1. Microwave oven

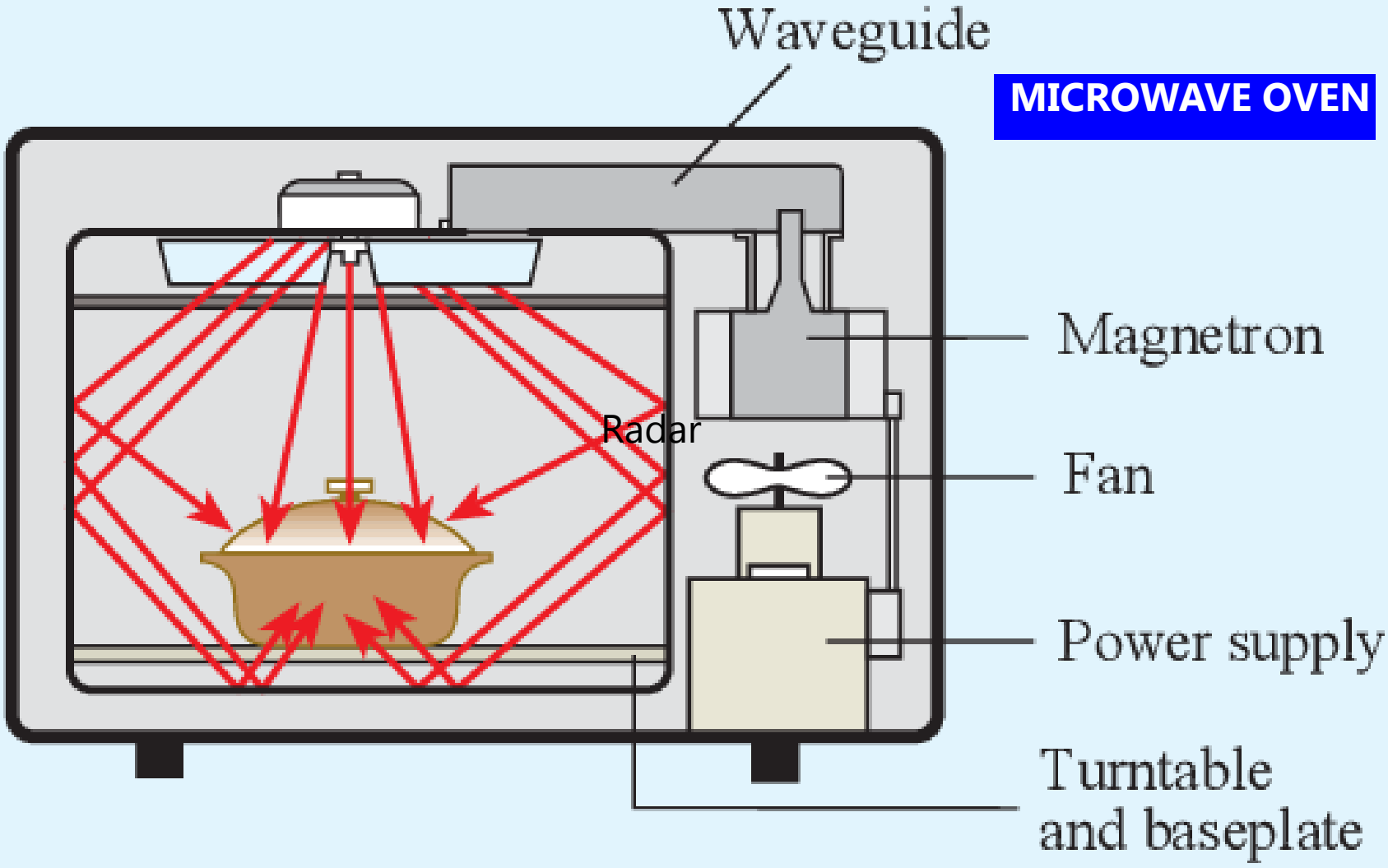


Figure 1. Schematic diagram of a typical microwave

MICROWAVE OVEN

- The principle behind the **microwave** is very simple i.e . When energy is give to an atom or molecule, **it vibrates**. If we give More energy more vibrations ,takes place and it will **generates heat.** This heat energy can make molecules to vibrate
- Water molecules act as "dipoles". Like a magnet, i.e each have a positive charge at one end and a negative at the other. This means they can be push around with a magnetic field.
- In a **microwave oven,** this is achieved by generating and passing short radio waves, known as microwaves, within the unit.
- The device that converts electrical energy to microwaves – called the **magnetron** i.e sends microwaves into the oven cavity, where they **bounce off the reflective inner surface**.
- Microwaves, like other waves on the electromagnetic spectrum, are wave-shaped patterns of electricity and magnetism that move together at the speed of light.
- When microwaves pass through food, their magnetic component **agitates water molecules within** to flip back and forth billions of times a second, that generating energy and building up heat in the process.
- This also means microwave ovens are very energy-efficient as the waves pass harmlessly through microwave-safe plastics, glass and ceramics, the device only expends energy heating the food.

