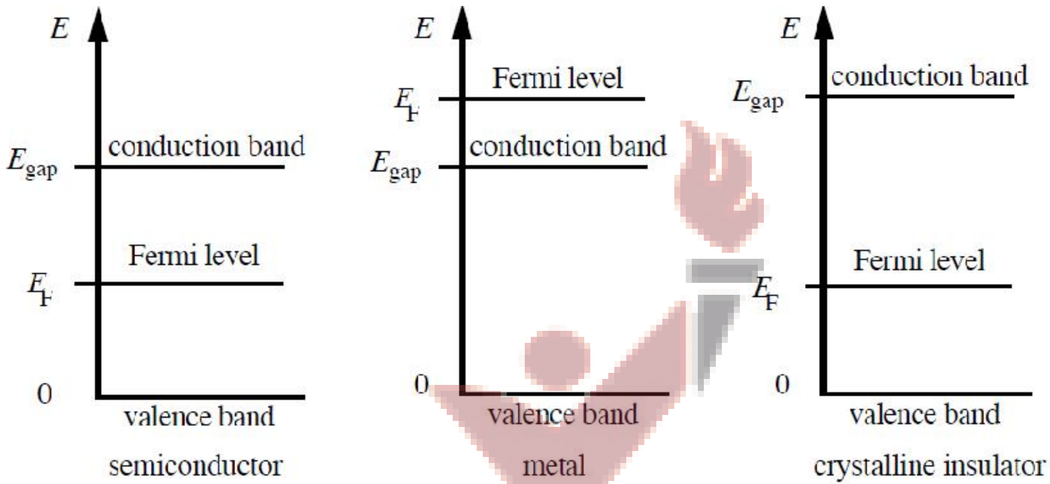
SOLID-STATE DEVICE

A **SOLID-STATE DEVICE** is an electronic device, which operates by virtue of the movement of electrons within a solid piece of semiconductor material. Eg – **Diodes and Transistors.**

DIODES

Diodes are made up of **Semiconductors**.

The energy levels of a semiconductor can be modified so that a material (e.g. silicon or germanium) that is normally an insulator will conduct electricity. Energy level structure of a semiconductor is quit complicated, requires a quantum mechanical treatment.



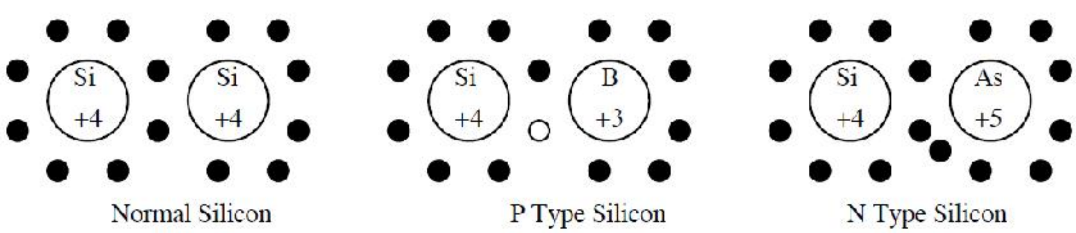
Doping is a process where impurities are added to the semiconductor to lower its resistivity to make them conduct current. For example, Silicon has 4 electrons in its valence level. We add atoms which have a different number of valence shell electrons (3 or 5) to a piece of silicon.
5 valence electrons: Phosphorous, Arsenic, Antimony
3 valence electrons: Boron, Aluminium, Indium

- **N** type silicon:

Adding atoms which have 5 valence electrons makes the silicon more negative.
The majority carriers are the excess electrons.

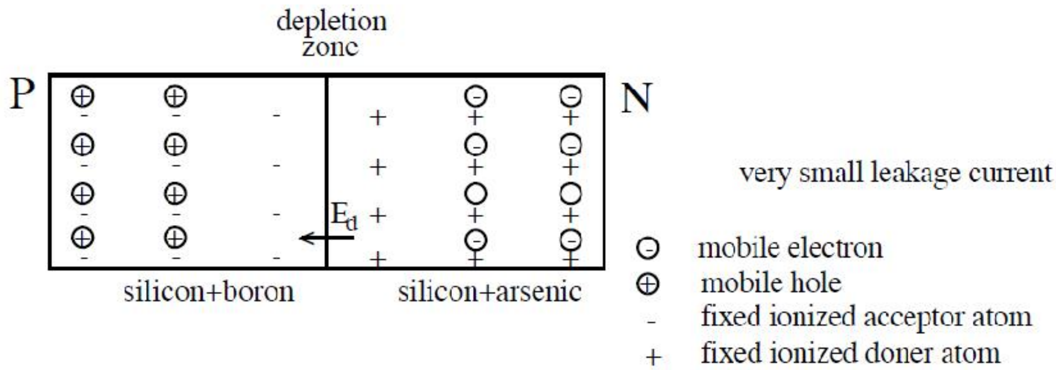
- **P** type silicon

Adding atoms which have 3 valence electrons makes the silicon more positive. The majority carriers are "holes". A hole is the lack of an electron in the valence shell.

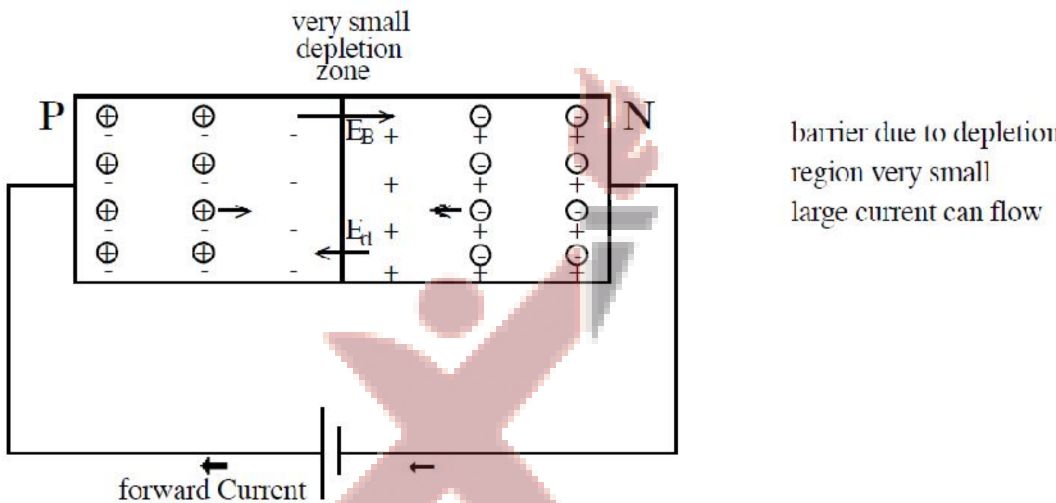


Put a piece of N type silicon next to a piece of P type silicon to make a PN diode.

