UNIT-IV

TYPES OF SOLARCELLS AND MODULES

ESSAY QUESTIONS

Q. 1. What types of solar cells are available ?

A solar cell (also called photovoltaic cell or photoelectric cell) is a solid state 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.

The most popular types of solar panels are given below :

(i) Monocrystalline cells.

(ii) Polycrystalline cells.

(iii) 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. However, the thing that matters most is the purity of the silicon. 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.

(1) Monocrystalline cells :

Monocrystalline solar cells are made from single crystalline silicon. They are very distinctive in their appearance as they are often coloured, and the cells hold a cylindrical shape. In order to keep the costs low and performance at optimal levels, manufacturers cut out the four sides of the monocrystalline cells. This gives them their recognisable appearance.

Advantages :

(i) Here are some of the advantages of monocrystalline solar cells.

(ii) They have the highest level of efficiency at 15-20%.

(iii) They require less space compared to other types due to their high efficiency.

(iv) Manufacturers state that this form of solar cell lasts the longest, with most giving them a 25-year warranty.

(v) They perform better in low levels of sunlight, making them ideal for cloudy areas.

Disadvantages :

(i) Here are some of the disadvantages to monocrystalline solar cells.

(ii) They are the most expensive solar cells on the market, and so not in everyone's price range.

(iii) The performance levels tend to suffer from an increase in temperature. However, it is a small loss when compared to other forms of solar cell.

(iv) There is a lot of waste material when the silicon is cut during manufacturing turing.

(2) Polycrystalline Solar Cells :

The polycrystalline solar panels were first introduced to the public in 1981. Unlike the monocrystalline cells, polycrystalline ones do not require each of the four sides to be cut. Instead, the silicon is melted and poured into square moulds. These then form perfectly shaped square cells.

Advantages :

Here are some of the advantages of polycrystalline solar cells:

(i) The manufacturing process is cheaper and easier than the monocrystalline cells.

(ii) It avoids silicon waste.

(iii) High temperatures have fewer negative effects on efficiency compared with monocrystalline cells. This makes the polycrystalline cells more attractive to people in warmer areas as the price is lower.

Disadvantages

Here are some of the disadvantages to polycrystalline solar cells:

(i) Efficiency is only around 13-16% due to low levels of silicon purity. So they are not the most efficient on the market.

(ii) They have lower output rates which make them less space efficient. So more roof space is needed for installation.

(iii) Thin Film Solar Cells :

Thin film solar cells are manufactured by placing several thin layers of photovoltaic on top of each other to creates the

module. There are actually a few different types of thin film solar cell, and the way in which they differ from each other comes down to the material used for the PV layers. The types are as follows:

(i) Amorphous silicon.

(ii) Cadmium telluride.

(iii) Copper indium gallium selenide.

(iv) Organic PV cells.

Depending on the technology that has been used, the efficiency rates for thin film solar cells tends to vary from 7% to 13%. Since 2002, the knowledge levels and popularity for thin film solar cells has risen dramatically, which also means that research and development have been increased. Due to this, we can expect future models to hold efficiency rates of 10-16%.

Advantages :

Here are some of the advantages of thin film solar cells:

(i) They can be manufactured to be flexible, making them widely applicable to a range of situations and building types.

(ii) Mass production is easy to achieve, making them potentially cheaper to produce than crystalline solar cells.

(iv) Shading has a similar effect on their efficiency.

Disadvantages :

Here are some of the disadvantages of thin film solar cells:

(i) They are not ideal for domestic use as thy take up a lot of space.

(ii) Low space efficiency means that they will cause further expenses in the form of enhancers, like cables of support structures.

(iii) They have a shorter lifespan and so shorter warranty periods.

Q. 3. How solar panels produced?

The Production of Crystalline Solar Modules :

A solar PV module consists of solar cells, glass, EVA, back sheet and frame.

There are three types of solar panels available :

(i) Monocrystalline solar panels.

