SIR CHHOTU RAM INSTITUTE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

RENEWABLE ENERGY RESOURCES (BT-806)

NOTES ON SOLAR CELL

THEORY OF SOLAR CELLS

SOLAR CELL - A **solar cell**, or **photovoltaic cell**, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon . It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Individual solar cell devices can be combined to form modules, otherwise known as solar panels.

HISTORY OF SOLAR CELL..

- The term “Photo” comes from the Greek meaning “light”, and “voltaic”, from the name of the Italian physicist “Volta”.
- The PHOTOELECTRIC EFEECT was first recognized in 1839 by French physicist A.E. BECQUEREL.
- ALBERT EINSTEIN explained the photoelectric effect in 1905 for which he received the Nobel prize in Physics in 1921.

- The modern photovoltaic cell was developed in 1954 at BELL LABORATORIES.
- The highly efficient solar cell was first developed by DARYL CHAPIN, CALVIN SOUTHER FULLER and GERALD PEARSON in 1954 using a diffused silicon p-n junction.
- Solar Cells were first used in Vanguard I satellite, launched in 1958.

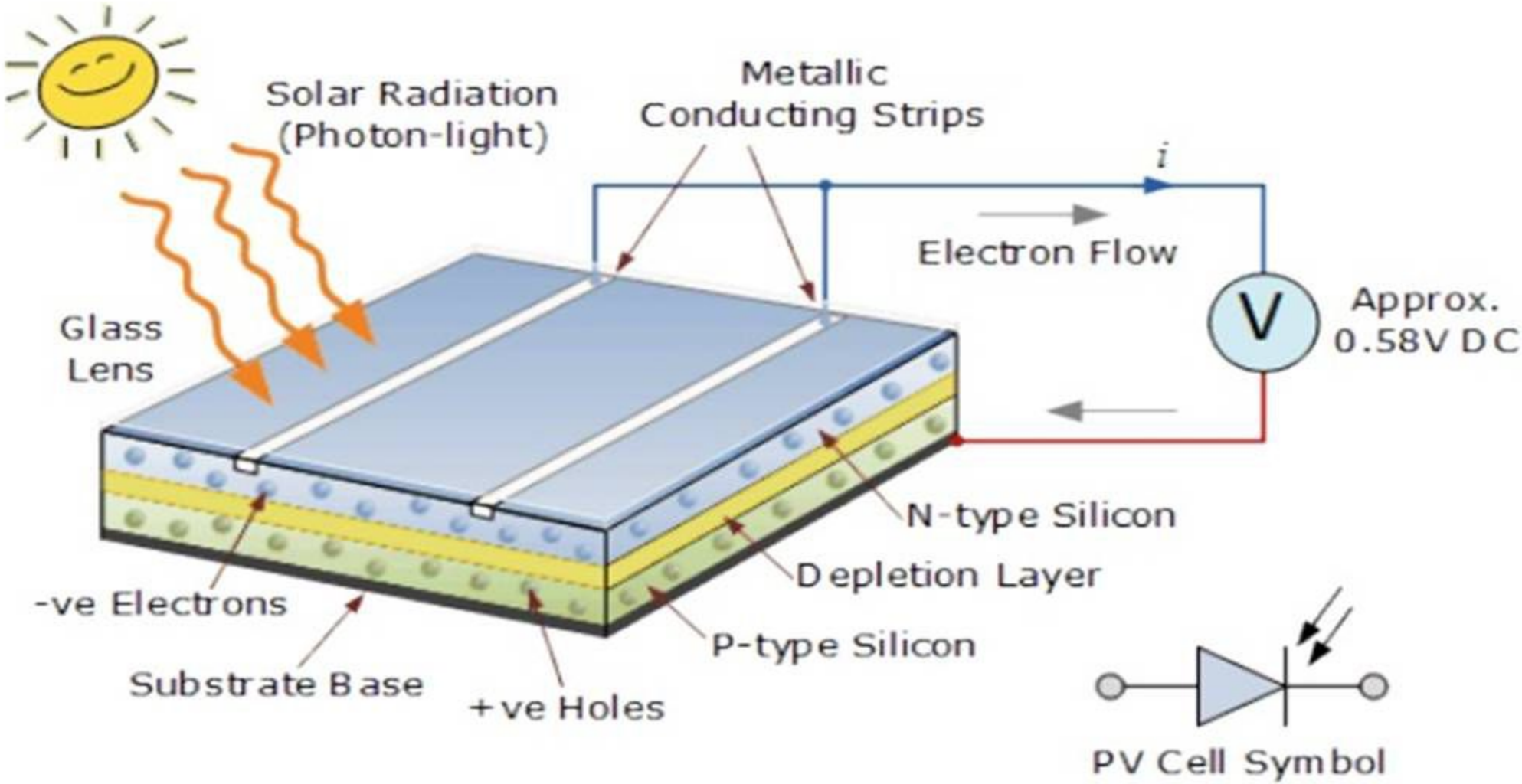
The **theory of solar cells** explains the process by which light energy in photons is converted into electric current when the photons strike a suitable semiconductor device. The theoretical studies are of practical use because they predict the fundamental limits of a solar cell, and give guidance on the phenomena that contribute to losses and solar cell efficiency.