Unbiased diode



Forward biased diode (Junction diode)

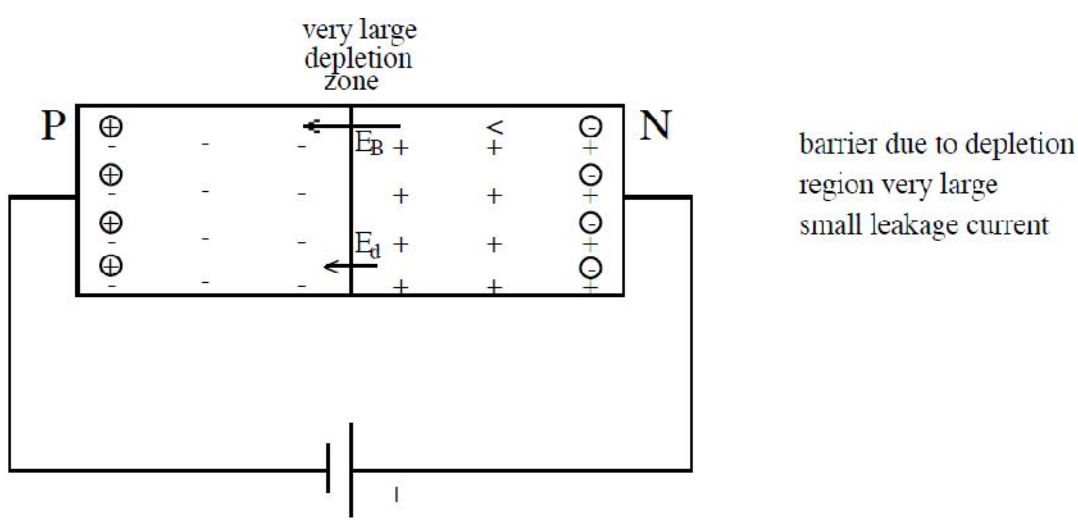


Diode is forward biased when $V_{anode} > V_{cathode}$.

Characteristics of a forward biased Diode: -

- Diode conducts current strongly.
- Voltage drop across diode is (almost) independent of diode current.
- Effective resistance (impedance) of diode is small.

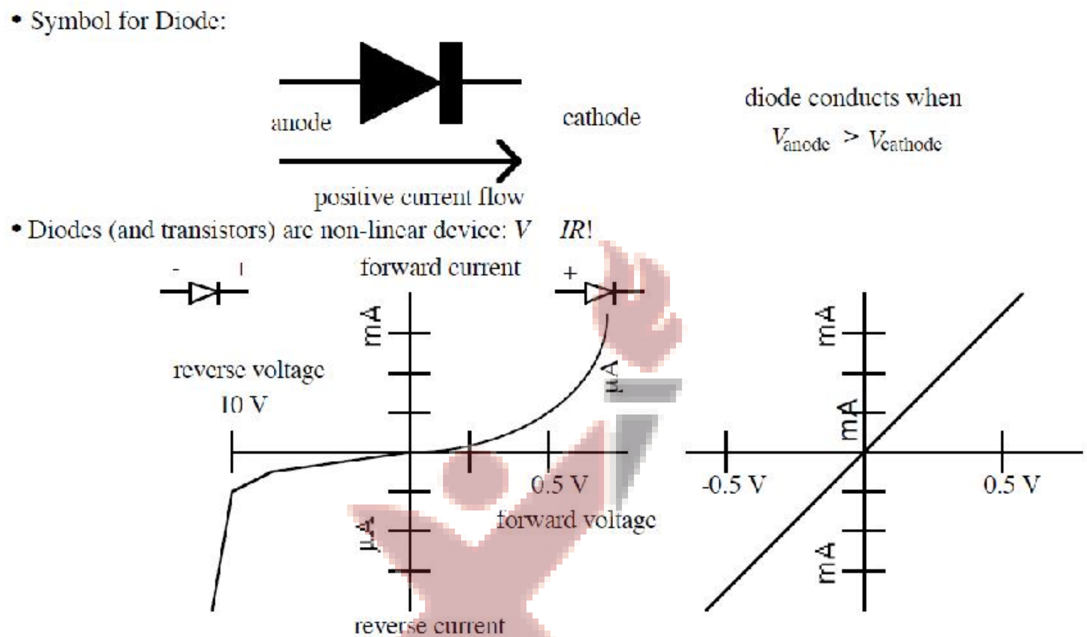
Reversed biased diode



Diode is reverse biased when $V_{anode} < V_{cathode}$.

Characteristics of a reverse biased diode:-

- Diode conducts current very weakly (typically <   A).
- Diode current is (almost) independent of voltage, until breakdown.
- Effective resistance (impedance) of diode is very large.



Current-voltage relationship for a diode can be expressed as:

$I = I_S\,(e^{eV/kT} - 1)$

This is known as: "diode", "rectifier", or "Ebers-Moll" equation , where

Is = reverse saturation current (typically <   A)

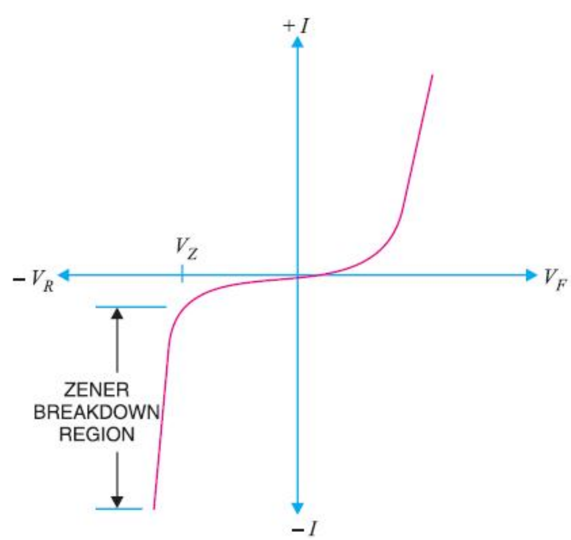
k = Boltzmann's constant, e = electron charge, T = temperature

At room temperature, kT/e = 25.3 mV,

Types of diodes:-

Zener Diode

A zener diode is a special type of diode that is designed to operate in the reverse breakdown region. An ordinary diode operated in this region will usually be destroyed due to excessive current.