RADAR

- We can see objects in the world around us because light (usually from the Sun) reflects off them into our eyes.
- If you want to walk at night, you can shine a torch in front to see where you're going. The light beam travels out from the torch, reflects off objects in front of you, and bounces back into your eyes.
- Your brain instantly computes what this means: it tells you how far away objects are and makes your body move so you don't trip over things.
- Radar works in much the same way. The word "radar" stands for **radio detection and ranging** Imagine an airplane flying at night through thick fog. The pilots can't see where they're going, but they can communicate with **air traffic controllers** on the ground who use **radar** to help them. Pilots themselves don't generally use radar as a "flight instrument" (something that helps them fly or navigate), but they do use it for tracking the weather.
- The basic principle behind radar is simple - extremely short bursts of radio energy (traveling at the speed of light) are transmitted, reflected off a target and then returned as an echo.
- . Radar makes use of a phenomenon we have all observed, that of the ECHO PRINCIPLE.

If, however the whistle sounded near an object such as a cliff some of the radiated sound waves would be reflected back to the ship as an echo. The form of electromagnetic signal radiated by the radar depends upon the type of information needed about the target. Radar, as designed for marine navigation applications, is pulse modulated. Pulse-modulated radar can determine the distance to a target by measuring the time required for an extremely short burst of radio-frequency (r-f) energy to travel to the target and return to its source as a reflected echo. Directional antennas are used for transmitting the pulse and receiving the reflected echo, thereby allowing determination of the direction or bearing of the target echo. Once time and bearing are measured, these targets or echoes are calculated and displayed on the radar display. The radar display provides the operator a birds eye view of where other targets are relative to own ship. Radar is an active device. It utilizes its own radio energy to detect and track the target. It does not depend on energy radiated by the target itself. The ability to detect a target at great distances and to loc

Radar uses electromagnetic energy pulses in much the same way, a. The radio-frequency (rf) energy is transmitted to and reflected from the reflecting object. A small portion of the reflected energy returns to the radar set. This returned energy is called an ECHO, just as it is in sound terminology. Radar sets use the echo to determine the direction and distance of the reflecting object.

targets produce a diffuse reflection i.e. it is reflected in a wide number of directions. The reflected signal is also-called scattering. **Backscatter** is the term given to reflections in the opposite direction to the incident rays.

Radar signals can be displayed on the traditional plan position indicator (PPI) or other more advanced radar display systems. A PPI has a rotating vector with the radar at the origin, which indicates the pointing direction of the antenna and hence the bearing of targets.

Transmitter

The radar transmitter produces the short duration high-power rf pulses of energy that are into space by the antenna.

Duplexer

The duplexer alternately switches the antenna between the transmitter and receiver so

Receiver

The receivers amplify and demodulate the received RF-signals. The receiver provides video signals on the output.

RadarAntenna

The Antenna transfers the transmitter energy to signals in space with the required distribution and efficiency. This process is applied in an identical way on reception.

Indicator

The indicator should present to the observer a continuous, easily understandable, graphic picture of the relative position of radar targets. The radar screen (in this case a PPI-scope) displays the produced from the echo signals bright blibs. The longer the pulses were delayed by the runtime, the further away from the center of this radar scope they are displayed. The direction of the deflection on this screen is that in which the antenna is currently pointing.

➢We know that one of the **core uses of Radar is to send and receive valuable information** in the form of **waves.**
➢RADAR is helpful in detecting incoming signals during war and also used by a geologist for earthquake detection.
➢Archaeologists use this technology for detection of buried artifacts. It is also used to understand the environment and climatic changes.

Applications and uses of Radar are given below: Military Law enforcement Space Remote sensing of environment Aircraft navigation Ship Navigation Air Traffic Controller

RADAR are used in **Military Radars** have a wide range of usage in military operations. They are used in Naval, Ground as well as Air defense purposes.
They are used for detection, tracking and surveillance purposes also. Weapon control and missile guidance often use various types of RADARs.
These are used **in Law Enforcement**
➢Law enforcement, especially highway police, has extensive use of RADARs during a pursuit in order to measure the speed of a vehicle.
➢Due to bad weather conditions, when the satellite is unable to get a clear image of traffic and barricades, then RADARs is used to get the desired results.

