Mechanism of Solidification of metals and alloys

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Why Crystallization ?

Because the knowledge of this process is very important to understanding it both as a natural phenomenon and manufacturing technology of most industrial products

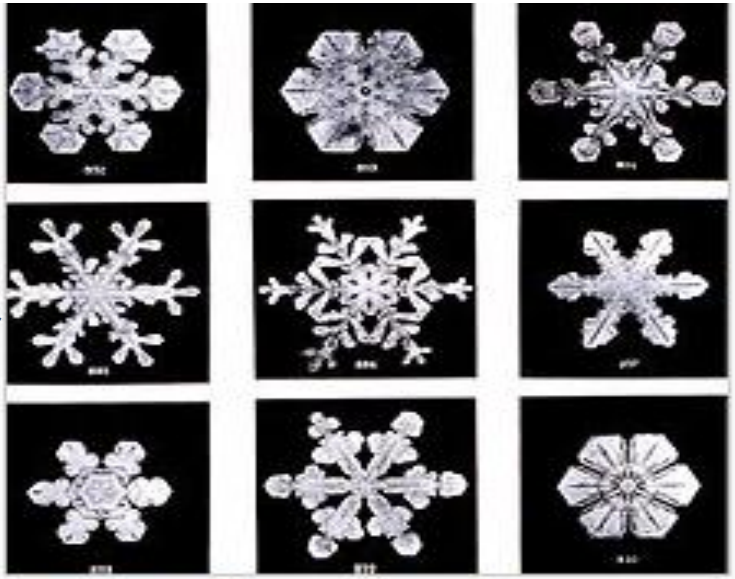
For examples,

- **Geological time scale - Natural (mineral) crystal formation;**
- **Stalactite/stalagmite, rings formation.**

There are many examples of natural process that involve crystallization.

Usual time scale process examples include:

Snow flakes formation;



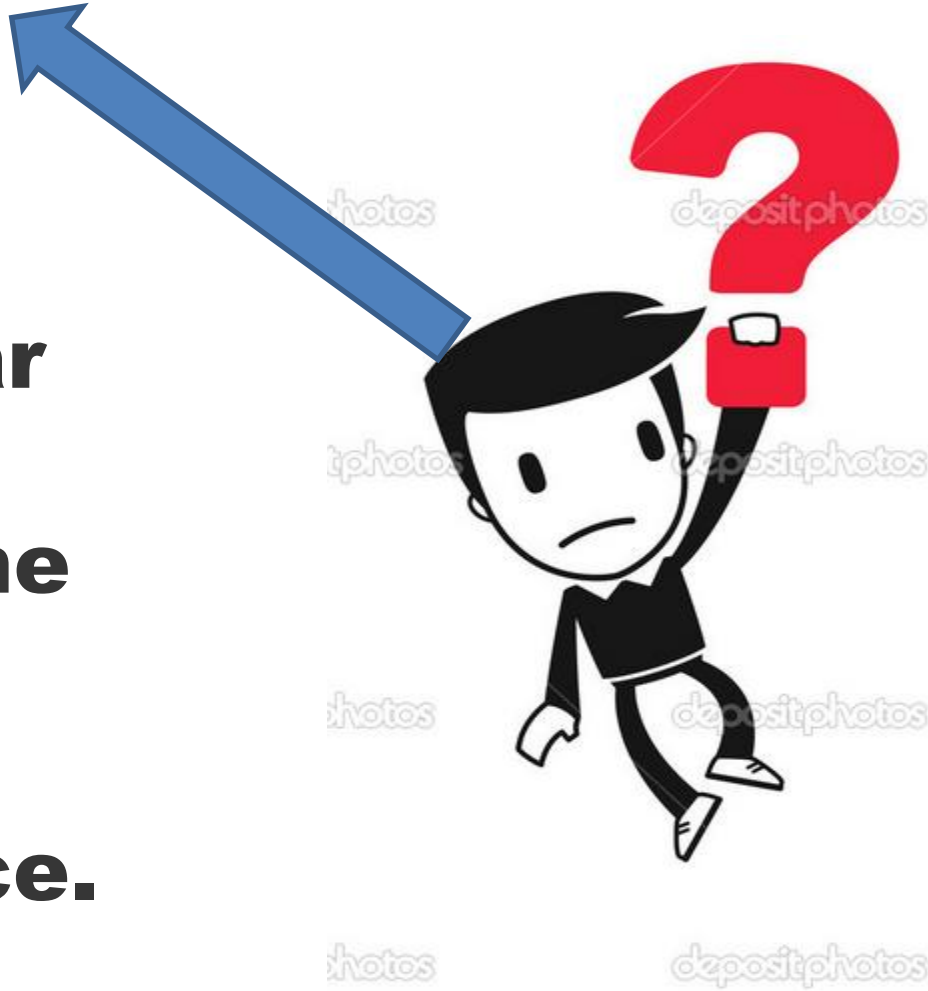
Snowflakes are a very well-known example, where subtle differences in *crystal growth* conditions result in different geometries.

