DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

19EE711 SOLAR AND WIND ENERGY

UNIT III-SOLAR RESOURCE

Types of Solar Cells:

Solar cells are mostly Silicon based. It is the second most abundant element on earth, comprising approximately 20% of the earth's crust. Pure silicon almost immediately forms a layer of SiO2 on its surface when exposed to air, so it exists in nature mostly in SiO_2−based minerals such as quartzite or in silicates such as mica, feldspars, and zeolites. The raw material for solar cells and other semiconductors is naturally purified, high−quality silica or quartz (SiO_2) from

mines. Such high quality Silica is converted into pure silicon in several energy− intensive chemical processing steps. We will study briefly about two most common types of Solar cells.

1.1 Single crystalline (Mono Crystalline) silicon cells:

They are manufactured by drawing small seed crystals slowly in molten silicon with required 'p' type of dopants added thus forming small P type Silicon Semiconductors. Usually the dopant is boron and the ingot is therefore a *p*−type semiconductor. This results in a solid single−crystal p type silicon ingot as shown in the figure (a) below.

The manufacturing process is slow and energy intensive, resulting in high raw material cost. The ingot is sliced using a diamond saw into 200 to 400 μm (0.005 to 0.010 inch) thick wafers. During the above wafer fabrication, to form the p−n junction, a thin 0.1− to 0.5−μm *n*−type layer is created by diffusing enough donor (phosphorous) atoms into the top of the wafer to overwhelm the already existing acceptors.

The wafers are further cut into rectangular cells to maximize the number of cells that can be effectively mounted together on a rectangular panel. Unfortunately, almost half of the expensive silicon ingot is wasted in slicing ingot and forming square cells.

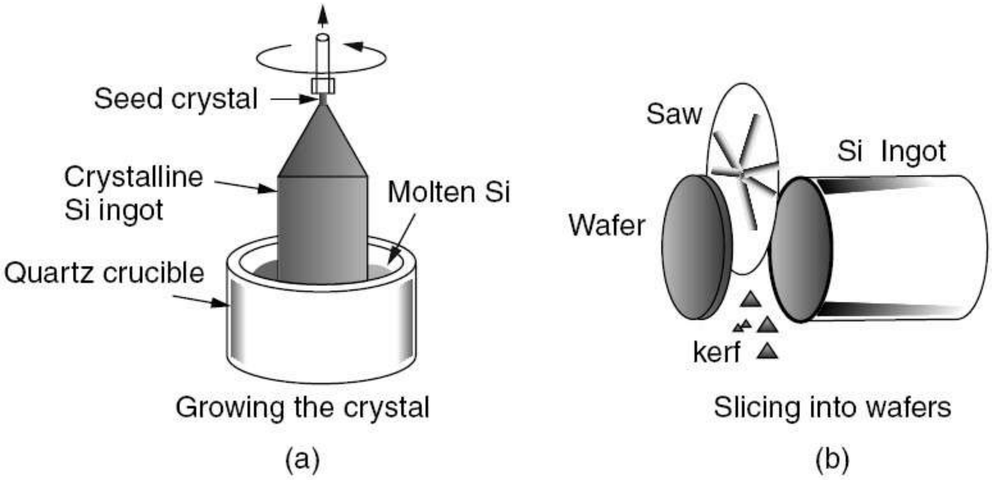

Figure-17: The Czochralski method for growing single-crystal silicon.

Since silicon is naturally quite reflective to solar wavelengths, some sort of surface treatment is required to reduce those losses. An antireflection (AR) coating of some transparent material such as tin oxide (SnO_2) is applied. These coatings tend to readily transmit the green, yellow, and red light into the cell, but some of the shorter−wavelength blue light is reflected, which gives the cells their characteristic dark blue color.

Figure-18: Mono crystalline Silicon

Panel Merits and demerits of Mono crystalline Solar

Panels:

Merits:

- Efficiency is high in the range of 15−24% as they are fabricated from the highest grade silicon, making them cost effective in the long term

Demerits:

- High initial cost and Fragility.
- Mono crystalline silicon is produced using the Czochralski process, which involves significant silicon wastage.

1.2 Multi (Poly) crystalline silicon cells:

One way to avoid the above costly Single−Crystal Czochralski (CZ) Silicon is based on carefully cooling and solidifying a crucible of molten silicon, yielding a large, solid rectangular ingot. They are cut into smaller, more manageable blocks, which are then sliced into silicon wafers using either the saw or wire−cutting techniques as shown in the figure below.

This is relatively a fast and low cost process to manufacture thick crystalline cells. Instead of drawing single crystals using seeds, the molten silicon is cast into ingots. In the process, it forms multiple crystals and hence the name Multi crystalline or Poly Crystalline. The conversion efficiency is lower, but the cost is much lower, giving a net reduction in cost per watt of power.

Defective atomic bonds in the crystal formation increase recombination and diminish current flow, resulting in lesser cell efficiencies than monocrystalline cells. Figure below illustrates the casting, cutting, slicing, and grain boundary structure of these multicrystalline silicon (mc−Si) cells.

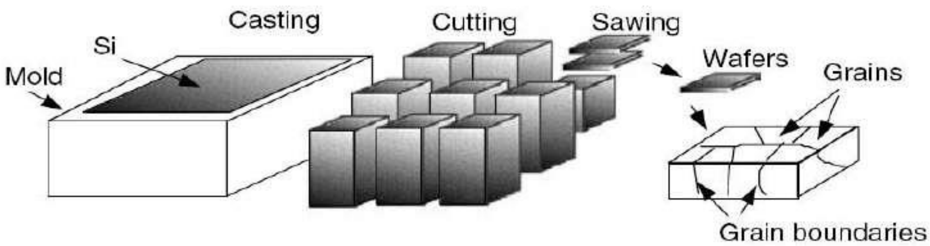

Figure-19: Casting, cutting and sawing of silicon results in wafers with individual grains of crystalline silicon separated by grain boundaries.

The appearance of polycrystalline cells is not as uniform as the monocrystalline solar cells. They have a surface with a random pattern of crystal borders rather than the solid blue color of single−crystal cells. Due to increased recombination rate and reduced current flow, their efficiency is typically in the range of 12%− 14%, a value slightly lesser than the monocrystalline cells, but much higher than other solar technologies such as thin film.

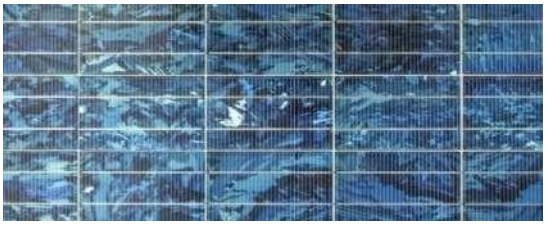

Figure-20: Polycrystalline Silicon Panel