This technology is used in Space

RADARs are used to track and detect satellites and spacecraft. They are also used for safely landing and docking of spacecraft. RADARs in satellites are used for remote sensing.
RADAR is used for Remote Sensing of Environment
Just like various type of waves are received by an antenna. This technology are also used to detect weather condition of atmosphere and are also used for tracking motions of

It is used in **Aircraft Navigation**

Ground mapping RADARs and weather avoidance RADARs are used in aircraft to navigate it properly. This technology enables an aircraft to ensure the location of obstacles which can be a threat to the flight plan.

Uses of RADAR in **Navigating Ships**

Ships are guided through high resolutions RADARs situated on the shores. Because of poor visibility in bad weather conditions, RADARs provides safety by warning threats. These ships often use this technology to measure the proximity of other ships and their speed on the water.

RADARs is used in **Air Traffic Controller**

RADARs are used for safely controlling the traffic in air. It is used to guide aircraft for proper landing and take-off during bad weather conditions. These type of RADARs also detect the proximity and the altitude of the aircraft.

- The field of radiology had its beginnings with Wilhelm Conrad Roentgen's discovery of X-rays in the late 1800s.
- One of the first X-ray images was of the bones of his hand rendered on a photographic plate.
- Then, as now, X-rays were produced by high-voltage electrons striking a metal target. Although X-rays are a part of the same electromagnetic spectrum as visible light and radio waves, their high energy gives them the ability to penetrate most solid materials.
- Physicists call X-rays "ionizing radiation" because their energy strips the electrons from atoms; to guard against the harmful effects of X-rays, technicians use lead-lined aprons, shields and other safety gear.

- **Radiography** is an imaging technique using **X-rays**, gamma **rays**, or similar ionizing radiation and non-ionizing radiation to view the internal form of an object.
- To create an image in conventional **radiography**, a beam of **X-rays** is produced by an **X-ray** generator and is projected toward the object.
- Rays were discovered by Wilhelm Conrad Roentgen on November 8, 1895. Since the initial discovery, technology has evolved rapidly.
- Radiography includes diagnostic radiography as well as additional imaging modalities such as mammography, computed tomography (CT), magnetic resonance imaging (MRI), PET-CT, PET-MRI, and sonography.
- Radiography has been an indispensable diagnostic tool of modern medicine. Broken bones can be aligned, ulcers can be detected, and many other injuries and conditions can be treated when the exact nature is known to the physician.

What is Radiography?

Radiography is the art and science of using radiation to provide images of the tissues, organs, bones, and vessels that comprise the human body.

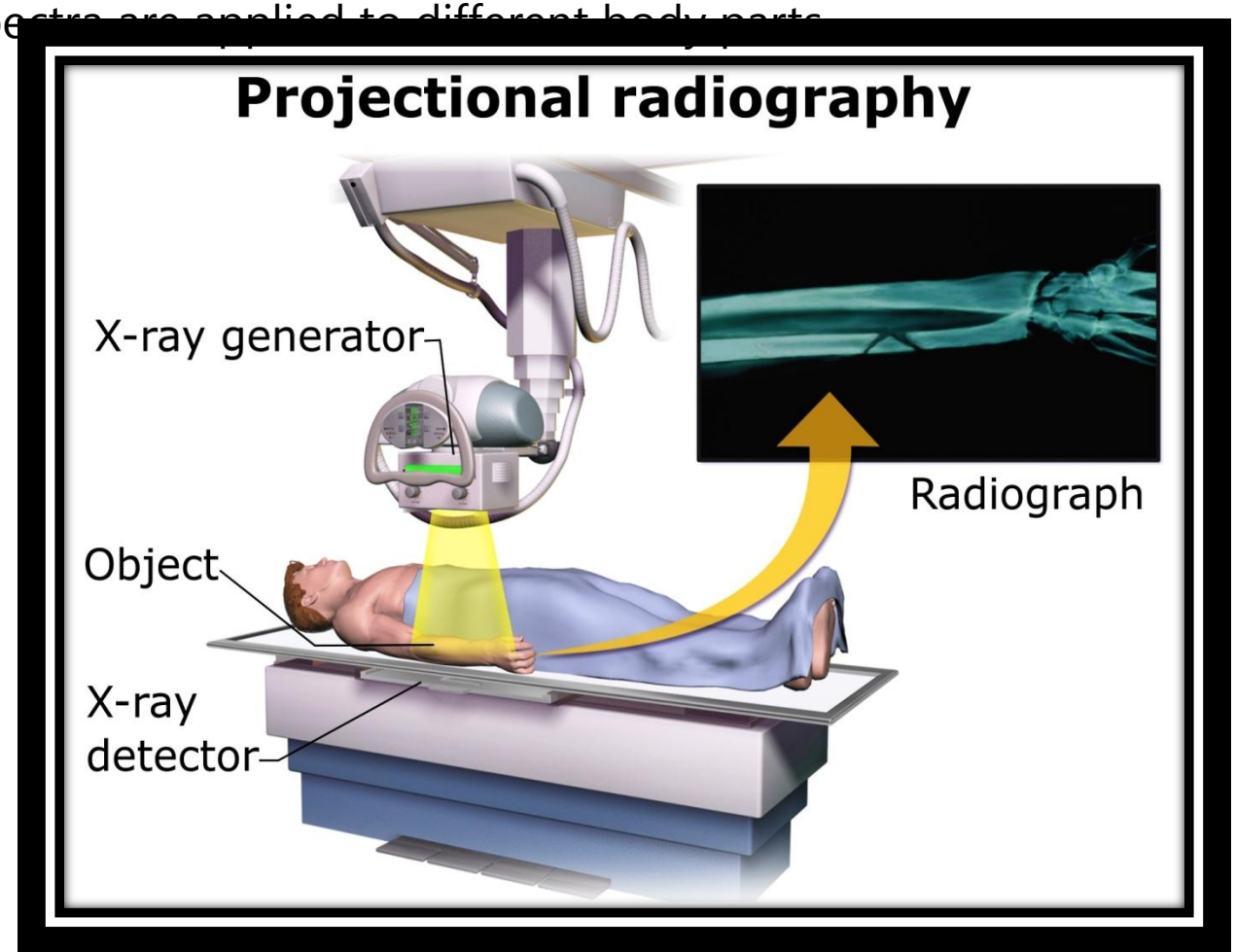
Radiologists, physicians who have had special training in interpreting diagnostic images, read or diagnose these images. Treatment of a patient depends on the accurate and precise production of radiographic images.