Solar cells are described as being photovoltaic, irrespective of whether the source is sunlight or an artificial light. In addition to producing energy, they can be used as a photodetector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of a photovoltaic (PV) cell requires three basic attributes:

- The absorption of light, generating either electron-hole pairs or excitons.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

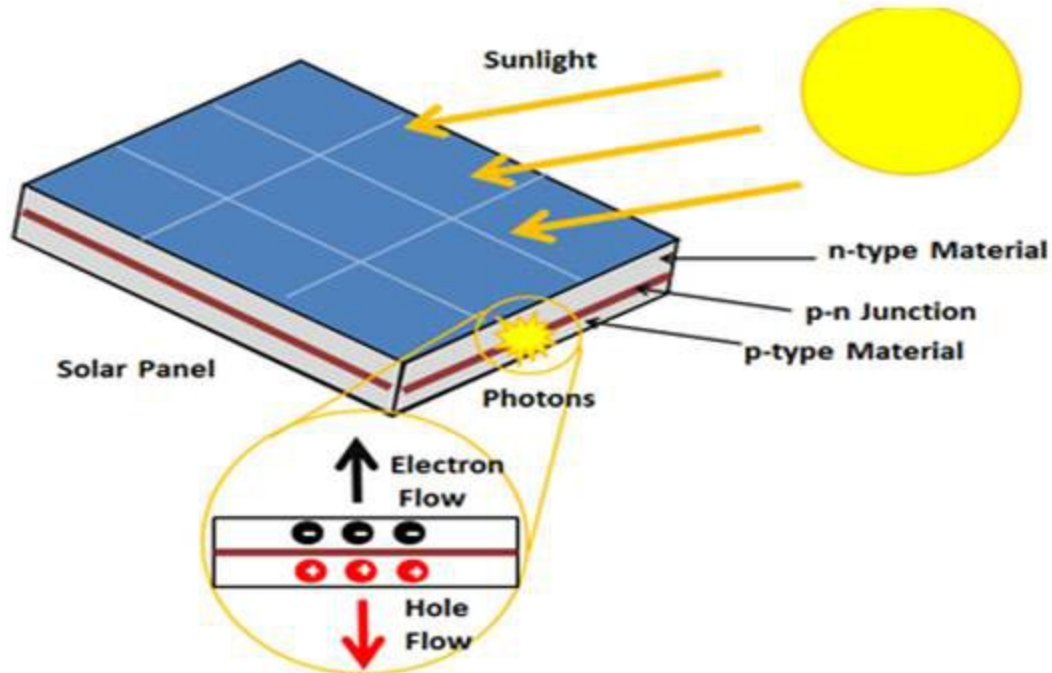
Construction



The solar cell works in several steps:

- Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as doped silicon.
- Electrons are excited from their current molecular/atomic orbital. Once excited an electron can either dissipate the energy as heat and return to its orbital or travel through the cell until it reaches an electrode. Current flows through the material to cancel the potential and this electricity is captured. The chemical bonds of the material are vital for this process to work, and usually silicon is used in two layers, one layer being doped with boron, the other phosphorus. These layers have different chemical electric charges and subsequently both drive and direct the current of electrons.
- An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.
- An inverter can convert the power to alternating current (AC).