Honey or sugar crystallization

Crystallized honey

Why Crystallization

Becouse –



Melting and Crystallization concern regular technological processes in the sphere of metallurgy and foundry practice.

The questions are the following:

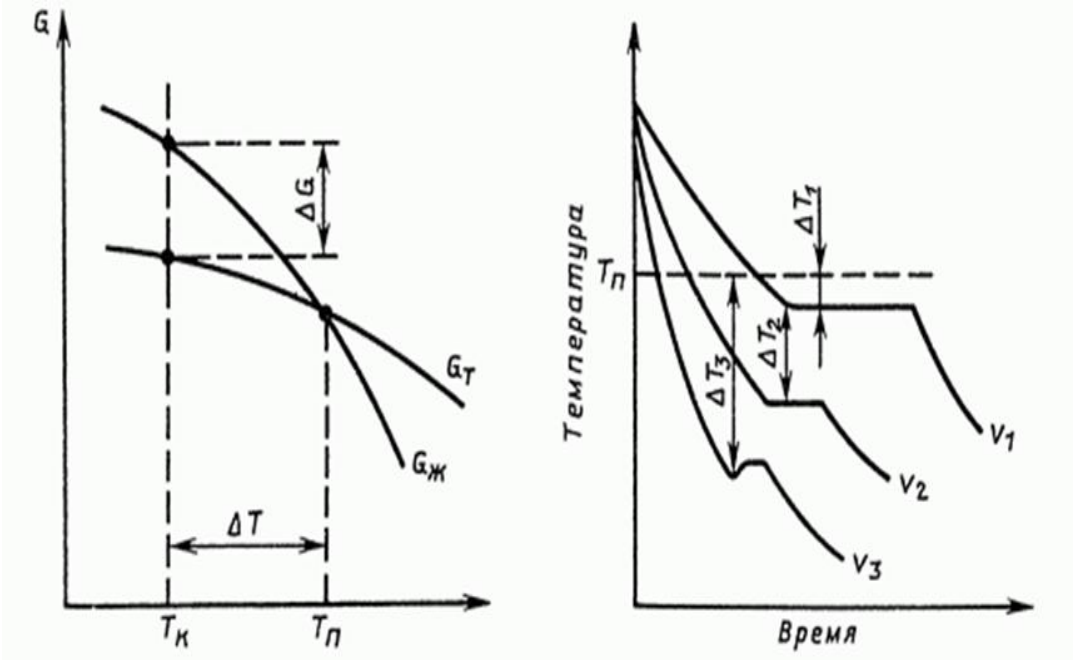
1. What is the cause of melting and crystallization?
2. What is the way they act? How do they develop, in other words, what is their mechanism?
3. How are melting and crystallization connected, what is the relation between liquid and solid metals?
4. What is the structure of liquid and solid metals?
5. And how is all that connected with the structure and properties of solid metals fnd alloys?

At the temperature below than the equilibrium The Gibbs energy of the solid state is less than the Gibbs energy of the liquid state.