This is not the case for the zener diode. A zener diode is heavily doped to reduce the reverse breakdown voltage. This causes a very thin depletion layer. As a result, a zener diode has a sharp reverse breakdown voltage VZ. This is clear from the reverse characteristic of zener diode shown in above figure. Note that the reverse characteristic drops in an almost vertical manner at reverse voltage VZ. As the curve reveals, two things happen when VZ is reached:

(i) The diode current increases rapidly.

(ii) The reverse voltage VZ across the diode remains almost constant.

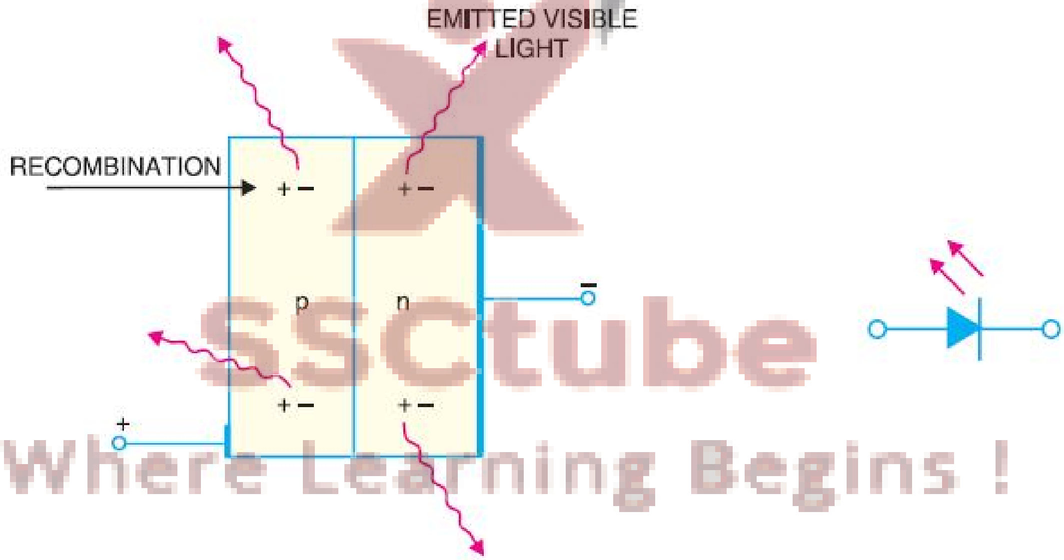
In other words, the zener diode operated in this region will have a relatively constant voltage across it, regardless of the value of current through the device. This permits the zener diode to be used as a **voltage regulator.**

Light-Emitting Diode (LED)

A light-emitting diode (LED) is a diode that gives off visible light when forward biased. Light-emitting diodes are not made from silicon or germanium but are made by using elements like gallium, phosphorus and arsenic. By varying the quantities of these elements, it is possible to produce light of different wavelengths with colours that include red, green, yellow and blue. For example, when a LED is manufactured using gallium arsenide, it will produce a red light. If the LED is made with gallium phosphide, it will produce a green light.

Theory:-

When light-emitting diode (LED) is forward biased as shown in figure below, the electrons from the n-type material cross the pn junction and recombine with holes in the p-type material. Recall that these free electrons are in the conduction band and at a higher energy level than the holes in the valence band. When recombination takes place, the recombining electrons release energy in the form of heat and light. In germanium and silicon diodes, almost the entire energy is given up in the form of heat and emitted light is insignificant. However, in materials like gallium arsenide, the number of photons of light energy is sufficient to produce quite intense visible light.



(i) (ii)

It is clear from the graph below that the intensity of radiated light is directly proportional to the forward current of LED.

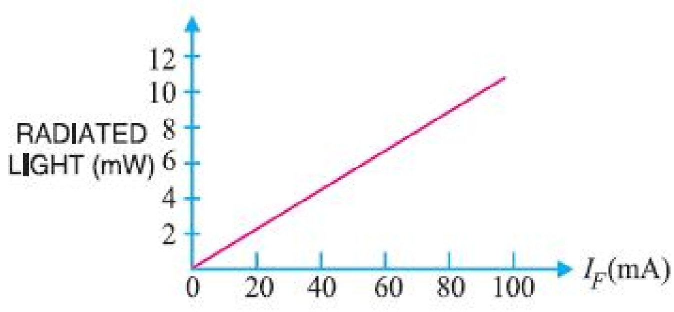


Photo-diode

A photo-diode is a reverse-biased silicon or germanium pn junction in which reverse current increases when the junction is exposed to light. The reverse current in a photo-diode is directly proportional to the intensity of light falling on its pn junction. This means that greater the intensity of light falling on the pn junction of photo-diode, the greater will be the reverse current.

Principle:-

When a rectifier diode is reverse biased, it has a very small reverse leakage current. The same is true for a photo-diode. The reverse current is produced by thermally generated electron hole pairs which are swept across the junction by the electric field created by the reverse voltage. In a rectifier diode, the reverse current increases with temperature due to an increase in the number of electron-hole pairs. A photo-diode differs from a rectifier diode in that when its pn junction is exposed to light, the reverse current increases with the increase in light intensity and vice-versa. This is explained as follows. When light (photons) falls on the pn junction, the energy is imparted by the photons to the atoms in the junction. This will create more free electrons (and more holes). These additional free electrons will increase the reverse current. As the intensity of light incident on the pn junction increases, the reverse current also increases. In other words, as the incident light intensity increases, the resistance of the device (photo-diode) decreases.

Applications of Photo-diodes

There are a large number of applications of photodiodes. However, we shall give two applications of photodiodes for example.

1. **Alarm circuit using photo-diode.**

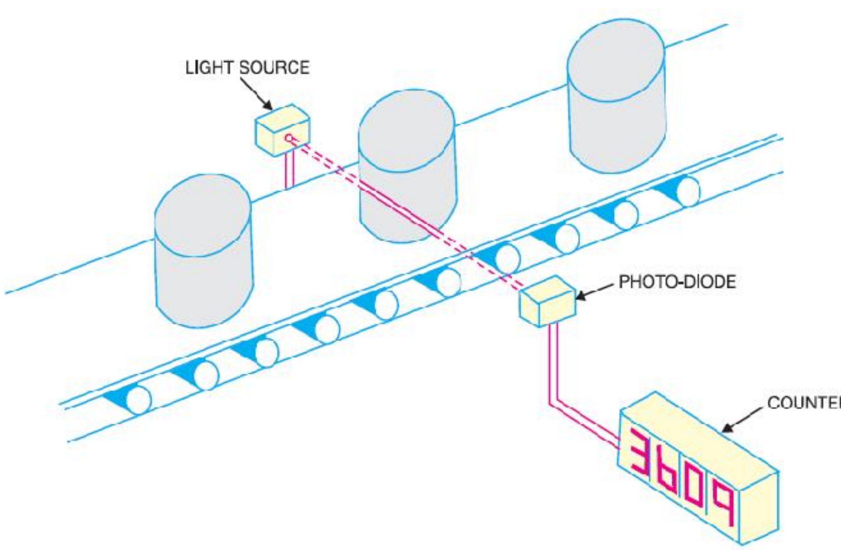
The use of photo-diode in an alarm system. Light from a light source is allowed to fall on a photo-diode fitted in the doorway. The reverse current IR will continue to flow so long as the light beam is not broken. If a person passes through the door, light beam is broken and the reverse current drops to the dark current level. As a result, an alarm is sounded.

