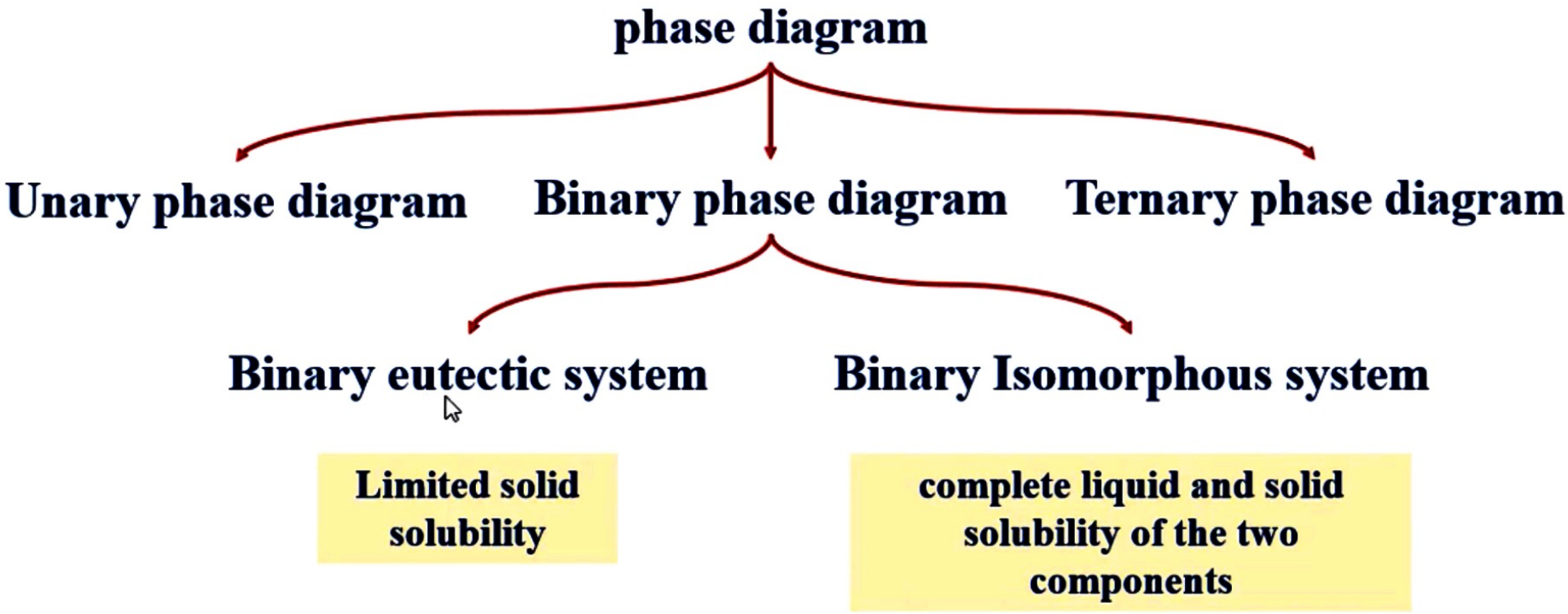
Importance of phase diagrams

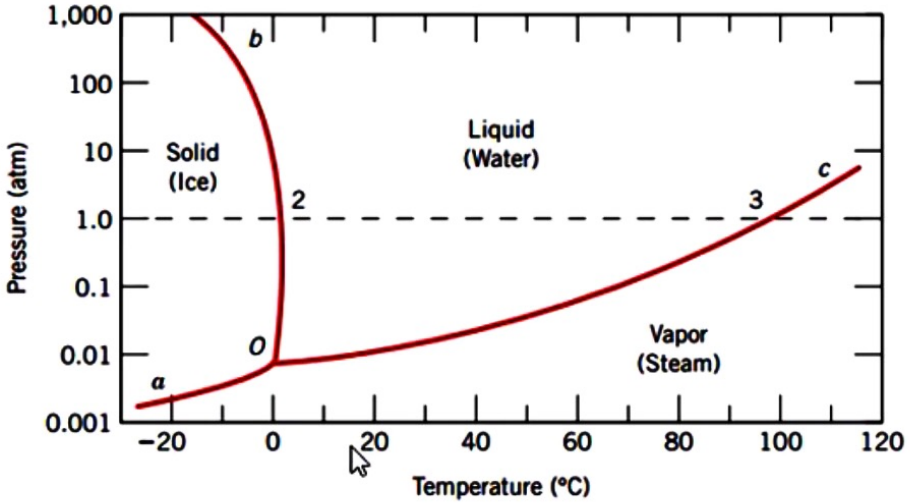
- **There is a strong correlation between microstructure and mechanical properties.**
- **Microstructure is determined from phase diagram.**
- **Phase diagrams provide valuable information about melting, casting, crystallization.**