Under these conditions

thermodynamically favorable

the crystallization process



degree of supercooling -

-the difference between the equilibrium and crystallization temperatures

$$\Delta T = T_р - T_к.$$

Its driving force is

The crystallization process consists of two major events:

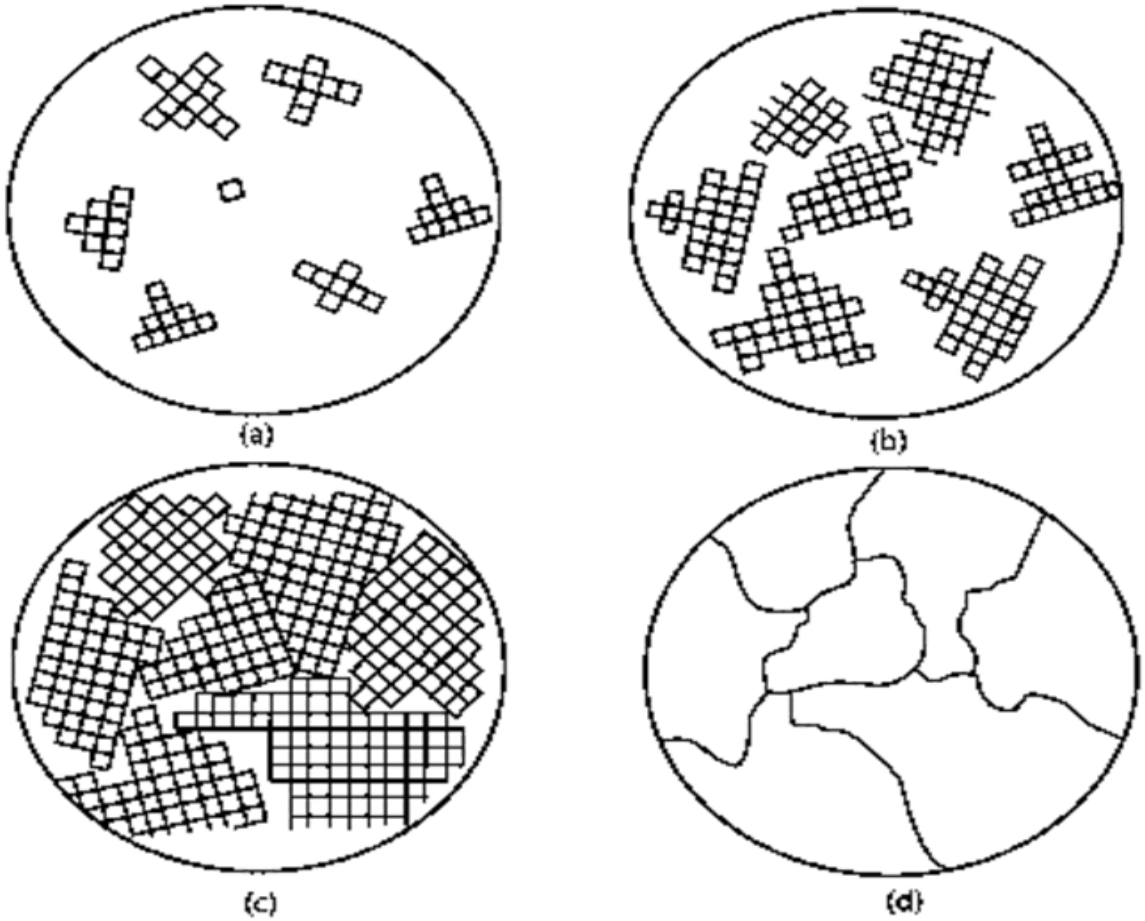
- **nucleation and**

- **crystal growth which are driven by thermodynamic properties as well as chemical properties.**

In crystal growth Nucleation is the step where the solute molecules or atoms dispersed and to gather into clusters.

These stable clusters constitute the nuclei.

Nucleation and growth



a) Nucleation of crystals, b) crystal growth, c) irregular grains form as crystals grow together, d) grain boundaries as seen in a microscope.

The critical size of the crystals is depend by many different factors :

- **temperature,**
- **pressure,**
- **supersaturation, etc.**

At the stage of nucleation some of the atoms or molecules arrange in a periodic manner that defines the crystal structure

"crystal structure" is a special term that refers to the relative arrangement of the atoms or molecules.

The crystal growth is increase of the nuclei which achieved the critical cluster size.

The crystal growth is a dynamic process occurring in equilibrium where solute molecules or atoms precipitate out of solution, and dissolve back into solution.