2. **Counter circuit using photo-diode.**

A photodiode may be used to count items on a conveyor belt. Below figure shows a photo-diode circuit used in a system that counts objects as they pass by on a conveyor. In this circuit, a source of light sends a concentrated beam of light across a conveyor to a photo-diode. As the object passes, the light beam is broken, IR drops to the dark current level and the count is increased by one.

Tunnel Diode

A tunnel diode is a pn junction that exhibits negative resistance between two values of forward voltage (i.e., between peak-point voltage and valley-point voltage). A conventional diode exhibits *positive resistance when it is forward biased or reverse biased. However, if a semiconductor junction diode is heavily doped with impurities, it exhibits negative resistance (i.e. current



decreases as the voltage is increased) in certain regions in the forward direction. Such a diode is called tunnel diode.

Principle:-

The tunnel diode is basically a pn junction with heavy doping of p-type and n-type semiconductor materials. In fact, a tunnel diode is doped approximately 1000 times as heavily as a conventional diode. This heavy doping results in a large number of majority carriers. Because of the large number of carriers, most are not used during the initial recombination that produces the depletion layer. As a result, the depletion layer is very narrow. In comparison with conventional diode, the depletion layer of a tunnel diode is 100 times narrower. The operation of a tunnel diode depends upon the tunnelling effect and hence the name.

Tunnelling effect:-

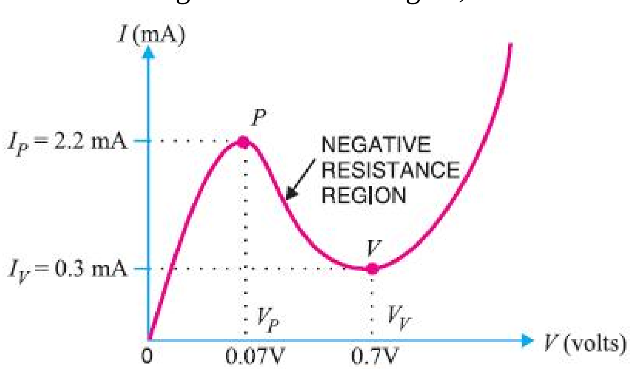
The heavy doping provides a large number of majority carriers. Because of the large number of carriers, there is much drift activity in p and n sections. This causes many valence electrons to have their energy levels raised closer to the conduction region. Therefore, it takes only a very small applied forward voltage to cause conduction. The movement of valence electrons from the valence energy band to the conduction band with little or no applied forward voltage is called tunnelling. Valence electrons seem to tunnel through the forbidden energy band.
As the forward voltage is first increased, the diode current rises rapidly due to tunnelling effect. Soon the tunnelling effect is reduced and current flow starts to decrease as the forward voltage across the diode is increased. The tunnel diode is said to have entered the negative resistance region. As the voltage is further increased, the tunnelling effect plays less and less part until a valley-point is reached.
From now onwards, the tunnel diode behaves as ordinary diode i.e., diode current increases with the increase in forward voltage.

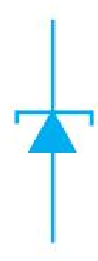
V-I Characteristic

Figure below shows the V-I characteristic of a typical tunnel diode.

(i) As the forward voltage across the tunnel diode is increased from zero, electrons from the N region “tunnel” through the potential barrier to the p-region. As the forward voltage increases, the diode current also increases until the peak-point P is reached. The diode current has now reached peak current IP (= 2.2 mA) at about peak-point voltage VP (= 0.07 V). Until now the diode has exhibited positive resistance.

(ii) As the voltage is increased beyond VP, the tunnelling action starts decreasing and the diode current decreases as the forward voltage is increased until valley-point V is reached at valley-point voltage VV (= 0.7V). In the region between peak-point and valley-point (i.e., between points P and V), the diode exhibits negative resistance i.e., as the forward bias is increased, the current decreases.This suggests that tunnel diode, when operated in the negative resistance region, can be used as an oscillator or a switch.

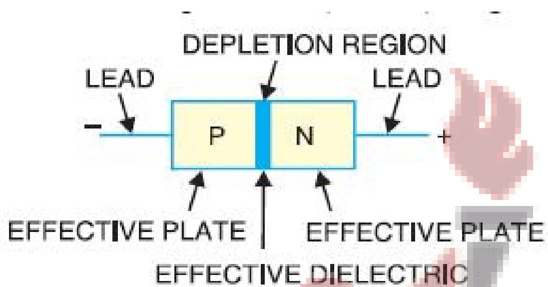




(iii) When forward bias is increased beyond valley-point voltage VV (= 0.7 V), the tunnel diode behaves as a normal diode. In other words, from point V onwards, the diode current increases with the increase in forward voltage i.e., the diode exhibits positive resistance once again.It may be noted that a tunnel diode has a high reverse current but operation under this condition is not generally used.

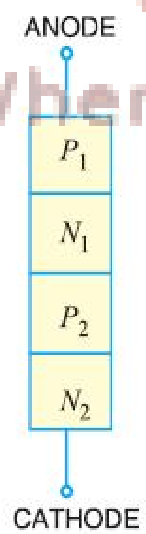
Varactor Diode

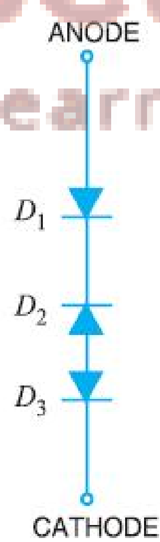
A junction diode which acts as a variable capacitor under changing reverse bias is known as a varactor diode. When a pn junction is formed, depletion layer is created in the junction area. Since there are no charge carriers within the depletion zone, the zone acts as an insulator. The p-type material with holes (considered positive) as majority carriers and n-type material with electrons (−ve charge) as majority carriers act as charged plates. Thus the diode may be considered as a capacitor with n-region and p-region forming oppositely charged plates and with depletion zone between them acting as a dielectric.
This is illustrated in below figure. A varactor diode is specially constructed to have high capacitance under reverse bias. Other figure shows the symbol of varactor diode. The values of capacitance of varactor diodes are in the Pico farad (10−12 F) range.