- **X-rays** are a type of electromagnetic radiation (just like visible light). There are three criteria that must be met to allow electromagnetic radiation to be used for imaging purposes:
- Ability to **create** to the electromagnetic radiation at the wavelength required
- Ability to **focus** the radiation on a particular area
- Ability to **detect** the radiation once it has passed through the patient.

➢X-rays are produced within the X-ray machine, also known as an X-ray tube. No external radioactive material is involved.

➢Radiographers can change the current and voltage settings on the X-ray machine in order to manipulate the properties of the X-ray beam produced.

➢Different X-ray beam spectra are applied to different body parts



➢The radiation is created when an electric current is generated from a high voltage generator. This causes electrons to "boil-off" from the **cathode** end of an X-ray tube assembly. These electrons are emitted from a filament on the cathode and rush towards a target material known as the **anode**. This process is known as **thermionic emission**.

➢The electrons emitted by the cathode rush towards the anode, which holds a disc made

➢When the electrons collide with the tungsten, several interactions occur at the atomic level. One of these interactions causes electrons to be expelled from the outer orbits of the atoms releasing a **X-ray photon**. Energy levels of the X-ray photon will vary and can be adjusted when selecting a parameter known as kVP or kilovolts peak.

➢These X-rays then travel through a **focusing cup**, focusing and accelerating the photons towards the area of the body to be imaged. Traditionally, radiographic film was used known as double emulsion film containing silver nitrate. With technological advancements, many instutions will be using a cassette receptor or if newer technology is available, a digital plate receptor may be used instead. These receptors are placed behind the patient to capture the x-ray photons that are transmitted through the patient and ultimately form the image.

COMPUTERIZED TOMOGRAPHY (CT)

➢A computerized tomography (CT) or computerized axial tomography (CAT) scan combines data from several X-rays to produce a detailed image of structures inside the body.

➢CT scans produce 2-dimensional images of a “slice” or section of the body, but the data can also be used to construct Trusted Source 3-dimensional images.

➢A CT scan can be compared to looking at one slice of bread within a whole loaf.

CT scans are used in hospitals worldwide.A CT scanner emits a series of narrow beams through the human body as it moves through an arc.

This is different from an X-ray machine, which sends just one radiation beam. The CT scan produces a more detailed final picture than an X-ray image.

The CT scanner’s X-ray detector can see hundreds of different levels of density. It can see tissues within a solid organ.

This data is transmitted to a computer, which builds up a 3-D cross-sectional picture of the part of the body and displays it on the screen.