Depending upon the conditions, nucleation or growth may be predominant over the other, dictating crystal size.

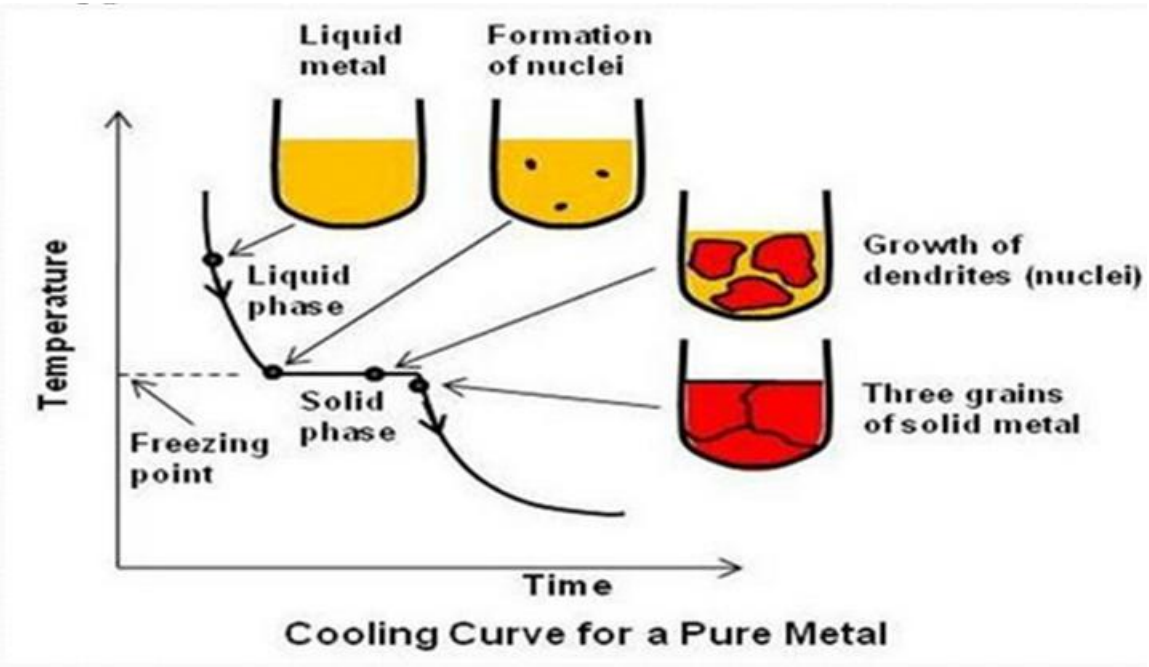
Many compounds have the ability to crystallize with some different crystal structures, this phenomenon called polymorphism.

Each polymorph modification is in fact a different thermodynamic solid state and different physical properties.

For this reason, polymorphism is of major importance in industrial manufacture of crystalline products.

Pure metals

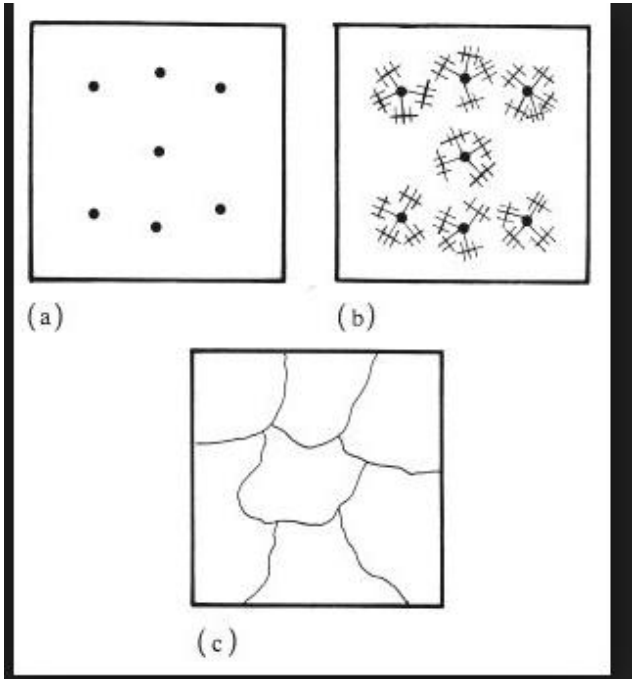
Characteristics of a pure metal are discussed in the crystallization. Under equilibrium conditions, all metals show a definite melting or freezing point.

