1. What are semi conductors? Give two examples

Semiconductors are substances with qualities halfway between those of conductors (substances that permit the flow of current) and insulators (substances that prevent the flow of current). They are capable of being controlled and have a moderate level of electrical conductivity.

Some properties of semi conductors include:

1. At 0 Kelvin, semiconductors behave like insulators. They become conductors as the temperature rises.
2. Semiconductors can be doped to change their extraordinary electrical properties, making semiconductor devices excellent for energy conversion, switches, and amplifiers.
3. lower losses in power.
4. Semiconductors are lighter and smaller than other materials.
5. In comparison to insulators, they have a higher resistivity than conductors.
6. When the temperature rises, semiconductor materials' resistance lowers, and the opposite is also true.

Examples of semi conductors include:

1. The most popular semiconductor material is silicon (Si). It is widespread in nature and serves as the foundation for contemporary technological devices. The production of integrated circuits (ICs), including microprocessors, memory chips, and other kinds of sensors, depends heavily on silicon.
2. Germanium (Ge): Although less popular than silicon, germanium is another type of semiconductor material. Germanium is used in a few specialized gadgets, such as high-performance transistors and infrared detectors.
3. What is Fermi distribution?

Between the valence and conduction bands is the Fermi level, which is represented by the letter EF. At zero degrees, it is the highest occupied molecular orbital. In this condition, the charge carriers have their own quantum states and are typically not in contact with one another. These charge carriers will start to inhabit states above the Fermi level once the temperature exceeds absolute zero. The density of empty states increases in a p-type semiconductor. more electrons can be accommodated at the lower energy levels as a result. In contrast, an n-type semiconductor has a larger state density, which can hold more electrons at higher energies.

1. What are the p-type and n-type semiconductors?

By adding impurities to the pure semiconductor material (such as silicon or germanium), the two types of semiconductors known as P-type and N-type are produced. Dopants, also referred to as these impurities, are carefully selected to change the material's electrical characteristics.

P-type Semiconductor:

In a p-type semiconductor, positively charged carriers known as holes are introduced by the dopant atoms that are mixed in with the pure semiconductor material. Trivalent impurities, which have one fewer valence electron than the atoms they replace in the crystal lattice, are the most often utilized dopant for making p-type semiconductors. As a result, there are too many holes that can be used for conduction. P-type semiconductors have an overall positive charge and a predominance of positive charge carriers (holes).

N-type Semiconductor:

Dopant atoms introduce electrons, which are negatively charged carriers, into an n-type semiconductor. Pentavalent impurities, like arsenic (As), which have an additional valence electron compared to the atoms they replace, are the dopants utilized to make n-type semiconductors. Due to the extra electrons' freedom to flow, the material's conductivity has increased. Negative charge carriers (electrons) predominate in N-type semiconductors, which also have a general negative charge.

1. Explain a process to fabricate p type and n type semi conductors.

Doping, a method used to introduce controlled impurities into the pure semiconductor material, is how p-type and n-type semiconductors are made. Doping modifies the semiconductor's electrical characteristics by introducing regions with an excess of positive or negative charge carriers.

A high-purity semiconductor material, such as silicon or germanium, is used as the first step in the fabrication process. A single crystal ingot or wafer is the usual shape of the semiconductor.

Doping for P-type Semiconductor: A trivalent impurity is added to the pure semiconductor material to produce a p-type semiconductor. For p-type semiconductors, boron (B) or gallium (Ga) are frequent dopants. The semiconductor material and the dopant atoms are combined before being put through a high-temperature process like diffusion or ion implantation. As a result of this procedure, holes are made in the material.

Doping for N-type Semiconductors: A pentavalent impurity is employed as the dopant for an n-type semiconductor. For n-type semiconductors, phosphorus (P) or arsenic (As) are frequent dopants. The dopant atoms are combined with the semiconductor material and put through a high-temperature process, much like the p-type doping procedure. The dopant atoms are incorporated into the crystal lattice during this process, producing extra electrons and increasing the quantity of carriers for negative charge. n excess of positive charge carriers are produced. Dopant atoms are inserted into the crystal lattice.

1. What is p-n junction?

A P-N junction is the boundary or interface between the p-type and n-type semiconductor material types inside of a semiconductor.

