SCHOOL OF STUDIES IN PHYSICS
JIWAJI UNIVERSITY GWALIOR

Topic: Crystal Growth Technique
(Czochralski method)

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Crystal Growth

Crystal growth is the process where a pre-existing crystal becomes larger as more growth units (e.g. molecules, ions) add in their positions in the crystal lattice or a solution is developed into a crystal and further growth is processed.

Nucleation and Growth are the main factors of crystal growth. If nucleation rates are slow and growth is rapid, large crystals will result. On the other hand, if nucleation is rapid, relative to growth, small crystals or even polycrystalline samples will result.

The growth of crystals generally occurs by means of following:

---- diffusion of the molecule of the crystallizing

---- Substance through the surrounding environment

Condition of Crystal Growth

- Achievement of super saturation or super cooling
- Formation of crystal nucleus of microscopic size
- Successive growth of crystals to yield distinct faces

Basic growth methods available for crystal growth

The basic growth methods available for crystal growth are broadly

1. **Growth from melt.**
2. **Growth from vapour .**
3. **Growth from solution.**
4. **Growth from solid.**

Crystal Growth Techniques

- Bridgmann method
- Czochralski method
- Vernuil method
- Zone melting method
- Kyropoulos technique.
- Skull melting.

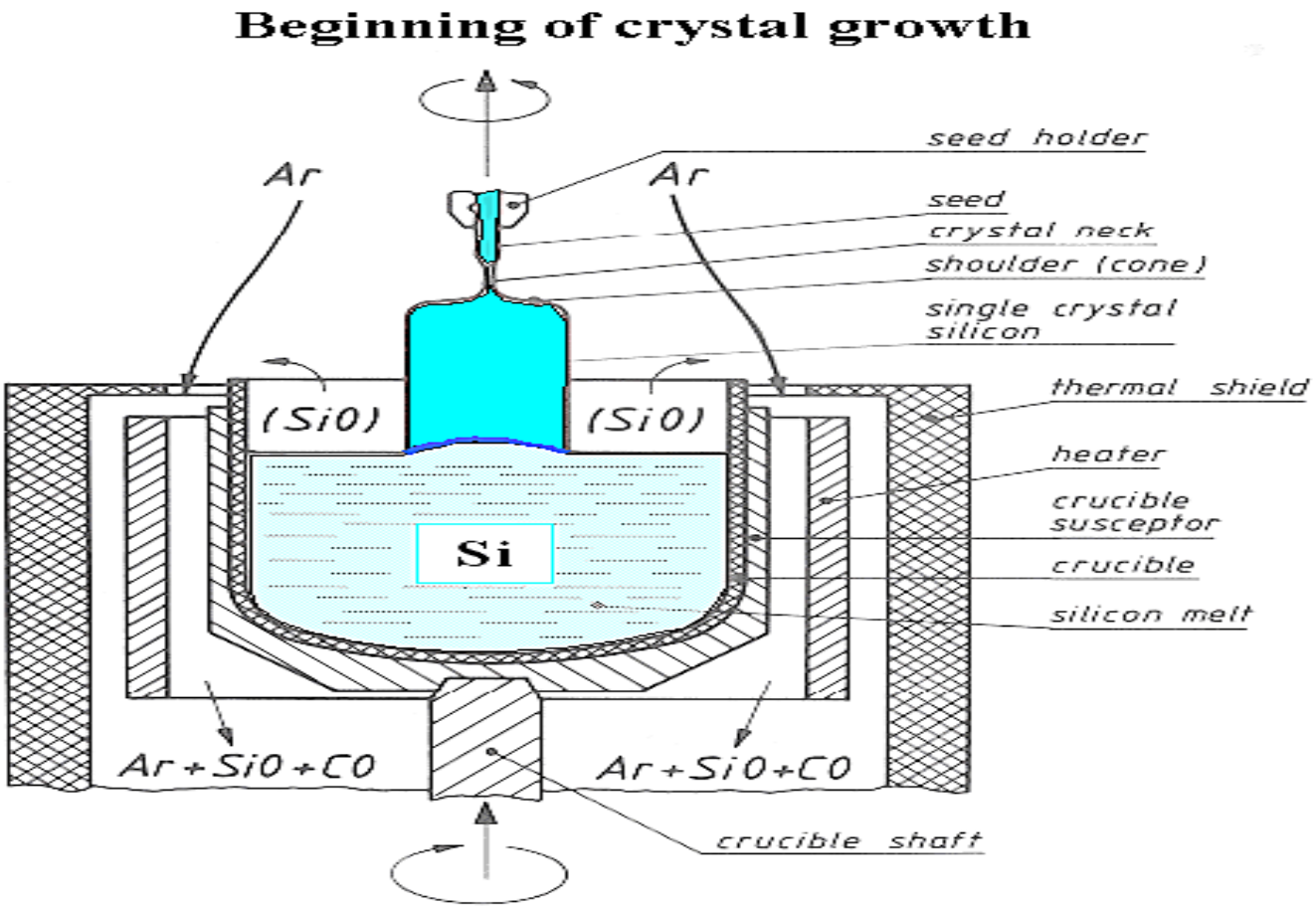
Czochralski method

- The Czochralski method or Czochralski process, is a method of crystal growth used to obtain single crystals of semiconductors (e.g. silicon, germanium and gallium arsenide), metals (e.g. palladium, platinum, silver, gold), salts and synthetic gemstones.
- It is also known as Pulling Technique
- This method is widely used for growing semi conducting material crystal. The shape of the crystal is free from the constraint due to the shape of the crucible.
- In this method the charge is melted and maintained at a temperature slightly above the melting point. The pulling rod is lowered to just touch the melt. Since the rod is at lower temperature of melt occurs at the point tip of the pulling rod. The crystal is pulled slowly.

