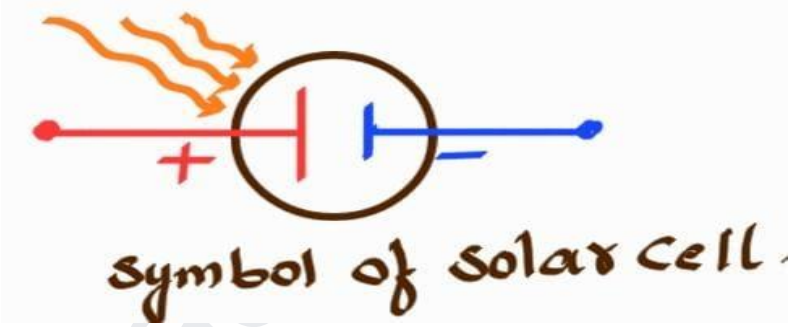
# SOLAR CELL

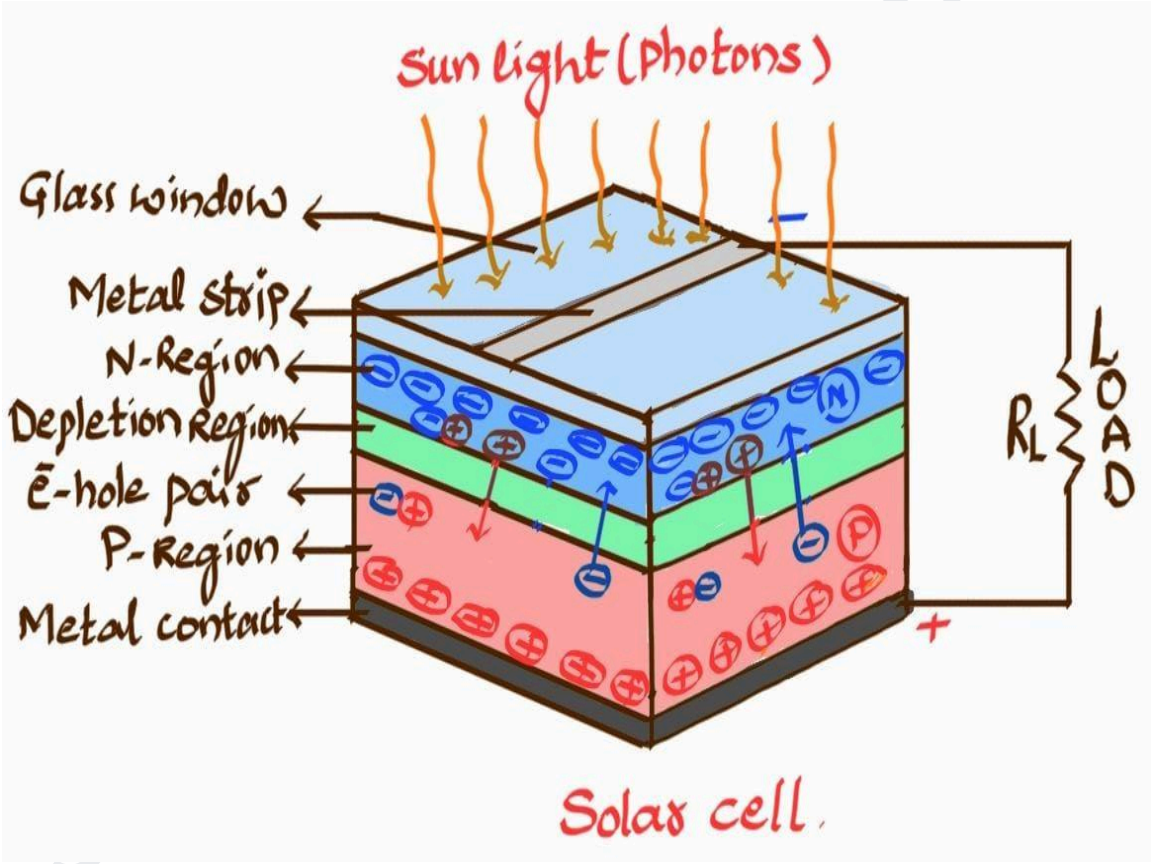
- **Introduction:**
- In 1883, American inventor Charles Fritts made the first solar cell from Selenium.
- These cells supply current without any external source of emf (Battery).
- Solar cells are also called photovoltaic cells or solar energy converters.
- **Definition:**
- A P-N junction diode which operates under **zero bias** and converts light energy directly into electrical energy through photovoltaic effect is called Solar cell.
- Generally, individual Solar cells can be combined to form Solar panels.