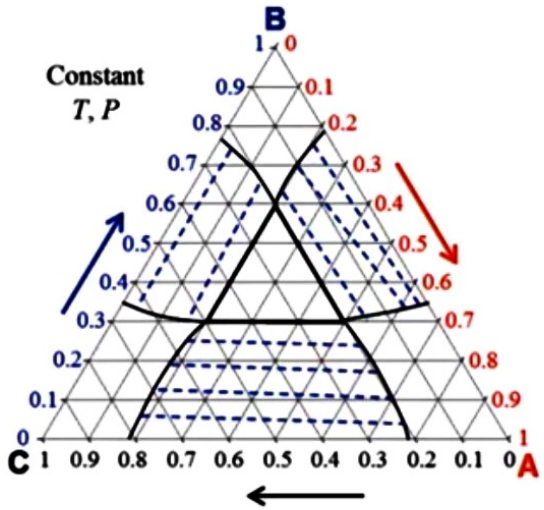
phase diagram terminology

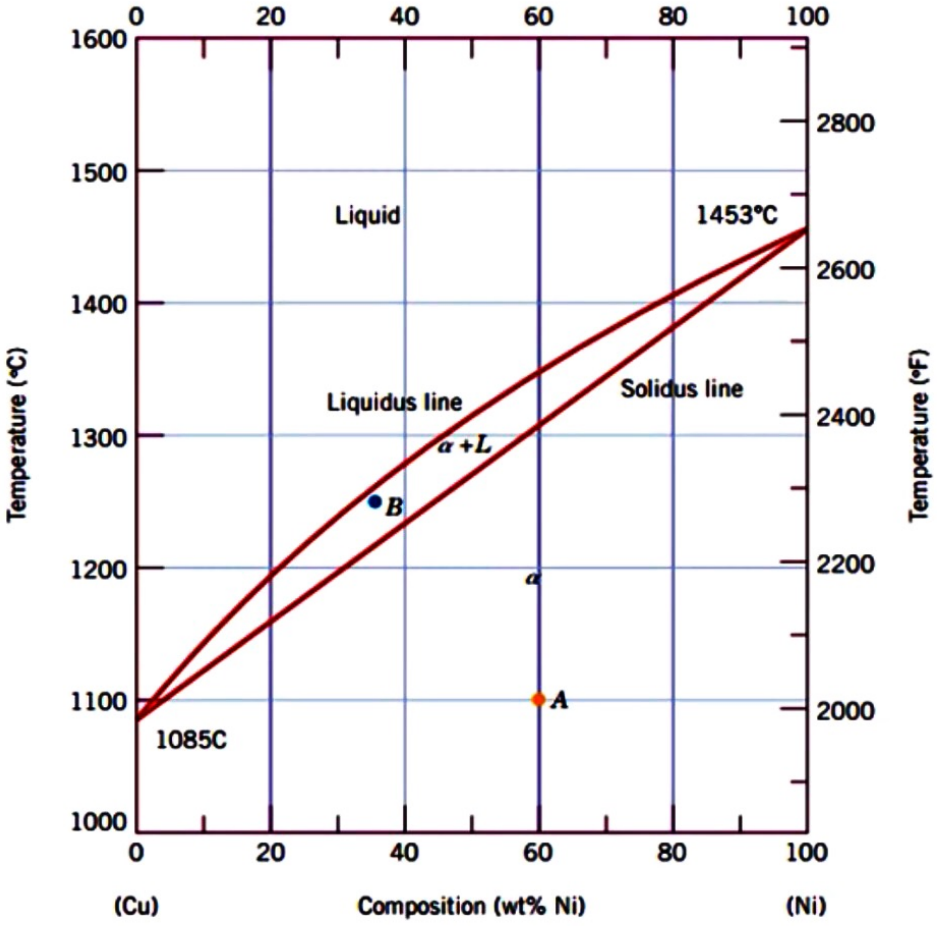
Component	**pure metals and/or compounds of which an alloy is composed**
System	**The series of possible alloys consisting of the same components but without regard to alloy composition**
Solubility limit	**maximum concentration of solute atoms that may dissolve in the solvent to form a solid solution**
Phase	**a homogeneous portion of a system that has uniform physical and chemical characteristics.**
Microstructure	**microstructure is characterized by the number of phases present, their proportions, and the manner in which they are distributed or arranged.**

