7B Unit 4

Unit -IV: TYPES OF SOLAR CELLS AND MODULES (10 hrs) Types of solar cells, Crystalline silicon solar cells, I-V characteristics, poly-Si cells, Amorphous silicon cells, Thin film solar cells-CdTe/CdS and CuInGaSe2/CdS cell configurations, structures, advantages and limitations, Multi junction cells – Double and triple junction cells. Module fabrication steps, Modules in series and parallel, Bypass and blocking diodes

Long Answer questions

1. Write about I-V characteristics of Crystalline silicon solar cells. Write about poly-Si cells, Amorphous silicon cells, Thin film solar cells-CdTe/CdS and CuInGaSe2/CdS cell,

2. Write down the Steps involved in the fabrication of the solar module. Write about Modules in series and parallel, Bypass and blocking diode.

Short Answer Questions

3. Multi junction cells – Double and triple junction cells. Describe advantages and limitations.
4. Write down the I-V characteristics of a Solar cell.
5. Describe the procedure of Modules in series and parallel
6. What are the uses of Bypass and Blocking diodes?

Monocrystalline cells

Monocrystalline solar cells are made from single crystalline silicon. It consists of silicon in which the crystal lattice of the entire solid is continuous, unbroken to its edges, and free of any grain boundaries.

Advantages

- They have the highest level of efficiency at 15-20%
- They require less space compared to other types due to their high efficiency
- Durability is high
- They perform better in low levels of sunlight, making them ideal for cloudy areas

Disadvantages

- They are the most expensive solar cells on the market
- The performance levels tend to suffer from an increase in temperature.

- There is a lot of waste material when the silicon is cut during manufacture

Polycrystalline Solar Cells

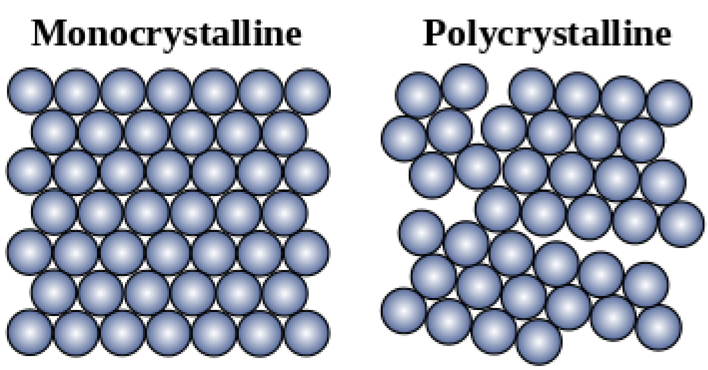
Polycrystalline silicon is a material consisting of multiple small silicon crystals. Several fragments of silicon are melted together to form the wafers of polycrystalline solar panels

Advantages

- The manufacturing process is cheaper and easier than the monocrystalline cells
- It avoids silicon waste
- High temperatures have less negative effects on efficiency compared with monocrystalline cells.

Disadvantages

- Efficiency is only around 13-16% due to low levels of silicon purity. So they are not the most efficient on the market
- They have lower output rates. More roof space is needed for installation



Amorphous silicon

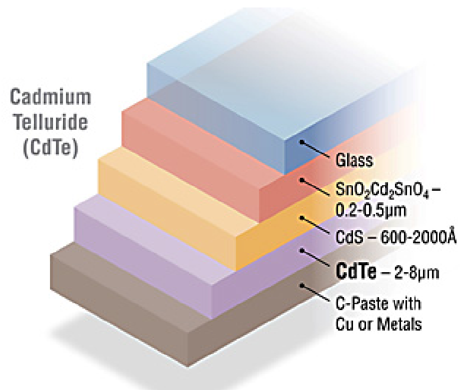
Amorphous silicon (a-Si) is the non-crystalline form of silicon used for solar cells.