- The common single junction silicon Solar cell can produce voltage 0.5V to 0.6V.
- **Symbol of Solar Cell:**



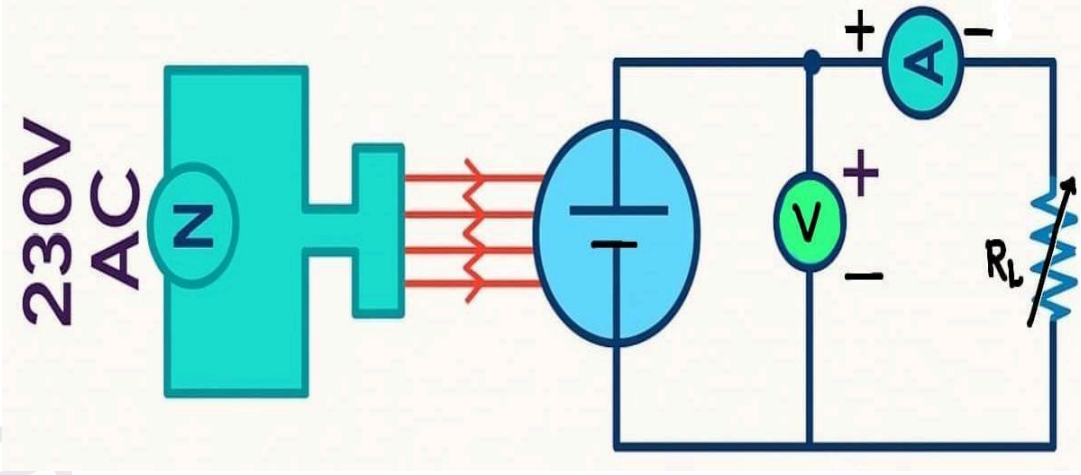

- **Working principle of solar cell:**
- The solar cells work based on the principles of photovoltaic effect.The Photovoltaic Effect is the photogeneration of charge carriers in light absorbing materials as a result of absorption of light radiation.
- **Construction of Solar Cell:**
- The main conditions while selecting a material for solar cell construction:
  i) Band gap (1 to 2 eV)
  ii)High optical absorption
  iii)Electrical conductivity.
  iv) Commonly used Semiconductors for Solar Cells are: Si, GaAs, CdTe, $Cu(InGa)Se_2$.

- A simple Solar cell consists of a P-N Junction diode having a large junction surface(depletion region) to allow large sunlight(photons) through a glass window.
- In this P-N Junction diode the P-region(Base) is very thick (100 x $10^{-6}$m) and the Holes generated from electron-hole pairs migrate toward this region.
- The N-region(Emitter) is very thin (0.3 x $10^{-6}$ m) so that the light(photon) incident on it reaches the depletion region where the electron-hole pairs are generated.
- Metal Strips(Front Contact) are conducting metal lines placed on top of the cell. They act as the **-ve** terminals by collecting and carrying the electrons generated in the N-region.
- Metal Contact (Back Contact) is the bottom layer, providing a conductive base for the entire cell. It serves as the **+ve** output terminal by collecting and transferring holes to the external circuit or load resistance ($R_L$).