Shockley Diode

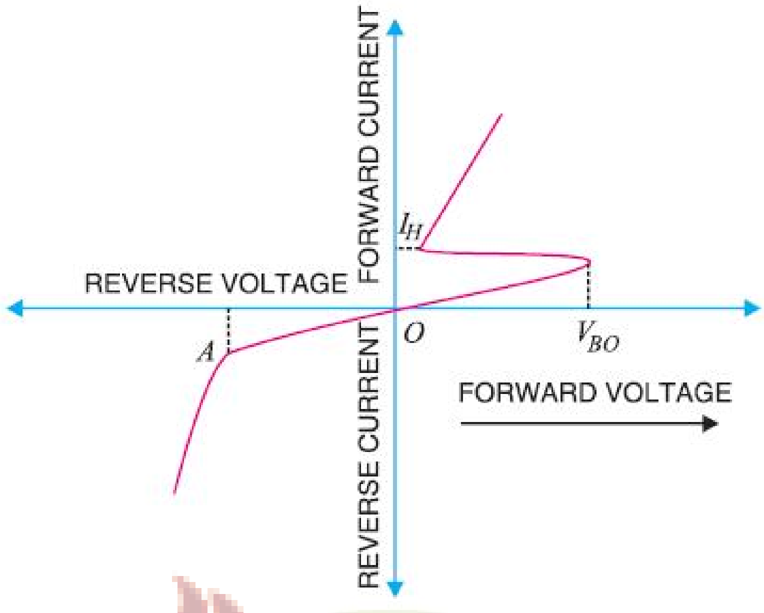
Named after its inventor, a Shockley diode is a PNPN device having two terminals as shown in figure. This device acts as a switch and consists of four alternate P-type and N-type layers in a single crystal. The various layers are labelled as P1, N1, P2 and N2 for identification. Since a P-region adjacent to an N-region may be considered a junction diode, the Shockley diode is equivalent to three junction diodes connected in series as shown in second Figure. The symbol of Shockley diode is shown in 3rd figure.





Working:-

(i) When Shockley diode is forward biased (i.e., anode is positive w.r.t. cathode), diodes D1 and D3 would be forward-biased while diode D2 would be reverse-biased. Since diode D2 offers very high resistance (being reverse biased) and the three diodes are in series, the Shockley diode presents a very high resistance. As the forward voltage increases, the reverse bias across D2 is also increased. At some forward voltage (called break over voltage VBO), reverse breakdown of D2 occurs. Since this breakdown results in reduced resistance, the Shockley diode presents a very low resistance. From now onwards, the Shockley diode behaves as a conventional forward-biased diode; the forward current being determined by the applied voltage and external load resistance. This behaviour of Shockley diode is indicated on its V-I characteristic in below Figure.



ii) When Shockley diode is reverse biased (i.e., anode is negative w.r.t. cathode), diodes D1 and D3 would be reverse-biased while diode D2 would be forward-biased. If reverse voltage is increased sufficiently, the reverse voltage breakdown (point A in Fig) of Shockley diode is reached. At this point, diodes D1 and D3 would go into reverse-voltage breakdown, the reverse current flowing through them would rise rapidly and the heat produced by this current flow could ruin the entire device. For this reason, Shockley diode should never be operated with a reverse voltage sufficient to reach the reverse-voltage breakdown point.

Conclusion:-

The above discussion reveals that Shockley diode behaves like a switch. So long as the forward voltage is less than break over voltage, Shockley diode offers very high resistance (i.e., switch is open) and practically conducts no current. At voltages above the break-over value, Shockley diode presents a very low resistance (i.e. switch is closed) and Shockley diode conducts heavily. It may be noted that Shockley diode is also known as PNPN diode or four layer diode or reverse blocking diode thyristor.

Note:- Once Shockley diode is turned ON (i.e., it starts conducting), the only way to turn it OFF is to reduce the applied voltage to such a value so that current flowing through Shockley diode drops below its holding current (IH) value. Diode D2 then comes out of its reverse-breakdown state and its high-resistance value is restored. This, in turn, causes the entire Shockley diode to revert to its high resistance (switch open) state.

RADAR

Full form of RADAR is Radio Detection and Ranging. Radar uses radio waves, which are a type of electromagnetic energy.

Principle:-

The basic principle of operation of primary radar is simple to understand. The implementation and operation of primary radar systems involve a wide range of disciplines such as building works, heavy mechanical and electrical engineering, high power microwave engineering, and advanced high speed signal and data processing techniques. Some laws of nature have a greater importance here.

Radar measurement of range, or distance, is made possible because of the properties of radiated electromagnetic energy.

1. Reflection of electromagnetic waves :-
   The electromagnetic waves are reflected if they meet an electrically leading surface. If these reflected waves are received again at the place of their origin, then that means an obstacle is in the propagation direction.

2. Electromagnetic energy travels through air at a constant speed, at approximately the speed of light, i.e. 300,000 kilometres per second.

This constant speed allows the determination of the distance between the reflecting objects (airplanes, ships or cars) and the radar site by measuring the running time of the transmitted pulses.

This energy normally travels through space in a straight line, and will vary only slightly because of atmospheric and weather conditions. By using of special radar antennas this energy can be focused into a desired direction. Thus the direction (in azimuth and elevation of the reflecting objects can be measured)

These principles can basically be implemented in a radar system, and allow the determination of the distance, the direction and the height of the reflecting object.

Radar has many advantages compared to an attempt of visual observation:

- Radar is able to operate day or night, in lightness or darkness over a long range;
- Radar is able to operate in all weathers, in fog and rain, it can even penetrate walls or layers of snow;
- Radar has very broad coverage; it is possible to observe the whole hemisphere;
- Radar detects and tracks moving objects, a high resolution imaging is possible, that results in an object recognition;
- Radar can operate unmanned, 24 hours a day, 7 days a week.

SONAR

Sonar, an acronym for **so**und **n**avigation **a**nd **r**anging, is a system that uses sound waves to detect and locate objects underwater.

Working Principle:

The principle behind sonar is simple, a pulse of ultrasonic waves is sent into the water where it bounces off a target and comes back to the source (ultrasonic waves are pitched too high for humans to detect). The distance and location can be calculated by measuring the time it takes for the sound to return. By knowing the speed of sound in water, the distance is computed by multiplying the speed by one-half of the time travelled (for a one-way trip). This is active sonar ranging (echolocation).