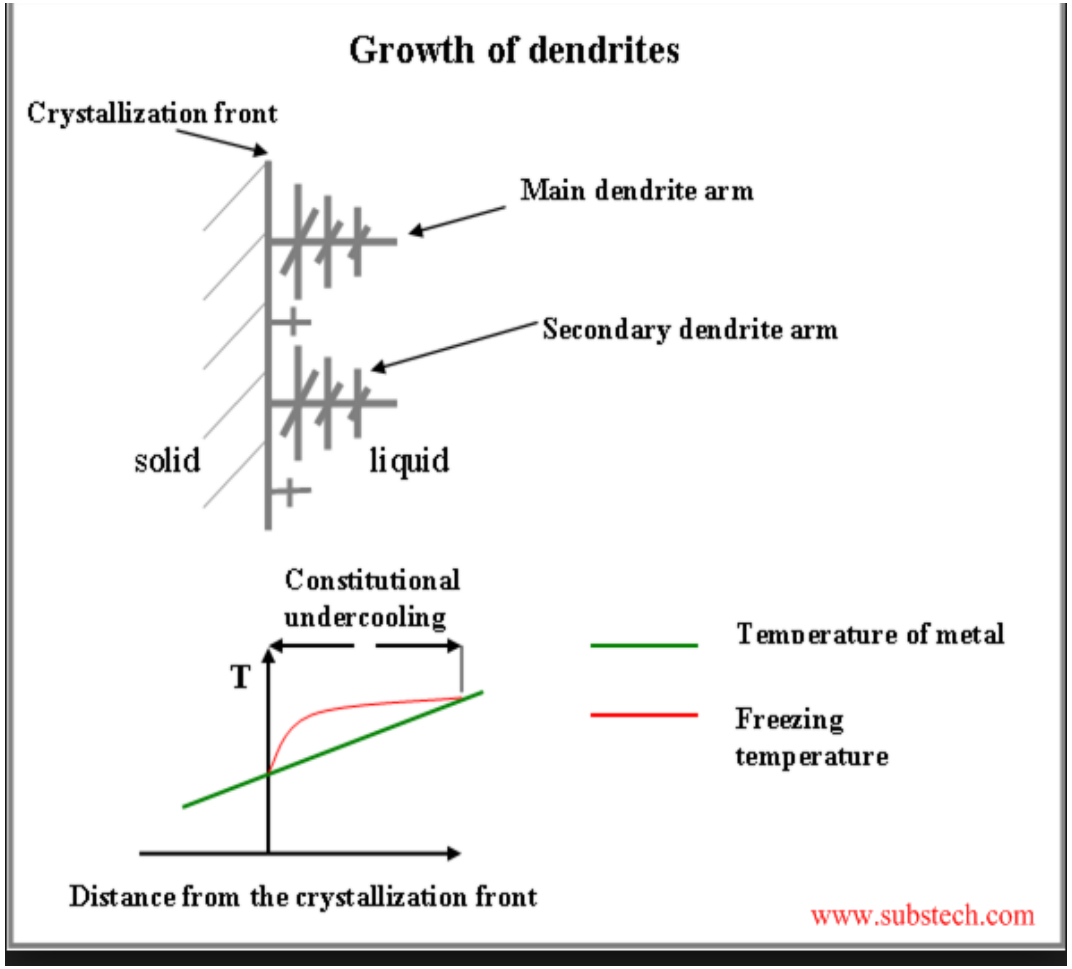


Cooling Curve for a Pure Metal

If a cooling curve is plotted for a pure metal, it will show a horizontal line at the melting or freezing point as shown in above figure.

Crystallization of metal





What are we doing during of laboratory work?

- **1. Prepare different salt solutions (CuSO4, NH4Cl and K2Cr2O7)**

- **2. Prepare biological microscope to observe the crystallization process.**

- **3. A drop of hot solution we must apply to cold or hot surface of the glass and then we can see the mechanism of crystallization process**

What we see?

Crystallization process

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