Thin film solar cells

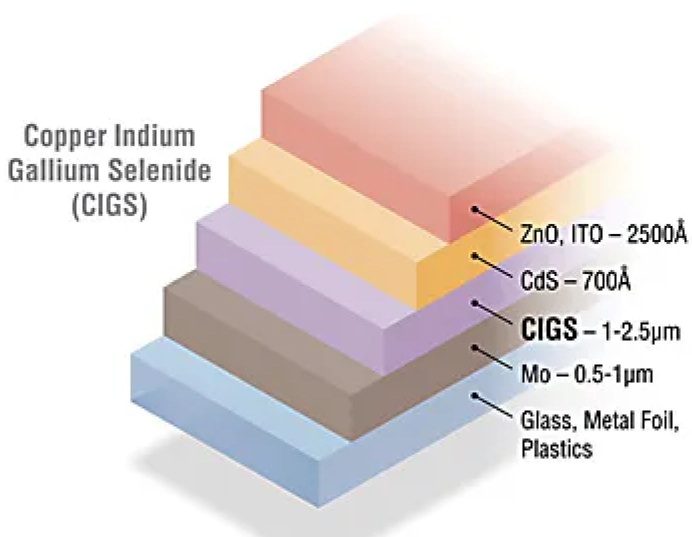
Thin film solar cells are manufactured by placing several thin layers of photovoltaic on top of each other to create the module. There are actually a few different types of thin film solar cells, The types are as follows:Cd Te, CuIGS

Cadmium telluride thin film solar cells

CdTe is a thin film solar cell, converts sunlight to electricity. A schematic of a typical CdTe solar cell is shown here. Transparent conducting oxide (TCO) layers such as SnO_2 or Cd_2SnO_4 are transparent to visible light and highly conductive to transport current efficiently. Intermediate layers such as CdS help in both the growth and electrical properties between the TCO and CdTe. The CdTe film acts as the primary photoconversion layer and absorbs most visible light within the first micron of material. Together, the CdTe, intermediate, and TCO layers form an electric field that converts light absorbed in the CdTe layer into current and voltage. Metal is placed on the back to form electrical contacts.

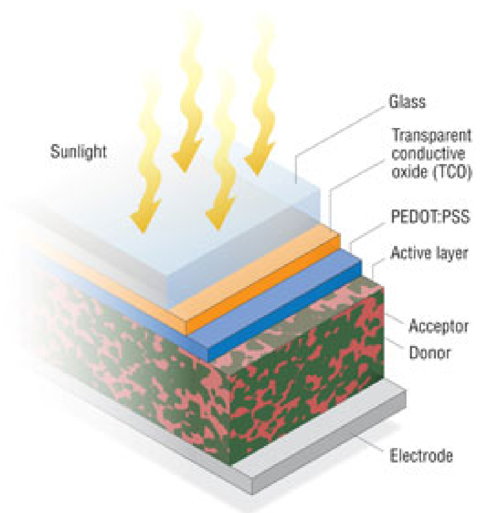


Copper indium gallium selenide: A copper indium gallium selenide solar cell (or CIGS cell, sometimes CI (G)S or CIS cell) is a thin-film solar cell used to convert sunlight into electric power. It is manufactured by depositing a thin layer of copper, indium, gallium and selenide on glass or plastic backing, along with electrodes on the front and back to collect current.



Organic PV cells

OPV cells use molecular or polymeric absorbers, which results in a localized exciton. The absorber is used in conjunction with an electron acceptor, such as a fullerene, which has molecular orbital energy states that facilitate electron transfer. Upon absorbing a photon, the resulting exciton migrates to the interface between the absorber material and the electron acceptor material. At the interface, the energetic mismatch of the molecular orbitals provides sufficient driving force to split the exciton and create free charge carriers (an electron and a hole).