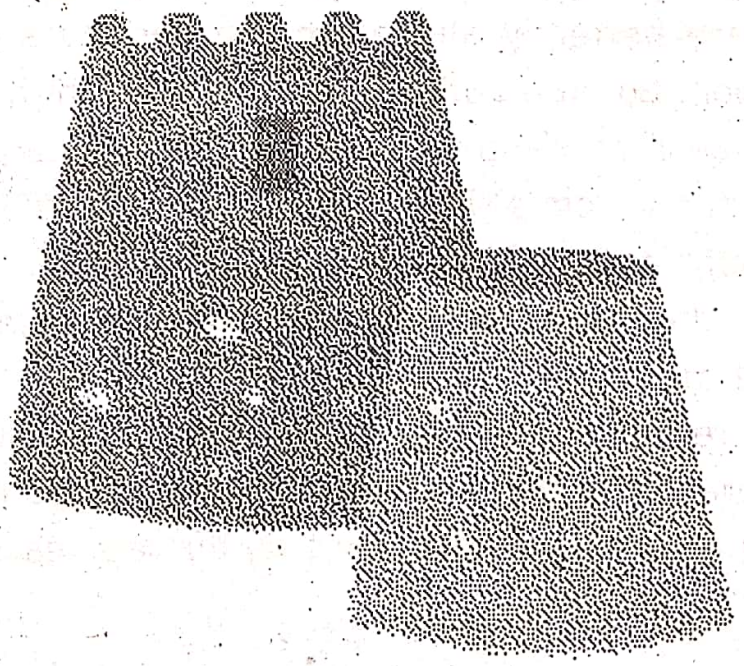
(ii) Polycrystalline solar panels.

(iii) Thin film solar panels.

Thus, at cell structure level, there are different types of material for manufacturing, such as mono silicon, polysilicon or amorphous silicon (AnSi). The first 2 kinds of cells have a somewhat similar manufacturing process. Read below about the steps of producing a crystalline solar panel.

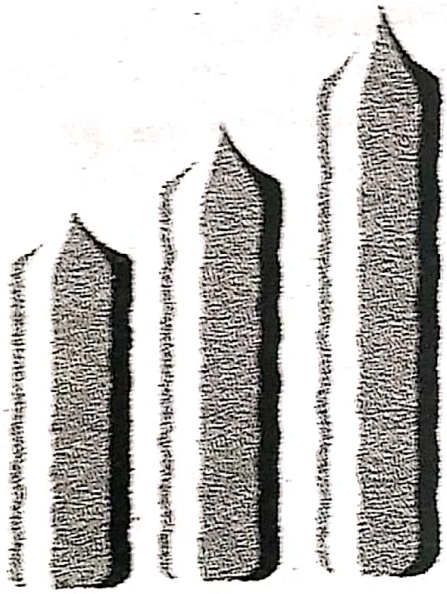
Step 1: Sand :

It all starts with the raw material, which in our case is sand. Most solar panels are made of silicon, which is the main component in natural beach sand.Silicon is abundantly available, making it the second most available element on Earth.However, converting sand into high grade silicon comes at a high cost and is an energy intensive process. High-purity silicon is produced from quartz sand in an arc furnace at very high temperatures.



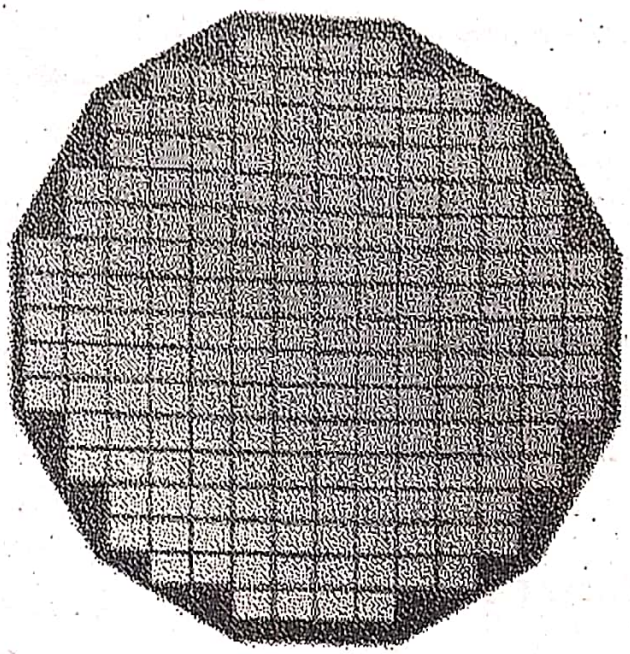
Step 2: Ingots :

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.