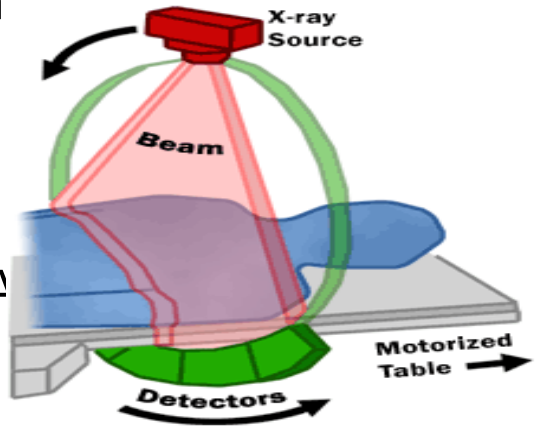
COMPUTERIZED TOMOGRAPHY (CT)

- Although also based on the variable absorption of x rays by different tissues, computed tomography (CT) imaging, also known as "CAT scanning" (Computerized Axial Tomography), provides a different form of imaging known as cross-sectional imaging.
- The origin of the word "tomography" is from the Greek word "tomos" meaning "slice" or "section" and "graphe" meaning "drawing."
- A CT imaging system produces cross-sectional images or "slices" of anatomy, like the slices in a loaf of bread.



COMPUTERIZED TOMOGRAPHY (CT)

- motorized table moves the patient through a circular opening in the CT imaging system.
- As the patient passes through the CT imaging rays rotates around the inside of the circular opening. A about 1 second.

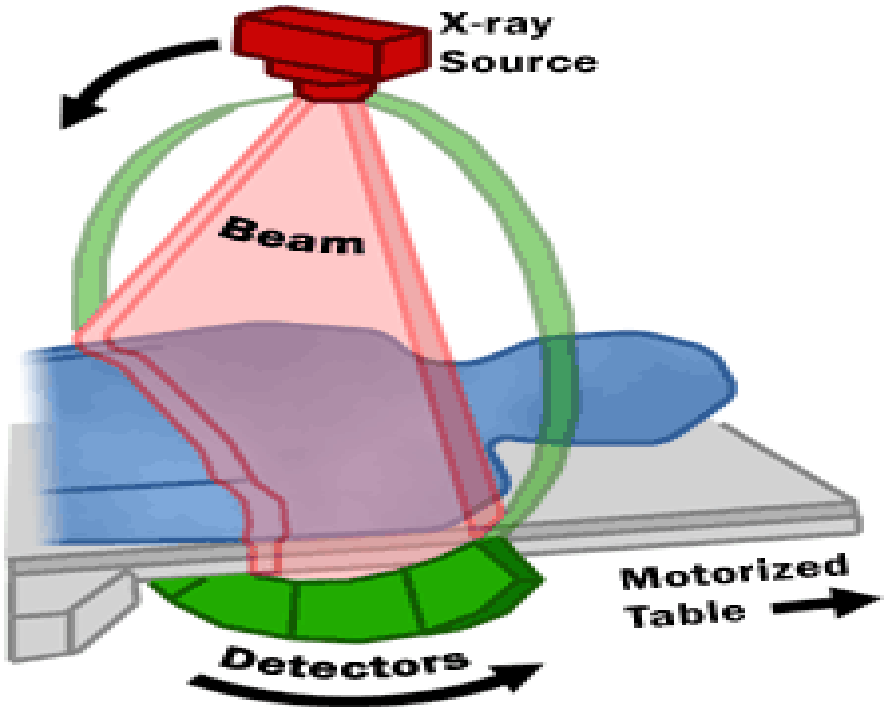


- The x-ray source produces a narrow, fan-shaped beam of x rays used to irradiate a section of the patient's body (Figure).
- The thickness of the fan beam may be as small as 1 millimeter or as large as 10 millimeters.
- In typical examinations there are several phases; each made up of 10 to 50 rotations of the x-ray tube around the patient in coordination with the table moving through the circular opening.
- The patient may receive an injection of a "contrast material" to facilitate visualization of vascular structure.

COMPUTERIZED TOMOGRAPHY (CT)

Detectors on the exit side of the patient record the x rays exiting the section of the patient's body being irradiated as an x-ray "snapshot" at one position (angle) of the source of x rays. Many different "snapshots" (angles) are collected during one complete rotation.

The data are sent to a computer to reconstruct all of the individual "snapshots" into a cross-sectional image (slice) of the internal organs and tissues for each complete rotation of the source of x rays.



COMPUTERIZED TOMOGRAPHY (CT)

What is solar cell principle?

Answer:

A **solar cell** is a device that directly converts the energy of light into electrical energy through the **photovoltaic effect**. Solar cells or photovoltaic cells are made based on the principle of the photovoltaic effect. They convert sunlight into direct current (DC) electricity. But, a single photovoltaic cell does not produce enough amount of electricity.

Silicon crystals are laminated into p-type and n-type layers, stacked on top of each other. Light striking the crystals induces the "photovoltaic effect," which generates electricity.

A solar cell is a sandwich of n-type silicon and p-type silicon. It generates electricity by using sunlight to make electrons hop across the junction between the different flavours of silicon:

The electrons use this energy to jump across the barrier into the upper, n-type layer and escape out into the circuit.