Advantages

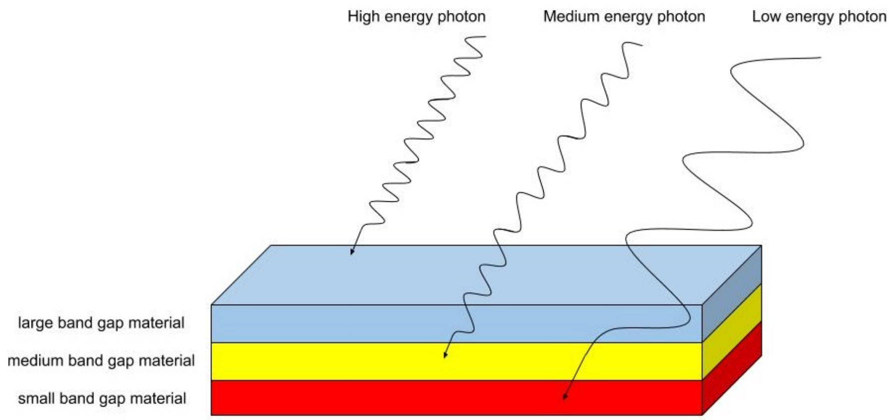
- They can be manufactured to be flexible, making them widely applicable to a range of situations and building types
- Mass production is easy to achieve, making them potentially cheaper to produce than crystalline solar cells
- Shading has a similar effect on their efficiency

Disadvantages
- They are not ideal for domestic use as thy take up a lot of space
- Low space efficiency means that they will cause further expenses in the form of enhancers, like cables of support structures
- They have a shorter lifespan and so shorter warranty periods

Multi junction solar cells

A multi-junction cell layers the materials in descending order, with the largest band gaps on top and smallest on the bottom, which creates a "photon sorting" effect . Photons with high energy are absorbed by the top layer and utilized more fully than if they were absorbed by the bottom layers, while lower energy photons pass through. Higher energy photons of the ones that are transmitted through the top layer are then absorbed by the middle layer, while the even lower energy photons continue to pass through. Through this process, the same amount of light that would have been absorbed by the lowest layer is still absorbed, yet higher energy photons are better utilized to generate energy.

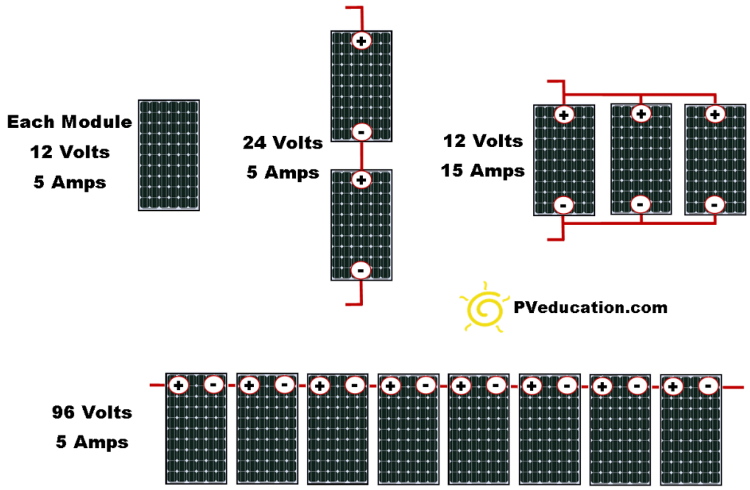
Ex: Gallium Arsenide, GaAs and GaInP



Solar modules series parallel

Series Wiring: Series wiring is when the voltage of a solar array is increased by wiring the positive of one solar module to the negative of another solar module. This is similar to installing batteries in a flashlight. As you slide the batteries into the flashlight tube the voltage increases.

Parallel Wiring: Parallel wiring increases the current (amps) output of a solar array while keeping the voltage the same. Parallel wiring is when the positives of multiple modules are connected together and all the negatives for the same modules are connected together.