The process of doping produces the P-N junction in a semiconductor. The semiconductor has an excess of holes on the p-side, also known as the positive side, and an excess of electrons on the n-side, also known as the negative side.

A p-n junction forms when several significant occurrences take place:

Region of Depletion: The surplus holes from the p-type region diffuse into the n-type region at the junction, while the excess electrons from the n-type region flow into the p-type region.

Forward Bias: A voltage source's positive terminal is connected to the p-type area, and its negative terminal is connected to the n-type region, when a forward bias voltage is provided to the p-n junction. By lowering the effective barrier potential, this forward bias permits current to pass through the junction. Current flows through the junction as a result of the recombination of holes from the p-type area and electrons from the n-type region.

Reverse Bias: When a reverse bias voltage is applied, the barrier potential rises and prevents current flow. The positive terminal of the reverse bias voltage should be linked to the n-type region, and the negative terminal should be attached to the p-type region. The depletion region is made larger by the electric field, further preventing charge carriers from moving.

1. What is the difference between photo electric effect and photo voltaic mechanisms?

Definition:

The emission of electrons from a substance's surface in response to incident light is known as the photoelectric effect.

The photovoltaic effect is a phenomenon whereby two different materials in close proximity generate an electrical potential when exposed to light.

Emission of Electrons:

Electrons are released during the photoelectric effect.

Electrons are not released during the photovoltaic effect.

Electric Current:

Photoelectric Effect: The photoelectric effect does not produce an electric current.

Photovoltaic Effect: This phenomenon produces an electric current.

Energy Needed:

Photoelectric Effect: Occurs when photon energy is greater than the energy needed to attach an electron.

When photons' energy is sufficient to get past the excitation-related barrier, the photovoltaic effect takes place.

1. How are batteries different from photo voltaic cells?

Source of energy: Batteries are a source of energy because they use chemical energy that has been stored. The electricity from an external power source or other methods, like as chemical reactions, can be used to charge them.

Photovoltaic Cells: Sunlight is the source of energy for photovoltaic cells. When exposed to sunlight, they produce electricity by converting the photons from the sun into electrical energy.

Storage of energy and power capacity: Batteries are measured in watt-hours (Wh) or ampere-hours (Ah). They have the capacity to store a sizable amount of electrical energy and provide it continuously.

Power output from photovoltaic cells is influenced by the brightness of the sun. They are capable of producing a sizable amount of electricity, but compared to batteries, they have a lesser power output. connected to the grid to ensure an ongoing supply of power.

Applications: Batteries: Portable gadgets, electric cars, backup power systems, and a wide range of devices needing a transportable power source all frequently use batteries.

Photovoltaic Cells: To produce electricity for household, commercial, and utility-scale uses, photovoltaic cells are widely utilized in solar panels and solar power systems. They are also used in remote off-grid sites and space applications.

Energy Conversion: Batteries are mechanisms for storing energy and are used to transform chemical energy into electrical energy. The chemical processes that take place between the battery's electrodes and electrolyte and are stored as energy.

Photovoltaic Cells: Using the photovoltaic effect, photovoltaic cells convert solar energy directly into electrical energy. An electric current is produced when sunlight (photons) interacts with the semiconductor material in the cell.

1. What are technologies used to improve efficiency of photo voltaic cells.

- Integrate effective system design techniques, such as devices that track the sun's position, solar panel orientation and tilt optimization, and shading effects reduction, into the system design and optimization process. With the help of these procedures, photovoltaic cells are guaranteed to get the most sunshine possible each day.

- Use concentrated photovoltaics to focus sunlight onto more compact, highly efficient solar cells by using optical components like mirrors or lenses. By dramatically increasing the amount of sunlight shining on the cells, CPV systems can increase the electrical output of those cells.

- Investigate and create materials with enhanced light-absorbing capabilities and increased conversion efficiency. This entails investigating brand-new semiconductor materials or improving already-existing ones, like silicon, to boost their effectiveness in catching photons and producing electricity.

- Implement methods, such as texturing the cell surface or integrating nanostructures, to improve light trapping within the solar cell. These techniques aid in lengthening the path of light inside the cell, improving absorption and decreasing reflection losses.

