UNIT -IV CRYSTAL PHYSICS

TOPIC – VIII CRYSTAL GROWTH TECHNIQUE BT AND CZ METHOD

1.17 CRYSTAL GROWTH TECHNIQUES

Growth of crystal ranges from a small inexpensive technique to a complex sophisticated expensive process and crystallization time ranges from minutes, hours, days and to months. Single crystals may be produced by the transport of crystal constituents in the solid, liquid or vapour phase. On the basis of this, crystal growth may be classified into three categories as follows,

1. Growth from solution
2. Growth from melt
3. Growth from vapour

There are a number of methods of growing crystals of a particular material. Choice of method of growth is made according to the physical properties of the material and to the size of crystal required.

1.19.3 BRIDGMAN TECHNIQUE (BT)

There are basically two different types of Bridgman technique (i) Horizontal Bridgman technique and (ii) Vertical Bridgman technique.

Principle:

In both the techniques a boat with the molten charge is moved accross a temperature gradient so as to allow the molten charge contained in the boat to solidify from an oriented seed.

Vertical Bridgman Growth Technique - Experimental Setup:

It consist of a vertical cylindrical in which the crystal to be grown is kept as shown in fig. The container is tappered conivally with a point bottom and is surrounded by two furnaces as shown in figure 1.35

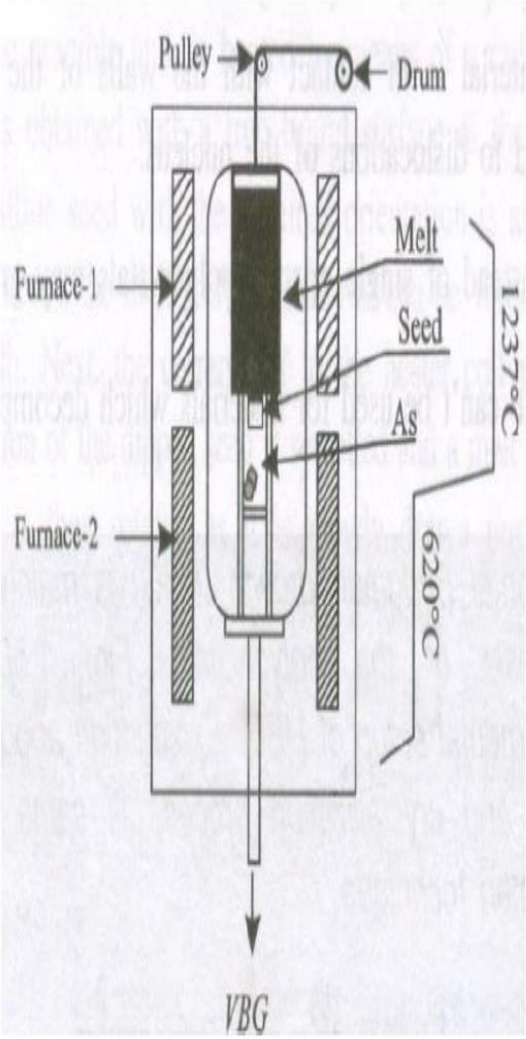

Fig 1.35

Furnace-1 maintains hot zone and Furnace-2 maintains cold zone. Using a pulley, the container can be moved up and down during crystallization process so as to heat/cool the melt.

Crytallization:

The material to be crystallized is taken in a boat and is kept inside the container. The furnace-1 is switched ON and the material is heated to a very high temperature. Now when the material attains molten state, it is slowly moved across a temperature gradient, i.e., it is lowered from the hot zone to the cold zone and vice versa. The movement should be in the range of 1 to 30 mm/hour. At this stage the crystallization begins in the tip and start growing from the first formed nucleus (seed) by solidification. Similar such process will make the crystal to grow further to a larger size.

Advantages:

i) Relatively cheaper when compared to other pulling techniques.
ii) Simpler technology
iii) Melt composition can be controlled during the growth
iv) The thermal gradients can be easily minimized with a consequent reduction of the dislocation and in addition it gives cylindrical crystals with no need of sophisticated diameter control devices.

Disadvantages:

i) Growth rate is very low.
ii) Since the material is in contact with the walls of the container for long period, it lead to dislocation of the nucleus.
iii) Sometimes instead of single crystal, polycrystals may grow.
iv) This technique can't be used for materials which decompose before melting.

1.19.4 CZOCHRALSKI METHOD (CRYSTAL PULLING)

Czochralski method or pulling from the melt is the principle method for the production of bulk single crystals of silicon. A schematic of the technique is shown in figure 1.36

The material to be grown as single crystal (i.e, a polycrystalline silicon) is taken in a suitable crucible and is heated by means of a radio frequency heater so that clear melt is obtained with a free liquid surface at the top.

A monocrystalline seed with the required orientation is attached to a pulling rod and is mounted above the melt surface. This rod can be vertically withdrawn and rotated during growth. Next, the current fed to the heater coil is carefully adjusted so that a certain portion of the dipped seed is remelted and a melt meniscus is formed.

The pull rod is then rotated as it is slowly drawn upwards. As the melt freezes on the crystal it does so in the same orientation as the seed and a single crystal is grown. The pulling

rate, the rotation rate and the power to the heater controls the desired shape of the crystal especially the diameter.

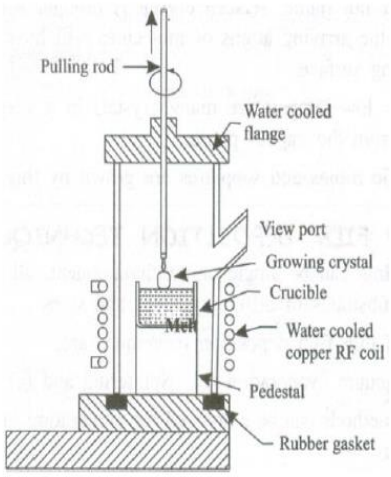

Fig 1.36

This technique is essential for the growth of dislocation free silicon and called "**necking procedure**".

As the atmosphere must be controlled during the growth process, the whole assembly is contained in a vessel filled with gas (inert gas argon for semiconductors, oxygen or air for oxides).