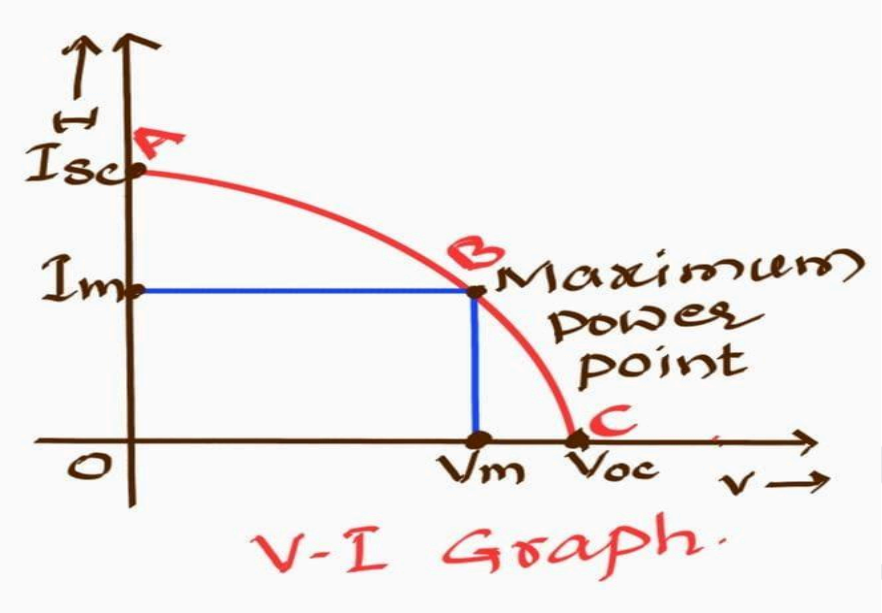



- **<u>Working of solar cell:</u>**
- The following steps are involved in the working of a Solar cell, when light strikes on it.
- **<u>1. Absorption of light:</u>**
- When light strikes the solar cell, photons are absorbed by the semiconductor materials, primarily Silicon.

- **2. Generation of charge carriers (e-h pair):** These absorbed photons excite electrons,causing them to break the covalent bond and create electron-hole pairs in both the P and N sides of the depletion region(junction).
- **3. Separation of Charge Carriers:**
- These electrons - holes reach the depletion region by diffusion. At the same time,the p-n junction(depletion region) acts as a barrier and creates an electric field. Due to this internal electric field, electrons move toward the metal strip through the N- region, and holes move toward the metal contact through the P- region.
- **4. Generation of dc current:**
- This movement of charge carriers generates dc electric current or voltage of 0.6 volt.
- **5. Collection of dc current:**
- This dc current is collected by the metal electrodes(ring & contact) and flows through the external load ($R_L$).
- The dc current is directly proportional to the illumination and also depends on the surface area being exposed to light.
- **V-I characteristics of solar cell:**
- The I-V characteristics of a solar cell can be determined by connecting load resistance across the voltmeter in series with the ammeter.




- By keeping the light intensity constant and varying the load resistance ($R_L$) in a sequential manner to observe corresponding voltmeter and Ammeter readings.
- A graph is plotted by taking voltage and current along the x and y axis with the given scale; obtaining an exponential curve decay in power.




- The curve passes through 3-significant points:
- **A. Short circuit current (Isc):**
- It occurs on a point of the curve, where the voltage is zero. At this point the power output of the solar cell is zero.
- **B. Open circuit voltage (Voc):**
- It occurs on a point of the curve, where the current is zero. At this point the power output of the solar cell is zero.
- The product of above two quantities, Isc & Voc gives the ideal power of the cell.
- Therefore Ideal power, $P_{ideal}$ = Voc xIsc ---------- (1)
- **C. Maximum power ($P_{max}$):**
- The cell delivers the maximum power, where the product $V_m I_m$ is maximum.
- The position of the maximum power is the area of the largest rectangle that can be formed in the V-I curve.
- Therefore $P_{max} = V_m I_m$ ----------(2)
- **Fill Factor ($F_f$):**
- The ratio of Maximum power to Ideal power of the cell is called Fill Factor
- Therefore, Fill factor, $\mathbf{F_f} = P_{max} / P_{ideal}$

  => $\mathbf{F_f} = (V_m I_m) / (Voc \times Isc)$
- **Where:** Voc is open circuit voltage

  Isc is short circuit current

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- **Energy conversion Efficiency (η):**
- It is the percentage of power converted and collected, when a solar cell is connected to an electrical circuit.
- It is the ratio of maximum useful power ($P_{max}$) to the product of input light irradiance & surface area of the solar Cell.
- Therefore, $\eta = P_{max}/(E \times Ac)$

  $$\eta = V_m I_m / (E \times Ac)$$
- **Where:** E is input light irradiance in $W/m^2$

  Ac is surface area of the cell in $m^2$

## Applications of Solar cell:

- It is used to charge batteries.
- It is used for power calculators & wrist watches.
- It is used in satellites and spacecraft to provide electrical energy.
- It is used in telecommunication systems.
- It is used for electrical power supply to remote villages, agriculture.
- It is used in ocean navigation aids.
- It is used in light meters.
- It has industrial applications such as Cathode protection, Alarm systems, Defense equipment, and etc.

## Advantages of Solar Cells:

- No pollution and not harmful to the environment.
- Easy to operate.
- Noise free.
- Long life.
- Low maintenance cost.

## Disadvantages of Solar Cell:

- High cost of installation.
- Still, it has low efficiency.
- Large area is needed to produce high power.
- Less energy is produced during cloudy days and at night.

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