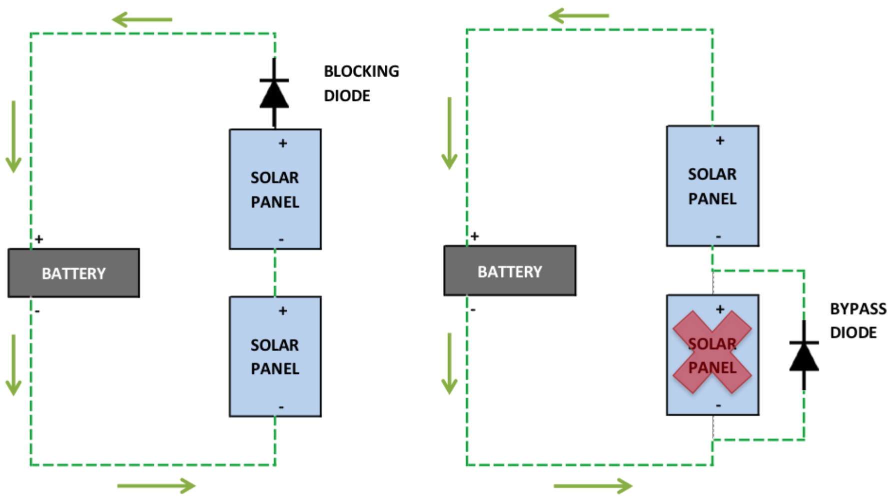
Bypass blocking diode

Blocking Diode:

A blocking diode allows the flow of current from a solar panel to the battery but prevents/blocks the flow of current from battery to solar panel thereby preventing the battery from discharging. In this setup, during the day the solar panel (at high potential) produces electricity and charges the battery (at low potential).During night, when the panel is not producing any electricity (low potential), the battery is at a higher potential.There is a possibility of the current flowing from the battery to the solar panel, thereby discharging the battery overnight.To prevent this from happening, a blocking diode is installed. It allows the current to flow from the panel to the battery but blocks the flow in the opposite direction.It is always installed in series with the solar panel.

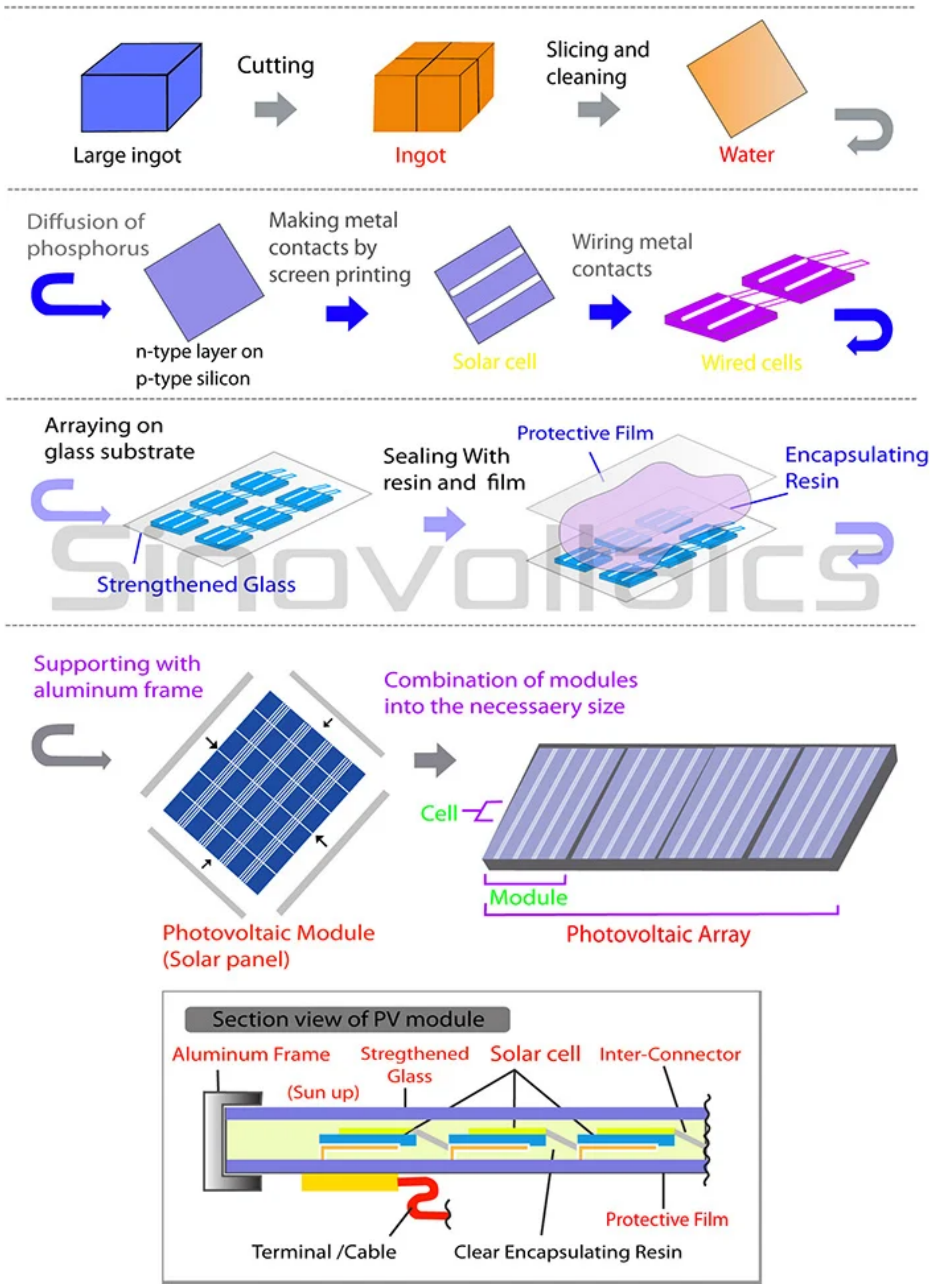
Bypass Diode:

A bypass diode is used in case one of the panels of a multi panel string is faulty, it bypasses the faulty panel by providing an alternative path to flow and thereby maintains the continuity of power production. The bypass diode in this case provides an alternate path for the current to flow and completes the circuit.It also prevents the current from other panels which are working (at high potential) to flow back to the faulty panel (at low potential).Thus even when a panel is faulty, the bypass diode still makes the whole solar system run and produce electricity at a lower rate.The bypass diodes should be installed in parallel to the panel.



Solar module fabrication steps

1) Sand : Solar panels are made of silicon
2) Ingots: The silicon is collected, usually in the form of solid rocks. Hundreds of these rocks are being melted together at very high temperatures in order to form ingots in the shape of a cylinder. To reach the desired shape, a steel, cylindrical furnace is used.
3) Wafers: The silicon ingot is sliced into thin disks, also called wafers.
4) Solar cells: Each of the wafers is being treated and metal conductors are added on each surface. The conductors give the wafer a grid-like matrix on the surface. This will ensure the conversion of solar energy into electricity. The coating will facilitate the absorption of sunlight, rather than reflecting it.In an oven-like chamber, phosphorous is being diffused in a thin layer over the surface of the wafers. This will charge the surface with a negative electrical orientation. The combination of boron and phosphorous will give the positive - negative junction, which is critical for the proper function of the PV cell.
5) From solar cell to panel: The solar cells are soldered together, using metal connectors to link the cells. Solar panels are made of solar cells integrated together in a matrix-like structure.



Cutting
Slicing and cleaning
Large ingot
Ingot
Water
Diffusion of phosphorus
Making metal contacts by screen printing
Wiring metal contacts
n-type layer on p-type silicon
Solar cell
Wired cells
Arraying on glass substrate
Sealing With resin and film
Protective Film
Encapsulating Resin
Strengthened Glass
Sinovoltaics
Supporting with aluminum frame
Combination of modules into the necessaery size
Cell
Module
Photovoltaic Array
Photovoltaic Module (Solar panel)
Section view of PV module
Aluminum Frame
Stregthened Glass
Solar cell
Inter-Connector
(Sun up)
Protective Film
Terminal /Cable
Clear Encapsulating Resin