Flowing around the circuit, the electrons make the lamp light up.

The photovoltaic effect can be observed in nature by variety of materials. But the materials that have shown the best performance in sunlight are the semiconductors e.g. germanium and silicon. These are the elements having resistivity of the order of 10^4 or 10^5 Ω m which lies between good conductor and insulator.

In an intrinsic semiconductor such as silicon, each one of four valence electrons of atom is tied in covalent bond and there are no free electrons at absolute zero. If material of pentavalent impurity like arsenic or phosphorus is doped with silicon, there will be excess of electrons and it will become n-type semiconductor. When impurity like boron is doped with silicon, there will be deficiency of electron leading to p-type semiconductor. This deficiency is expressed in terms of excess of holes free to move. When p-type and n-type semiconductors are joined together, p-n junction is formed (See Fig. 4.6).

Depletion Region or window

Consider a p-n junction as shown in the Fig. 4.6 below :

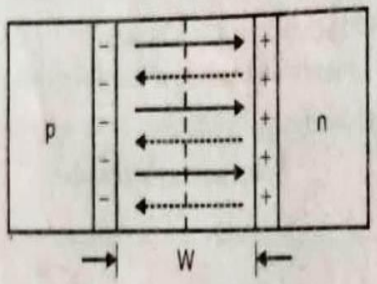


Fig. 4.6 : Depletion region

When the junction of p and n type semiconductor is formed the mobile charge carriers holes and electrons, due to their high concentrations in p and n regions respectively, diffuse into opposite sides at the junction. Due to recombination of holes and electrons near the junction, there is the accumulation of positive charge at border of n region and negative charge at border of p region. Thus a dipole layer exists at p-n junction and these bound charges do not allow other majority carriers to cross the junction. Hence a *barrier region* is formed near the junction. In this region, there are no holes on p-side and no electrons on n-side. Thus the region is *devoid of free charge carriers*. This region is called "*Transition*" or *Depletion region*" or "*Window*". It is represented by W.

Photo-voltaic effect :

Consider a p-n junction diode as shown in the Fig. 4.7 below :

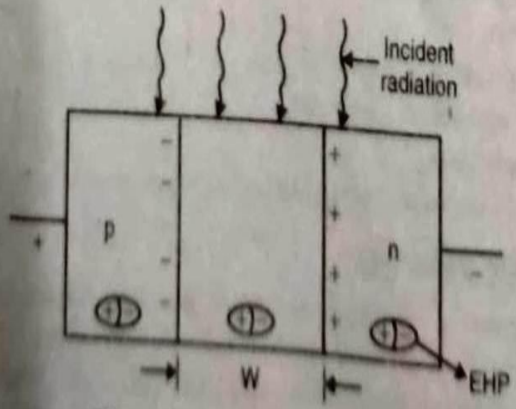


Fig. 4.7 : Photo-voltaic effect

When solar radiations fall on this junction diode then if the incident photon sufficient energy to knock out the electron from covalent bond, the electron-hole pair (E is created. If EHP is created in the p-region then current cannot be set up across junc due to bound charges at the boundary of depletion region i.e. at window. Similar situa exists if EHP is created in the n-region due to bound positive charge.

But when EHP is created in the depletion region then the holes are attracted tow p-region and electrons are attracted towards n-region. Thus an electric current is s through the diode. As a result a voltage drop is developed across the semiconductor d incident solar radiations. In this way the p-n diode is used as a device to collect energy and convert it into electricity. When a load is connected across these polaritie electron current flows through it and useful power is available across the external loa

This is p-n diode solar cell.

Types of Solar Cells

is p-n diode solar cell.

Types of Solar Cells :

(1) p-n Junction solar cell :

The first solar cells were made of silicon in the U.S.A. in 1954. Silicon cells are th only cells having commercial status. Conventional silicon cells are then wafers abou 300 μm in thickness and 3 to 6 cm in diameter sliced from a single crystal of *n*-type an *p*-type doped silicon. A shallow junction is formed at one end by diffusion of the other typ of impurity. Metal electrodes made from Ti - Ag solder are attached to the front and bac side of the cell. On the front side, the electrode is in the form of a metal grid with finge which permit the sunlight to go through, while on the back side, the electrode completel covers the surface. An anti reflection coating of SiO, having a thickness of 0.1 μm is al put on the top surface as shown in Fig. 4.8.