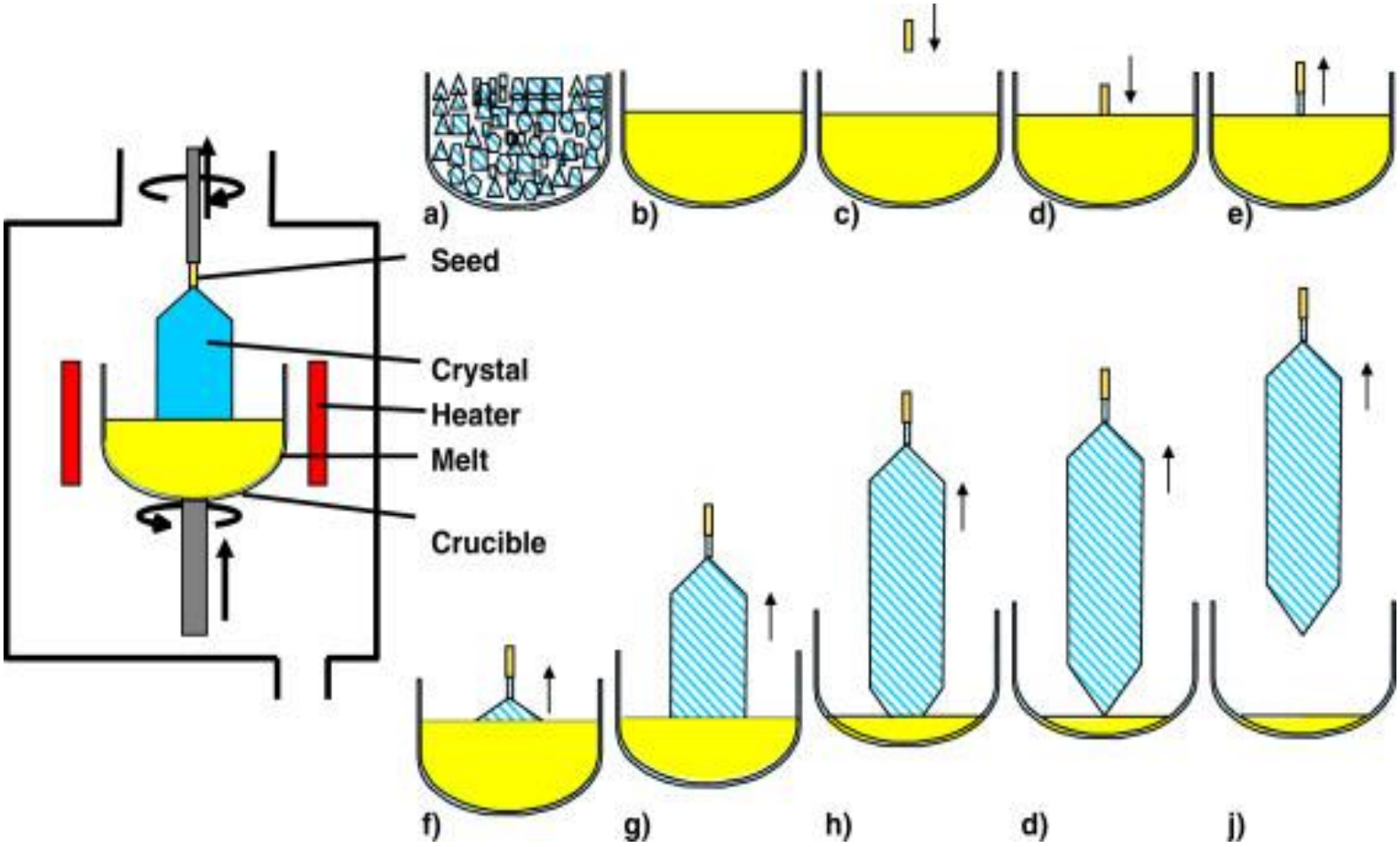
Czochralski method

- The rate of pulling upon various factors like thermal conductivity, latent heat of fusion of charge and rate of cooling of the pulling rod. The seed is rotated to keep the grow crystal uniform and cylindrical.
- A seed crystal is attached to a rod, which is rotated slowly.
- The seed crystal is dipped into a melt held at a temperature slightly above the melting point.
- A temperature gradient is set up by cooling the rod and slowly withdrawing it from the melt (the surrounding atmosphere is cooler than the melt)
- Decreasing the speed with which the crystal is pulled from the melt, increases the quality of the crystals (fewer defects) but decreases the growth rate.

Czochralski Crystal Growth Process



Czochralski Process



APPLICATION

- The most important application of the Czochralski Process may be the growth of large cylindrical ingots, or boules, of single crystal silicon used in the electronics industry to make semiconductor devices like integrated circuits. Other semiconductors, such as gallium arsenide can also be grown by this method.
- Monocrystalline silicon (mono-Si) grown by the *Czochralski method* is often referred to as *monocrystalline Czochralski silicon* (Cz-Si). It is the basic material in the production of integrated circuits used in computers, TVs, mobile phones and all types of electronic equipment and semiconductor devices. Monocrystalline silicon is also used in large quantities by the photovoltaic industry for the production of conventional mono-Si solar cells. The almost perfect crystal structure yields the highest light-to-electricity conversion efficiency for silicon.

Advantages

- This method is used to grow large single crystals. Thus it is used extensively in the semiconductor industry.
- There is no direct contact between the crucible walls and the crystal which helps to produce unstressed single crystal.

Disadvantages

- In general this method is not suitable for incongruently melting compounds and of course the need for a seed crystal of the same composition limits is used as tool for exploratory synthetic research.


Thank You