Two types:

1. Active Sonar: Mode of echo location by sending a signal and detecting the returning echo.
2. Sensitive listening/Passive Sonar -only mode to detect the presence of objects making noise.

Most moving objects underwater make some kind of noise. Marine life, cavitation (small collapsing air pockets caused by propellers), hull popping of submarines changing depth, and engine vibration are all forms of underwater noise. In passive sonar ranging, no pulse signal is sent. Instead, the searcher listens for the characteristic sound of another boat or submarine. By doing so, the searcher can identify the target without revealing his own location. This method is most often used during wartime.

However, since a submarine is usually completely submerged, it must use active sonar at times, generally to navigate past obstacles. In doing so, the submarine risks alerting others of its presence. In such cases, the use of sonar has become a sophisticated military tactical exercise.

Sonar devices have become standard equipment for most commercial and many recreational ships. Fishing boats use active sonar to locate schools of fish. Other applications of sonar include searching for shipwrecks, probing harbours where visibility is poor, mapping the ocean floor, and helping submerged vessels navigate under the Arctic Ocean ice sheets.

LASER

Principles and Applications of Laser

Laser is the abbreviation of **L**ight **A**mplification by the **S**timulated **E**mission of **R**adiation. It is a device that creates a narrow and low-divergent beam [1] of coherent light, while most other light sources emit incoherent light, which has a phase that varies randomly with time and position. Most lasers emit nearly "monochromatic" light with a narrow wavelength spectrum.

Principle of Lasers

The principle of a laser is based on three separate features: a) stimulated emission within an amplifying medium, b) population inversion of electronics and c) an optical resonator.

<u>Spontaneous Emission and Stimulated Emission</u>

According to the quantum mechanics, an electron within an atom can have only certain values of energy, or energy levels. There are many energy levels that an electron can occupy, but here we will only consider two. If an electron is in the excited state with the energy E2 it may spontaneously decay to the ground state, with energy E1, releasing the difference in energy between the two states as a photon. [2] (See Fig.2a) this process is called **spontaneous emission**, producing fluorescent light. The phase and direction of the photon in spontaneous emission are completely random due to Uncertainty Principle.

Conversely, a photon with a particular frequency satisfying would be absorbed by an electron in the ground state. The electron remains in this excited state for a period of time typically less than 10-6 second. Then it returns to the lower state spontaneously by a photon or a phonon. These common processes of absorption and spontaneous emission cannot give rise to the amplification of light. The best that can be achieved is that for every photon absorbed, another is emitted.

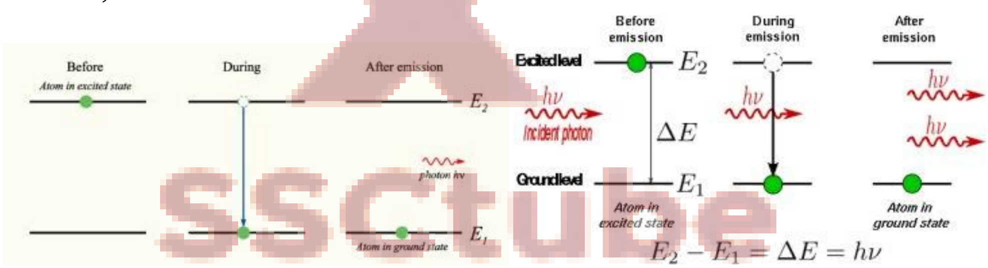


Diagram of (a) spontaneous Emission; and (b) stimulated Emission

Alternatively, if the excited-state atom is perturbed by the electric field of a photon with frequency ω, it may release a second photon of the same frequency, in phase with the first photon. The atom will again decay into the ground state. This process is known as stimulated emission.

The emitted photon is identical to the stimulating photon with the same frequency, polarization, and direction of propagation. And there is a fixed phase relationship between light radiated from different atoms. The photons, as a result, are totally coherent. This is the critical property that allows optical amplification to take place.

<u>Population Inversion of the Gain Medium</u>

If the higher energy state has a greater population than the lower energy state, then the light in the system undergoes a net increase in intensity. And this is called population inversion.

<u>Optical Resonator</u>

Although with a population inversion we have the ability to amplify a signal via stimulated emission, the overall single-pass gain is quite small, and most of the excited atoms in the population emit spontaneously and do not contribute to the overall output [6]. Then the resonator is applied to make a positive feedback mechanism.

An optical resonator usually has two flat or concave mirrors, one on either end, that reflect lasing photons back and forth so that stimulated emission continues to build up more and more laser light. Photons produced by spontaneous decay in other directions are off axis so that they won't be amplified to compete with stimulated emission on axis. The "back" mirror is made as close to 100% reflective as possible, while the "front" mirror typically is made only 95 - 99% reflective so that the rest of the light is transmitted by this mirror and leaks out to make up the actual laser beam outside the laser device. [7]

Types of Lasers and Applications

According to the gain material, lasers can be divided into the following types. Several common used lasers are listed in each type.

Gas Lasers:

Laser Gain Medium	Operation Wavelength(s)	Pump Source	Applications and Notes
Helium-neon laser	632.8nm	Electrical discharge	Interferometry, holography, spectroscopy, barcode scanning, alignment, optical demonstrations
Argon laser	454.6 nm, 488.0 nm, 514.5 nm	Electrical discharge	Retinal phototherapy (for diabetes), lithography, confocal microscopy, spectroscopy pumping other lasers
Carbon dioxide laser	10.6 μm, (9.4 μm)	Electrical discharge	Material processing (cutting, welding, etc.), surgery
Excimer laser	193 nm (ArF), 248 nm (KrF), 308 nm (XeCl), 353 nm (XeF)	Excimer recombination via electrical discharge	Ultraviolet lithography for semiconductor manufacturing, laser surgery

Solid State Lasers:

Laser Gain Medium	Operation Wavelength(s)	Pump Source	Applications and Notes
Ruby laser	694.3nm	Flash Lamp	Holography, tattoo removal. The first type of visible light laser invented; May 1960.
Nd:YAG laser	1.064 μm, (1.32 μm)	Flash Lamp, Laser Diode	Material processing, laser target designation, surgery, research, pumping other lasers. One of the most common high power lasers.