In the process of melting, attention is given so that all atoms are perfectly aligned in the desired structure and orientation. Boron is added to the process, which will give the silicone positive electrical polarity.Mono crystalline cells are manufactured from a single crystal of silicon. Mono Silicon has higher efficiency in converting solar energy into electricity, therefore the price of monocrystalline panels is higher.Polysilicon cells are made from melting several silicon crystals together. You can recognise them by the shattered glass look given by the different silicon crystals. After the ingot has cooled down, grinding and polishing are being performed, leaving the ingot with flat sides.

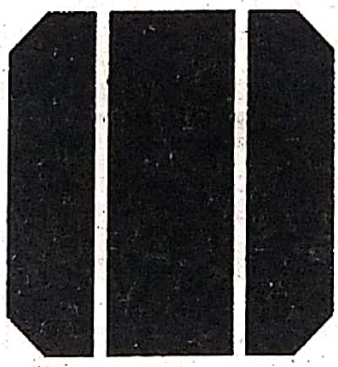
Step 3: Wafers :



Wafers represent the next step in the manufacturing process.The silicon ingot is sliced into thin disks, also called wafers. A wire saw is used for precision cutting. The thinness of the wafer is similar to that of a piece of paper.Because pure silicon is shiny, it can reflect the sunlight. To reduce the amount of sunlight lost, an anti-reflective coating is put on the silicon wafer.

Step 4: Solar cells :

The following processes will convert a wafer into a solar cell capable of converting solar power into electricity.



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.

Step 5: From Solar Cell to Solar 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.

The current standard offering in the market are:

(i) 48 cell panels - suitable for small residential roofs.

(ii) 60-cell panels - this is the standard size.

(iii) 72-cell panels -used for large-scale installations.

After the cells are put together, a thin layer (about 6-7 mm) of glass is added on the front side, facing the sun. The

back sheet is made from highly durable, polymer-based material. This will prevent water, soil, and other materials from entering the panel from the back. Subsequently, the junction box is added, in order to enable connections inside the module.It all comes together once the frame is assembled. The frame will also provide protection against impact and weather. The use of a frame will also allow the mounting of the panel in a variety of ways, for example with mounting clamps. EVA (Ethylene Vinyl Acetate) is the glue that binds everything together. It is very important that the quality of the encapsulant is high so it doesn't damage the cells under harsh weather conditions.

Step 6: Testing the Modules :

Once the module is ready, testing is carried out to ensure the cells perform as expected. STC (Standard Test Conditions) are used as a reference point. The panel is put in a flash tester at the manufacturing facility. The tester will deliver the equivalent of 1000W/m_2 irradiance, 25°C cell temperature and an air mass of 1.5g. Electrical parameters are written down and you can find these results on the technical specification sheet of every panel. The ratings will reveal the power output, efficiency, voltage, current, impact and temperature tolerance.Apart from STC, every manufacturer uses NOCT (Nominal Operating cell Temperature). The parameters used are closer to 'real life' scenario: open-circuit module operation temperature at 800W/m_2 irradiance, 20°C ambient temperature, 1m/s wind speed. Again, the ratings of NOCT can be found on the technical specification sheet.

SHORT ANSWER QUESTIONS

silicon and amorphous silicon.

Q. 3. What is amorphous silicon solar cells?

Amorphous silicon (a-Si) is the non-crystalline allotropic form of the semiconductor silicon. It has a *high absorption capacity* and can therefore be used in solar cells with very small layer thicknesses (usually about a factor of 100 smaller than in crystalline silicon), saving on material costs and compensating for performance deficiencies caused by its comparably low industry-maximum efficiency which is about 13%.Despite its lower performance as compared to *crystalline silicon (c-Si) solar cells,* amorphous silicon solar cells can be deposited at very low temperatures and on *various structures*, not only on glass but also plastic. Due to their simplified and lower cost production, a-Si solar cells have mostly been used for electronic devices with very little power requirements such as watches and pocket calculators.However, in recent years improving production techniques and higher achievements in performance efficiency have resulted in a wider range of applications of a-Si modules, including *building integrated photovoltaics (BIPV)* applications.

