SNS COLLEGE OF ENGINEERING

Coimbatore-641 107

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DEPARTMENT OF PHYSICS

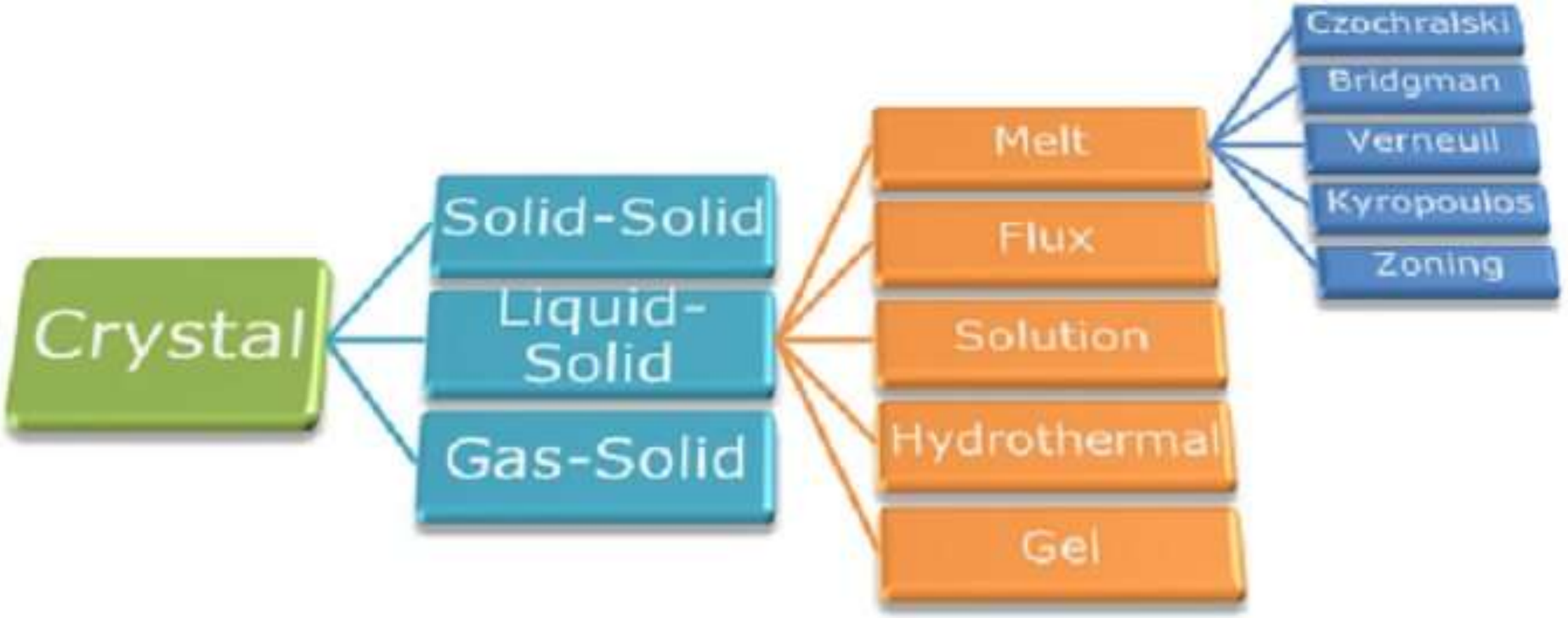
COURSE NAME :19PY101-ENGINEERING PHYSICS