Erbium doped glass lasers	1.53-1.56 μm	Laser diode	um doped fibers are commonly used as optical amplifiers for telecommunications.
F-center laser	Mid infrared to far infrared	Electrical current	Research

Metal-vapor Lasers:

Laser Gain Medium	Operation Wavelength(s)	Pump Source	Applications and Notes
Helium-cadmium (HeCd) metal-vapor laser	441.563 nm, 325 nm	Electrical discharge in metal vapour mixed with helium buffer gas.	Printing and typesetting applications, fluorescence excitation examination (i.e. in U.S. paper currency printing)
Copper vapor laser	510.6 nm, 578.2 nm	Electrical discharge	Dermatological uses, high speed photography, pump for dye lasers

Other types of lasers:

Laser Gain Medium	Operation Wavelength(s)	Pump Source	Applications and Notes
Dye lasers	Depending on materials, usually a broad spectrum	Other laser, flash lamp	Research, spectroscopy, birthmark removal, isotope separation.
Free electron laser	A broad wavelength range (about 100 nm - several mm)	Relativistic electron beam	Atmospheric research, material science, medical applications

Types of communication:

- Simplex
  - One direction only
  - Radio broadcast
- Half-duplex
  - One direction at any one point in time
- Full duplex
  - Both directions at the same time
  - Telephone lines

The first mobile generations (1G to 2.5G)

The first operational cellular communication system was deployed in the Norway in 1981 and was followed by similar systems in the US and UK. These first generation systems provided voice transmissions by using frequencies around 900 MHz and analogue modulation. The second generation (2G) of the wireless mobile network was based on low-band digital data signaling. The most popular 2G wireless technology is known as Global Systems for Mobile Communications (GSM). The first GSM systems used a 25MHz frequency spectrum in the 900MHz band. FDMA (Frequency Division Multiple Access), which is a standard that lets multiple users access a group of radio frequency bands and eliminates interference of message traffic, is used to split the available 25MHz of bandwidth into 124 carrier frequencies of 200 kHz each. Each frequency is then divided using a TDMA (Time Division Multiple Access) scheme into eight timeslots and allows eight simultaneous calls on the same frequency. This protocol allows large numbers of users to access one radio frequency by allocating time slots to multiple voice or data calls. TDMA breaks down data transmission, such as a phone conversation, into fragments and transmits each fragment in a short burst, assigning each fragment a time slot. With a cell phone, the caller does not detect this fragmentation. Today, GSM systems operate in the 900MHz and 1.8 GHz bands throughout the world with the exception of the Americas where they operate in the 1.9 GHz band. Within Europe, the GSM technology made possible the seamless roaming across all countries.

CDMA uses spread spectrum technology to break up speech into small, digitized segments and encodes them to identify each call. CDMA distinguishes between multiple transmissions carried simultaneously on a single wireless signal. It carries the transmissions on that signal, freeing network room for the wireless carrier and providing interference-free calls for the user. Several versions of the standard are still under development. CDMA promises to open up network capacity for wireless carriers and improve the quality of wireless messages and users' access to the wireless airwaves. Whereas CDMA breaks down calls on a signal by codes, TDMA breaks them down by time. The result in both cases is an increased network capacity for the wireless carrier and a lack of interference for the caller. While GSM and other TDMA-based systems have become the dominant 2G wirelesses technologies, CDMA technology are recognized as providing clearer voice quality with less background noise, fewer dropped calls, enhanced security, greater reliability and greater network capacity. The Second Generation (2G) wireless networks mentioned above are also mostly based on circuitswitched technology, are digital and expand the range of applications to more advanced voice services. 2G wireless technologies can handle some data capabilities such as fax and short message service at the data rate of up to 9.6 kbps, but it is not suitable for web browsing and multimedia applications. So-called '2.5G' systems recently introduced enhance the data capacity of GSM and mitigate some of its limitations. These systems add packet data capability to GSM networks, and the most important technologies are GPRS (General Packet Radio Service) and WAP (Wireless Application Protocol). WAP defines how Web pages and similar data can be passed over limited bandwidth wireless channels to small screens being built into new mobile telephones. At the next lower layer, GPRS defines how to add IP support to the existing GSM infrastructure. GPRS provides both a means to aggregate radio channels for higher data bandwidth and the additional servers required to off-load packet traffic from existing GSM circuits. It supplements today's Circuit Switched Data and Short Message Service. GPRS is not related to GPS (the Global Positioning System), a similar acronym that is often used in mobile contexts. Theoretical maximum speeds of up to 171.2 kilobits per second (kbps) are achievable with GPRS using all eight timeslots at the same time. This is about ten times as fast as current Circuit Switched Data services on GSM networks. However, it should be noted that it is unlikely that a network operator will allow all timeslots to be used by a single GPRS user. Additionally, the initial GPRS terminals (phones or modems) are only supporting only one to four timeslots. The bandwidth available to a GPRS user will therefore be limited.

Transport Technology	Description	Typical Use / Data Transmission Speed	Pros/cons
TDMA	Time Division Multiple Access is 2G technology	Voice and data Up to 9.6kbps	Low battery consumption, but transmission is one-way, and its speed pales next to 3G technologies
GSM	Global System for Mobile Communications is a 2G digital cell phone technology	Voice and data. This European system uses the 900MHz and 1.8GHz frequencies. In the United States it operates in the 1.9GHz PCS band up to 9.6kbps	Popular around the globe. Worldwide roaming in about 180 countries, but GSM's short messaging service (GSM-SMS) only transmits one-way, and can only deliver messages up to 160 characters long
GPRS	General Packet Radio Service is a 2.5G network that supports data packets	Data Up to 115kbps; the AT&T Wireless GPRS network will transmit data at 40kbps to 60kbps	Messages not limited to 160 characters, like GSM SMS
EDGE	Enhanced Data GSM Environment is a 3G digital network	Data Up to 384kbps	May be temporary solution for operators unable to get W-CDMA licenses
CDMA	Code Division Multiple Access is a 2G technology developed by Qualcomm that is transitioning to 3G		Although behind TDMA in number of subscribers, this fast-growing technology has more capacity than TDMA
W-CDMA (UMTS)	Wideband CDMA (also known as Universal Mobile Telecommunications System-UMTS) is 3G technology. On November 6, 2002, NTT DoCoMo, Ericsson, Nokia, and Siemens agreed on licensing arrangements for W-CDMA, which should set a benchmark for royalty rates	Voice and data. UMTS is being designed to offer speeds of at least 144kbps to users in fast-moving vehicles Up to 2Mbps initially. Up to 10Mbps by 2005, according to designers	Likely to be dominant outside the United States, and therefore good for roaming globally. Commitments from U.S. operators are currently lacking, though AT&T Wireless performed UMTS tests in 2002. Primarily to be implemented in Asia-Pacific region
CDMA2000 1xRTT	A 3G technology, 1xRTT is the first phase of CDMA2000	Voice and data Up to 144kbps	Proponents say migration from TDMA is simpler with CDMA2000 than W-CDMA, and that spectrum use is more efficient. But W-CDMA will likely be more common in Europe
CDMA2000 1xEV-DO	Delivers data on a separate channel	Data Up to 2.4Mbps	(see CDMA2000 1xRTT above)
CDMA2000 1xEV-DV	Integrates voice and data on the same channel	Voice and data Up to 2.4Mbps	(see CDMA2000 1xRTT above)

(3G):

Multimedia services add high speed data transfer to mobile devices, allowing new video, audio and other applications (including Internet services) through mobile phones.