Chemical structure :

Silicon is a tetravalent metalloid that has a fourfold coordination and is tetrahedrally bonded to neighboring silicon atoms. In c-Si this structure is regular and continues over a large range, forming a stable and consistent crystal lattice. On the contrary, a-Si does not have a consistent large range structure and its atoms are rather randomly ordered with some of its atoms having dangling bonds, thus causing anomalous electrical output behaviour.

Q. 5. Explain series Combination of Solar panels in series?

Just like a battery, solar panels have two terminals: one positive and one negative.

When you connect the positive terminal of one panel to the negative terminal of another panel, you create a series connection. When you connect two or more solar panels like this, it becomes a PV source circuit.

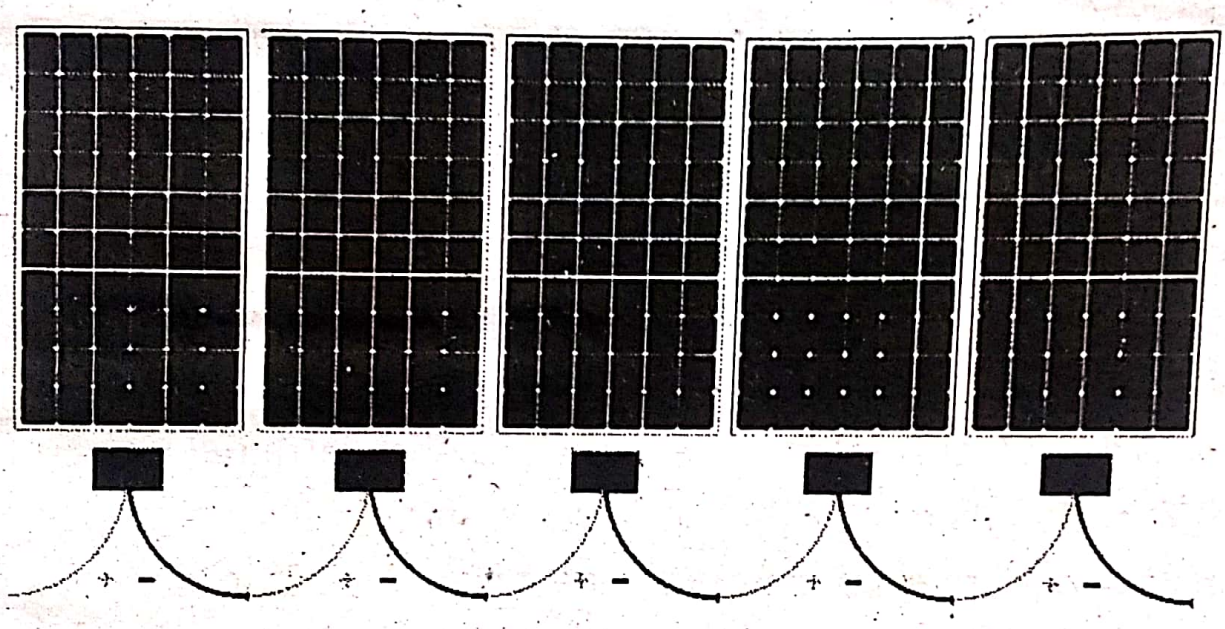


Fig : Solar panels are wired in series when you connect the positive terminal of one panel to the negative terminal of another.

When solar panels are wired in series, the voltage of the panels adds together, but the amperage remains the same. Putting panels in series makes it so the voltage of the array increases. This is important, because a solar power system needs to operate at a certain voltage in order for the inverter

to work properly. So, you connect your solar panels in series to meet the operating voltage window requirements of your inverter.

VERY SHORT ANSWER QUESTIONS

Q. 2. What is multiple junction?

Multi-junction (MJ) solar cells are solar cells with multiple p–n junctions made of different semiconductor materials. Each material's p-n junction will produce electric current in response to different wavelengths of light.

Q. 5. What is blocking diode for solar panel?

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.