I YEAR / I SEMESTER

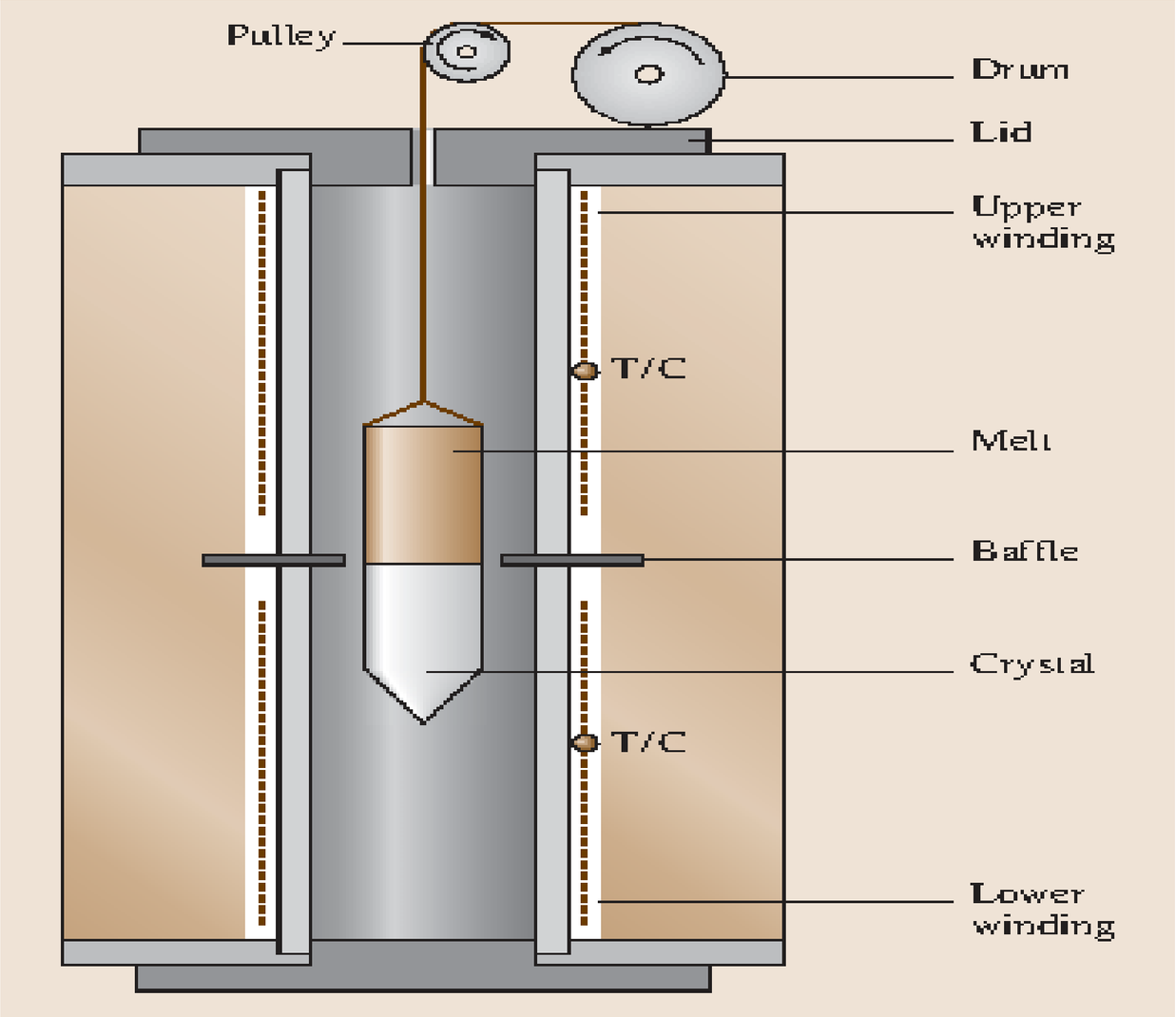
UNIT 4 – CRYSTAL PHYSICS

TOPIC 8 – GROWTH OF SINGLE CRYSTALS SOLUTION GROWTH TECHNIQUES

(BRIDGMAN METHOD)


Crystal
Solid-Solid
Liquid-Solid
Gas-Solid
Melt
Flux
Solution
Hydrothermal
Gel
Czochralski
Bridgman
Verneuil
Kyropoulos
Zoning

- The Bridgman technique (also known as Bridgman-Stockbarger method) is one of the oldest techniques used for growing crystals.
- Similar to Czochralski technique, the Bridgman technique employs also a crystal growth from melt.
- In Bridgman technique the crucible containing the molten material is translated along the axis of a temperature gradient in a furnace, whereas in Stockbarger technique, which is just a modification to the Bridgman technique, there is a high-temperature zone, an adiabatic loss zone and a low-temperature zone.


Pulley
Drum
Lid
Upper winding
T/C
Melt
Baffle
Crystal
T/C
Lower winding

- The principle of the Bridgman technique is the directional solidification by translating a melt from the hot zone to the cold zone of the furnace.
- At first the polycrystalline material in the crucible needs to be melted completely in the hot zone and be brought into contact with a seed at the bottom of the crucible.
- This seed is a piece of single crystal and ensures a single-crystal growth along a certain crystallographic orientation.
- Part of the seed will be re-melted after the contact with the melt. This provides a fresh interface for the crystal growth.

➢The crucible is then translated slowly into the cooler section of the furnace.

➢ The temperature at the bottom of the crucible falls below the solidification temperature and the crystal growth is initiated by the seed at the melt-seed interface.

➢ After the whole crucible is translated through the cold zone the entire melt converts to a solid single-crystalline ingot.

- The Bridgman technique can be implemented in either a vertical (vertical Bridgman technique) or a horizontal system configuration (horizontal Bridgman technique).
- The concept of these two configurations is similar. The vertical Bridgman technique enables the growth of crystals in circular shape, unlike the D-shaped ingots grown by horizontal Bridgman technique
- The crystals grown horizontally exhibit high crystalline quality (e.g. low dislocation density) since the crystal experiences lower stress due to the free surface on the top of the melt and is free to expand during the entire growth process.

- Instead of moving the crucible, the furnace can be translated from the seed end while the crucible is kept stationary.
- In this manner a directional solidification can be achieved, too.
- A further modification is the so called gradient freezing technique, with which neither the crucible nor the furnace needs to be translated. Instead, a translation of the temperature gradient is implemented by using a multiple-zone furnace wherein the power to each zone is programmed and controlled by individual controllers.

- This system can maintain the same temperature gradient at the liquid-solid (i.e. melt-crystal) interface, which changes in turn its location with time during the growth.
- Analogous to the Bridgman technique, the gradient freezing technique can also be realized in vertical and horizontal configurations.

➢ Advantages :

1. Relatively cheaper when compared to other pulling technique.
2. Simple technology
3. Melt composition can be controlled during the growth.
4. The thermal gradients can be easily minimized with a consequent reduction of the dislocation density and in addition it gives cylindrical crystal with no need of sophisticated diameter control devices.

Disadvantages:

1. Growth rate is very low.
2. Since the materials is in contact with the walls the container for long period it lead to dislocations the nucleus.
3. Sometimes instead of single crystal, Poly crystals may be grow.
4. This technique can’t be used for materials which decompose before melting.

References

- https://www.alineason.com/en/knowhow/crystal-growth/
- https://images.app.goo.gl/mZG4bKo5x1KrGWH38