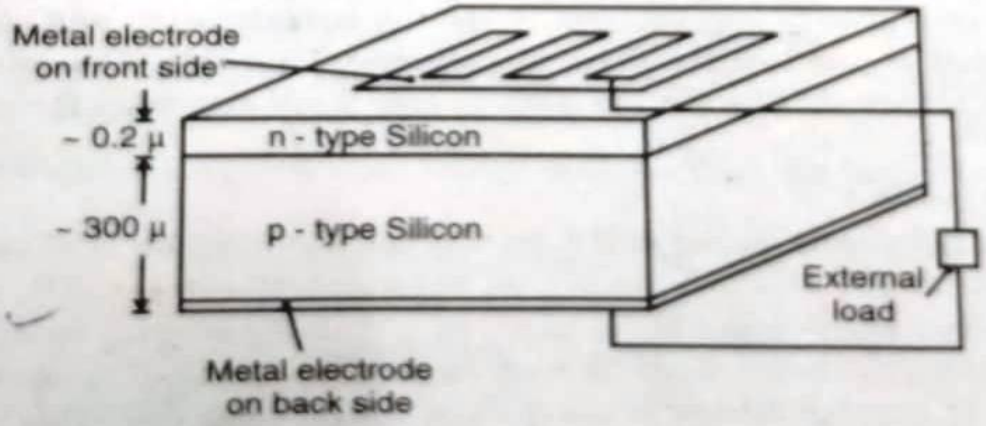


Fig. 4.8 : Diagram of a solar cell

When radiation falls on a cell, it penetrates through n-type silicon and it is absorb This produces pairs of positive and negative charges called electron hole pairs. T positive and negative charges are separated by the *p-n* junction bound charges.

The charge carriers of current across junction are collected by metal electrodes. T levelopes potential difference (voltage) across electrodes. When load is connected acr electrodes a current flows through load. In this way solar radiations are directly conver o electricity by p-n junction solar cell. This cell is called homojunction solar cell wher and n type semiconductors are of the same element.

I-V Characteristics of Solar Cell :

A typical current-voltage (I-V) characteristic of p-n silicon solar cell is shown in the Fig. 4.10 below.

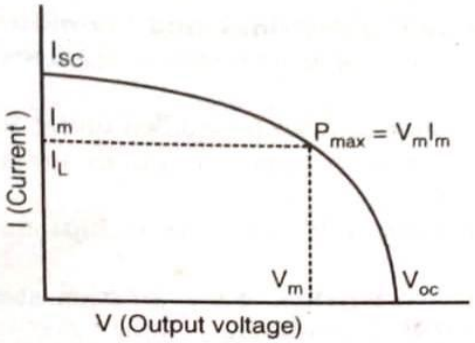


Fig. 4.10 : I-V characteristic of silicon solar cell

Generally, the silicon solar cells employed for terrestrial applications are round wafers of 5 cm diameter and thickness of 0.3 to 0.5 millimetres. This cell delivers in full sun and at room temperature a power of 0.2 watt at 0.45 volt. For higher power or higher voltage, number of cells must be assembled. e.g. to double the voltage, two cells are connected in series and to double the power at constant voltage, two cells are connected in parallel. For assembly of cells matching the electrical characteristic is important. For parallel assembly same open circuit voltage and same maximum power point voltage is necessary and for series assembly same short circuit current and same maximum power point current is necessary.

The short circuit current I_{SC} and open circuit voltage V_{OC} are the output parameters of solar cell.

The current voltage (I-V) characteristic of solar cell curve Fig. 4.10 shows that the maximum voltage is obtained across solar cell when *no current* is drawn from the cell. This occurs when the external circuit is *open*. This voltage is called *open circuit voltage* and denoted by V_{OC}. Similarly current delivered by solar cell is *maximum* when there is *no resistance* in the external circuit. This occurs when the solar cell is *short-circuited*. This current is called *short circuit current* and denoted by I_{SC}. The product V_{OC} I_{OC} is the *ideal power* of the solar cell.

The co-ordinates of points on the I-V curve at which maximum power is drawn from the solar cell are V_m and I_m. Thus maximum useful power is V_m I_m. The maximum useful power is given by the area of the largest rectangle under I-V curve (See Fig. 4.8). Typical values of V_{OC} and I_{SC} for a silicon cell are given below :

V_{OC} — 450 to 600 mV

I_{SC} — 30 to 50 mA

When such junction is illuminated, excess electron hole pairs are generated by light throughout the material. If we short the illuminated p-n junction, a current will flow in the short circuiting wire. The light generated current is superimposed on the normal diode rectifying characteristics which give an operating region in the fourth quadrant where power can be extracted from the solar cell as shown in Fig. 4.12.