1. What is multi junction cell? Explain how efficiency of cell improved using this technique.

A particular kind of solar cell made up of several semiconductor layers stacked on top of one another. Each layer is made to efficiently absorb a certain range of solar radiation. Multijunction cells are more efficient than single-junction cells because they combine different semiconductor materials with distinct bandgaps.

Here is how the multijunction approach can increase a cell's effectiveness:

Reduced Thermalization Losses: In a multijunction cell, high-energy photons can be absorbed by following layers with higher bandgaps if they are not absorbed by the first layer. Thus, thermalization losses are decreased.

Enhanced Voltage Output: Based on its bandgap energy, each semiconductor layer in a multijunction cell produces a particular voltage level. The cell can generate a greater overall voltage output by stacking numerous layers with various bandgaps.

Multijunction cells can also be used in conjunction with spectral concentration techniques, such as employing mirrors or lenses to direct sunlight onto the cell.

1. What is shockley-quesser limit?

The maximum possible efficiency of a solar cell using a single p-n junction to gather electricity from the cell, where the only loss mechanism is radiative recombination in the solar cell, is known as the Shockley-Queisser limit.

The Shockley–Queisser limit is calculated by examining the amount of electrical energy that is extracted per incident photon.

There are three primary considerations in the calculation.

1. Blackbody radiation

The blackbody radiation from solar cell at room temperature (300 K) cannot be captured by

the cell, and represents about 7% of the available incoming energy. Energy lost in a cell is

generally turned into heat, so any inefficiency in the cell increases the cell temperature

when it is placed in sunlight. As the temperature of the cells increases, the blackbody

radiation also increases, until equilibrium is reached. In practice this equilibrium is normally

reached at temperatures as high as 360 K, and cells normally operate at lower efficiencies

than their room temperature rating.

2. Recombination

Recombination places an upper limit on the rate of electron-hole production. In silicon this

reduces the theoretical performance under normal operating conditions by another 10% over

and above the thermal losses. Voc is limited by recombination.

The limit for the maximum open-circuit current of a solar cell within the Shockley-Queisser

model. The red dotted line is Voc=Eg.

3. Spectrum losses

The limit for short-circuit current density (i.e., current density at zero voltage). This assumes

that each solar photon gets converted into an electron that flows through the circuit. At higher

bandgaps, there are fewer photons above the bandgap, and therefore the current density

decreases.

1. With a diagram explain the process of solar-electricity generation in a p-n junction cell.



The p-n junction receives light in the form of photons, which have enough energy to generate a number of electron-hole pairs there. Incident light disturbs the meeting's thermal equilibrium condition. The depletion region's free electrons can move quickly to the junction's n-type side. The holes from the depletion zone also reach the p-type side of the junction. The freshly formed holes that come to the p-type side after the newly created free electrons reach the n-type side cannot cross the junction further due to the intersection's barrier potential.

Electrons concentration becomes higher on the n-type side of the junction, and hole concentration becomes more elevated on the p-type side, so the p-n hub behaves like a small battery cell. Thus voltage is set up, which is photovoltage. When we connect a small load across the junction, current flows through it.

1. Explain the power and voltage characteristics of a typical solar cell.

Isc, or short-circuit current, is the flow of current through a solar cell when its terminals are connected (there is no external resistance). Isc stands for the maximum current that a solar cell is capable of producing. Isc is primarily influenced by incident light intensity, efficiency of light absorption, and production of charge carriers in the cell.

 I-V curve squareness is gauged by the fill factor, which also serves as a general indicator of solar cell quality. It is defined as the ratio of the solar cell's maximum power to the sum of Voc and Isc. A solar cell that performs well and efficiently has a greater fill factor.

 Efficiency: The quantity of incident light energy that can be turned into electrical energy is represented by a solar cell's efficiency. The ratio of the maximal output to the incidence power of the sunlight striking the cell is commonly used to calculate it. The technology and materials utilized can have an impact on the efficiency of solar cells.

 Maximum Power Point (MPP): The I-V curve's operating point at which the solar cell produces the most power is known as the maximum power point (MPP). When the voltage and current's product (P = V \* I) is at its highest, it happens at a given voltage and current.