The most commonly known solar cell is configured as a large-area p-n junction made from silicon. Other possible solar cell types are organic solar cells, dye sensitized solar cells, perovskite solar cells, quantum dot solar cells etc. The illuminated side of a solar cell generally has a transparent conducting film for allowing light to enter into active material and to collect the generated charge carriers. Typically, films with high transmittance and high electrical conductance such as indium tin oxide, conducting polymers or conducting nanowire networks are used for the purpose.



How do solar cells work?

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

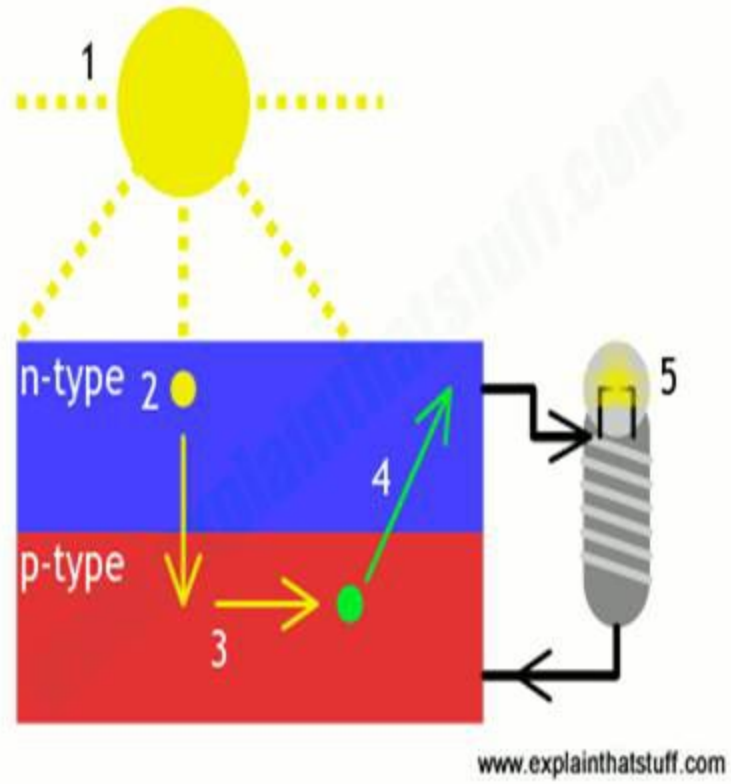
When sunlight shines on the cell, photons (light particles) bombard the upper surface.

The photons (yellow blobs) carry their energy down through the cell.

The photons give up their energy to electrons (green blobs) in the lower, p-type layer.

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.



Types of Solar cell

Based on the types of crystal used, soar cells can be classified as,

1. Monocrystalline silicon cells
2. Polycrystalline silicon cells
3. Amorphous silicon cells

1. The Monocrystalline silicon cell is produced from *pure silicon (single crystal).* Since the Monocrystalline silicon is pure and defect free, the efficiency of cell will be higher.

2. In polycrystalline solar cell, *liquid silicon* is used as raw material and polycrystalline silicon was obtained followed by *solidification process*. The materials contain various crystalline sizes. Hence, the efficiency of this type of cell is less than Monocrystalline cell.

Amorphous Silicon

Amorphous silicon is obtained by *depositing silicon film on the substrate like glass plate.*

- The layer thickness amounts to less than 1μm – the thickness of a human hair for comparison is 50-100 μm.

- The efficiency of amorphous cells is much lower than that of the other two cell types.

  - As a result, they are used mainly in low power equipment, such as watches and pocket calculators, or as facade elements.