Efficiency of the Solar Cell :

The energy conversion efficiency (η) of a solar cell is defined as *maximum output power* extracted from solar cell divided by the total input power given to the solar cell i.e. total power in the incident solar radiations. Thus,

$$\text{efficiency } (\eta) = \frac{(P_{output})_{max}}{(P_{input})}$$

$$\therefore \quad \eta = \frac{V_m \times I_m}{P_{input}} \qquad \ldots (4.4)$$

But from equation (4.3),

$$V_m \times I_m = (FF) \times V_{OC} \times I_{SC}$$

$$\therefore \quad \eta = \frac{V_{OC} \times I_{SC} \times (FF)}{P_{input}} \qquad \ldots (4.5)$$

The efficiency of solar cell is very low. The best silicon solar cell produced in the laboratory today has an efficiency of about 20 %. The commercial solar cells have the efficiencies between 12 % and 14 %.

Fill factor (FF) of solar cell :

It is defined as the ratio of the maximum useful power to the ideal power.

$$\therefore \quad \text{F. F.} = \frac{\text{Maximum useful power}}{\text{ideal power}}$$

$$= \frac{V_m \times I_m}{V_{OC} \times I_{SC}} \qquad \ldots (4.3)$$

The fill factor is always less than one and for solar cells of reasonable efficiency, it has a value in the range 0.7 to 0.85. Ideally, it is a function of open circuit voltage V_{OC} only.

I-V characteristics of solar cell under dark and illuminated conditions :

Silicon solar cells show the response to the radiations of wavelengths less than 11500 A°.

The I-V characteristics of solar cell can be studied under following two conditions :

(1) Dark condition : When no solar radiations are incident, it is called *"Dark condition"*.

(2) Illuminated condition : When solar radiations are incident, it is called *"Illuminated condition"*.

Let us analyse the I-V characteristics of p-n junction solar cell when it is under (i) dark condition and (ii) illuminated condition.

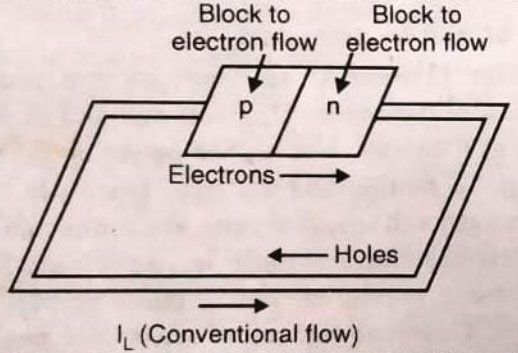


Fig. 4.11 : Asymmetrical properties of a p-n junction diode

The basic requirement for photovoltaic conversion is an electronic asymmetry in the structure of a semiconductor as shown in Fig. 4.11.

This figure shows that a p-n junction possesses required asymmetry, n-type regions have large electron densities but small hole densities. Hence electrons flow quickly through such material but holes find great difficulty. In p-type regions, exactly the opposite is true.

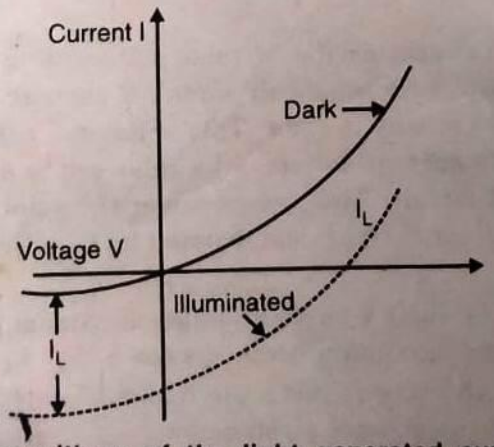


Fig. 4.12 : Superimpositions of the light generated current on normal rectifying current-voltage characteristics of the diode. This results in an operating region in the fourth quadrant where electrical power is extracted from the solar cell.

APPLICATIONS OF SOLAR CELLS

Amorphous Silicon solar cell (a-Si) Biohybrid solar cell. Cadmium telluride solar cell (CdTe) Concentrated PV cell (CVP and HCVP) Copper indium gallium selenide solar cells (CI(G)S) Crystalline silicon solar cell (c-Si) Float-zone silicon.

We'll start by listing the available types below.

Crystalline silicon cells Monocrystalline cells Polycrystalline cells Thin film solar cells

Presently, around 90% of the world's photovoltaics are based on some variation of silicon, and around the same percentage of the domestic solar panel, systems use the crystalline silicon cells. Crystalline silicon cells also form the basis for mono and polycrystalline cells.

The silicon that is in solar cells can take many different forms. This is because it directly affects its efficiency. What purity means, in this case, is the way in which the silicon molecules have been aligned. The better the alignment, the purer the resulting silicon is. This, ultimately, leads to better conversion rates of sunlight into electricity.

As previously mentioned, the levels of efficiency work alongside the purity of the silicon molecules – and purity can be quite a costly aspect to upgrade. However, it may come as a surprise to learn that efficiency is not the driving force for people who want to invest in solar energy. The cost and the amount of space it takes up tend to be the most