During the first and second generations, different regions of the world pursued different mobile phone standards, such as NMT and TACS for analogue and GSM for digital, North America pursued AMPS for analogue and a mix of TDMA, CDMA and GSM for digital.

3G, based on CDMA technology, will bring these incompatible standards together.

3G Features

1. With 3G, the information is split into separate but related packets before being transmitted and reassembled at the receiving end. Packet switched data formats are much more common than their circuit switched counterparts.

2. The World Wide Web (WWW) is becoming the primary communications interface. People access the Internet for entertainment, services, and information collection, the intranet for accessing enterprise information and connecting with colleagues and the extranet for accessing customers and suppliers. These are all derivatives of the World Wide Web aimed at connecting different communities of interest. Information and other resources are being stored in remote Web servers, which serves the various needs of human beings through Web browsers at their ends.

3. Speeds of up to 2 Megabits per second (Mbps) are achievable with 3G. The data transmission rates will depend upon the environment, the call is being made in, however, only indoors and in stationary environments that these types of data rates will be available. For high mobility, data rates of 144 kbps are expected to be available.

In case of mobile communication, which is a form of wireless communication, the only restraint on communication is the bandwidth restraint which means we have a limited frequency range that we can use for communication. Hence, we must somehow, allow multiple users communicate in the same frequency range.

Multiple Access Techniques are ways to access a single channel by multiple users. They provide multiple access to the channel. A "channel" refers to a system resource allocated to a given mobile user enabling the user to establish communication with the network (other users). Based on the type of channel, we can use a particular multiple access technique for communication.

The types of channel and the corresponding multiple access techniques are listed below:

1. Frequency Channels [FDMA - Frequency Division Multiple Access] - Frequency band divided into small frequency channels and different channels are allocated to different users – like in FM radio. Multiple users can transmit at the same time but on different frequency channels.

2. Time-slot Within Frequency Bands [TDMA - Time Division Multiple Access] – Each user is allowed to transmit only in specified time-slots with a common frequency band. Multiple users can transmit at the same frequency band at different times.

3. Distinct Codes [CDMA - Code Division Multiple Access] – Users may transmit at the same time using the same frequency band but using different codes so that we can decode to identify a particular user. We often use a combination of TDMA+FDMA to achieve a greater number of multiple access channels.

BLUETOOTH

Bluetooth is a **standardized protocol** for sending and receiving data via a 2.4GHz wireless link. It's a secure protocol, and it's perfect for short-range, low-power, low-cost, wireless transmissions between electronic devices.

Bluetooth basics

The first release of Bluetooth was for a wireless data system that could carry data at speeds up to 721 Kbps with the addition of up to three voice channels. The aim of Bluetooth technology was to enable users to replace cables between devices such as printers, fax machines, desktop computers and peripherals, and a host of other digital devices. One major use was for wirelessly connecting headsets for to mobile phones, allowing people to use small headsets rather than having to speak directly into the phone.

Another application of Bluetooth technology was to provide a connection between an ad hoc wireless network and existing wired data networks.

The technology was intended to be placed in a low cost module that could be easily incorporated into electronics devices of all sorts. Bluetooth uses the licence free Industrial, Scientific and Medical (ISM) frequency band for its radio signals and enables communications to be established between devices up to a maximum distance of around 100 metres, although much shorter distances were more normal..

Bluetooth is well established, but despite this further enhancements are being introduced. Faster data transfer rates, and greater flexibility. In addition to this efforts have been made to ensure that interoperation has been improved so that devices from different manufacturers can talk together more easily.

CATHODE RAY TUBE (CRT)

A CRT works by moving an electron beam back and forth across the back of the screen. Each time the beam makes a pass across the screen, it lights up phosphor dots on the inside of the glass tube, thereby illuminating the active portions of the screen. By drawing many such lines from the top to the bottom of the screen, it creates an entire screenful of images.

The terms **anode** and **cathode** are used in electronics as synonyms for positive and negative terminals. For example, you could refer to the positive terminal of a battery as the anode and the negative terminal as the cathode.

In a cathode ray tube, the "cathode" is a heated filament (not unlike the filament in a normal light bulb). The heated filament is in a vacuum created inside a glass "tube." The "ray" is a stream of electrons that naturally pour off a heated cathode into the vacuum.

Electrons are negative. The anode is positive, so it attracts the electrons pouring off the cathode. In a TV's cathode ray tube, the stream of electrons is focused by a focusing anode into a tight beam and then accelerated by an accelerating anode. This tight, high-speed beam of electrons flies through the vacuum in the tube and hits the flat screen at the other end of the tube. This screen is coated with phosphor, which glows when struck by the beam.

LCD

A liquid crystal display (LCD) is a parallel plate capacitor with a dielectric, in this case the liquid crystal fluid, between the plates. First we select glass coated with a transparent metal coating for the electrodes of the display. The glass is usually made of soda lime, but in some instances it can be a more expensive borosilicate, or because few manufacturers provide borosilicate any more without a fight, alumina silicate type.

The transparent metal coating can be any thin layer of conductive material, such as gold, silver or tin. In order to keep the cost down and have a reasonable process window with a highly transparent coating, the industry has been using indium-tin oxide (ITO) as the preferred electrode material.

IRNSS

The Indian Regional Navigation Satellite System (IRNSS) is an autonomous regional satellite being developed by the Indian Space Research Organisation (ISRO) which would be under complete control of the Indian government. The requirement of such a navigation system is driven because access to foreign government-controlled global navigation satellite systems is not guaranteed in hostile situations, as happened to the Indian military depending on American GPS during the Kargil War.[2] The IRNSS would provide two services, with the Standard Positioning Service open for civilian use, and the Restricted Service (an encrypted one) for authorised users (including the military).

IRNSS would have seven satellites, out of which four are already placed in orbit. The constellation of seven satellites is expected to operate from 2016 onwards.