Comparison of Types of solar cell

Material	Efficiency (%)
Monocrystalline silicon	14-17
Polycrystalline silicon	13-15
Amorphous silicon	5-7

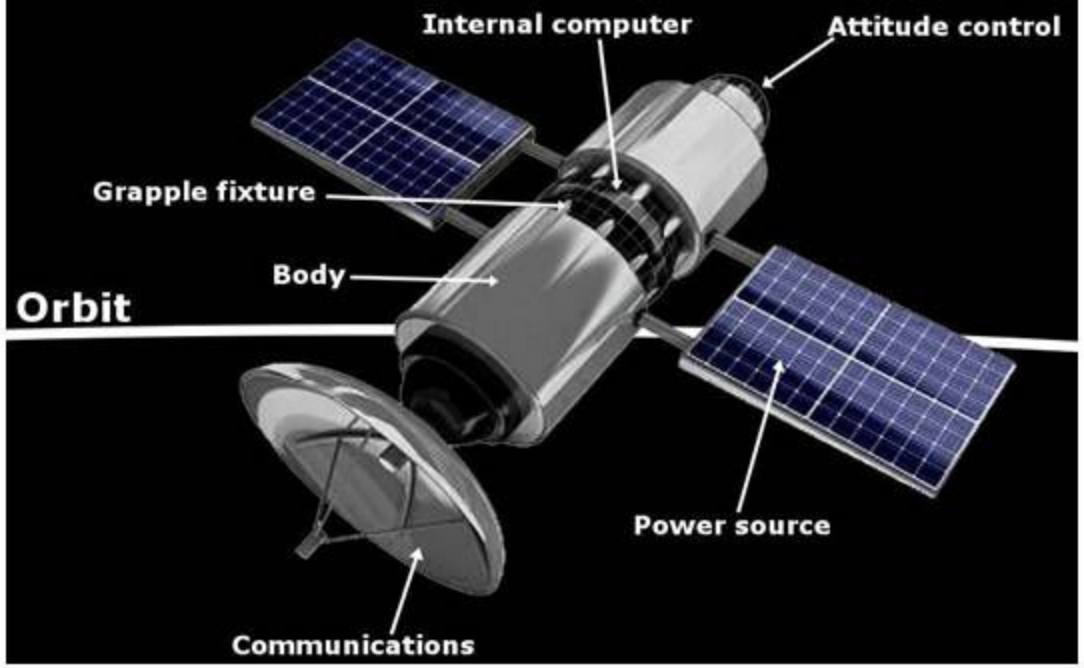
USES OF SOLAR CELLS:

Space

Solar cells are very useful in powering space vehicles such as satellites and telescopes (e.g. Hubble). They provide a very economical and reliable way of powering objects which would otherwise need expensive and cumbersome fuel sources.

Solar powered vehicles

Solar powered cars are cars which are powered by an array of photovoltaic cells. The electricity created by the solar cells either directly powers the vehicle through a motor, or goes into a storage battery. Even if a vehicle is completely covered in solar cells, it will only receive a smaller amount of solar energy and will be able to convert only a small amount of that to useful energy. Because of this, most solar powered vehicles are only used in research, educational tools or to compete in the various races for solar powered vehicles.


Internal computer
Attitude control
Grapple fixture
Body
Orbit
Power source
Communications


Solar-Powered Drive


Telecommunication
Offshore Oil Drilling
PV Refrigerator
Power Pack (Army Tent)
Solar Lentern
Domestic lighting System
Battery Charging Station
PV Integrated Building
PV Pump
Railway Signaling

Advantages

It is clean and non-polluting

It is a renewable energy

Solar cells do not produce noise and they are totally silent.

They require very little maintenance

They are long lasting sources of energy which can be used almost anywhere

They have long life time

There are no fuel costs or fuel supply problems

Disadvantage

Solar power can`t be obtained in night time

Solar cells (or) solar panels are very expensive

Energy has not be stored in batteries

Air pollution and whether can affect the production of electricity

They need large area of land to produce more efficient power supply