Types of phase diagrams




1,000
100
10
1.0
0.1
0.01
0.001
Pressure (atm)
b
Solid
(Ice)
Liquid
(Water)
c
2
3
O
a
Vapor
(Steam)
−20
0
20
40
60
80
100
120
Temperature (°C)


B
Constant
T, P
C
A
1 0
0.9 0.1
0.8 0.2
0.7 0.3
0.6 0.4
0.5 0.5
0.4 0.6
0.3 0.7
0.2 0.8
0.1 0.9
0 1
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0


0
20
40
60
80
100
1600
1500
1400
1300
1200
1100
1000
2800
2600
2400
2200
2000
Temperature (°C)
Temperature (°F)
Liquid
1453°C
Liquidus line
Solidus line
α +L
B
α
A
1085C
(Cu)
Composition (wt% Ni)
(Ni)

Binary phase diagram

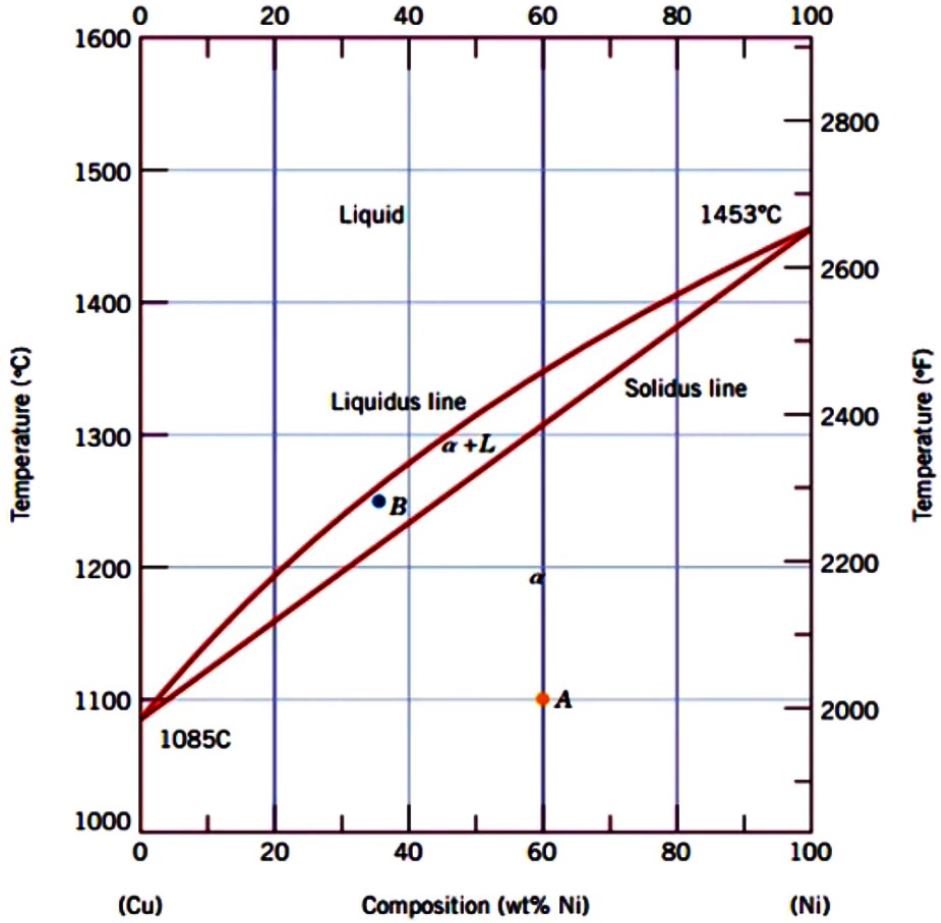
1. Binary Isomorphous

complete liquid and solid solubility of the two components

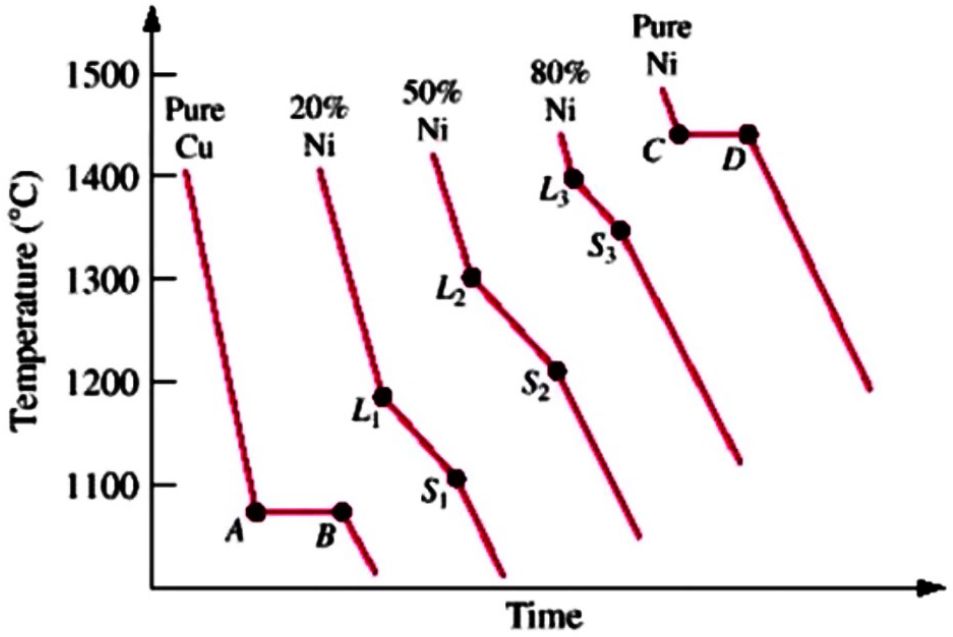
Composition axis
Temperature axis

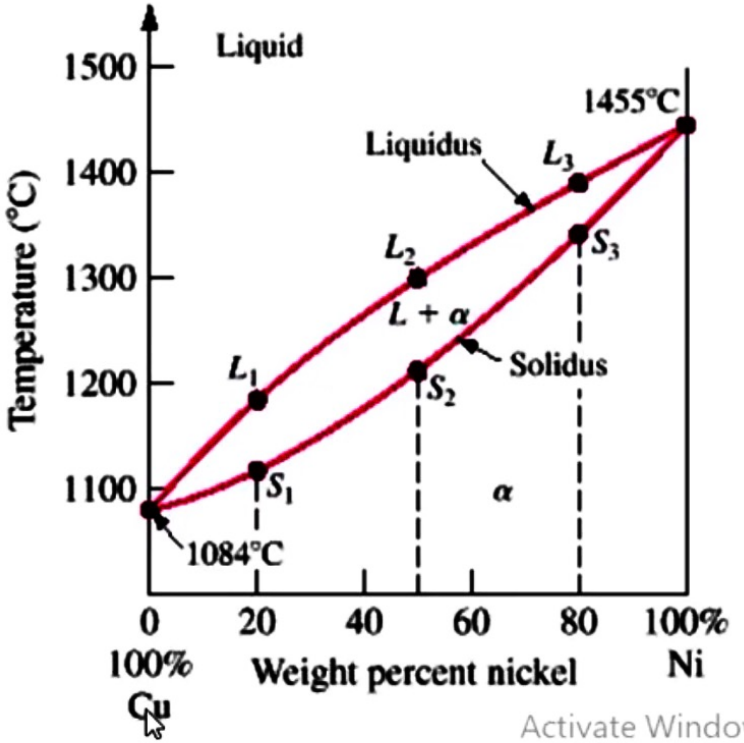
Points
Melting point of Cu: 1085
Melting point of Ni: 1453

Lines
Liquidus line: the line between L and L+α
Solidus line: the line between L+α and α



Cooling curves





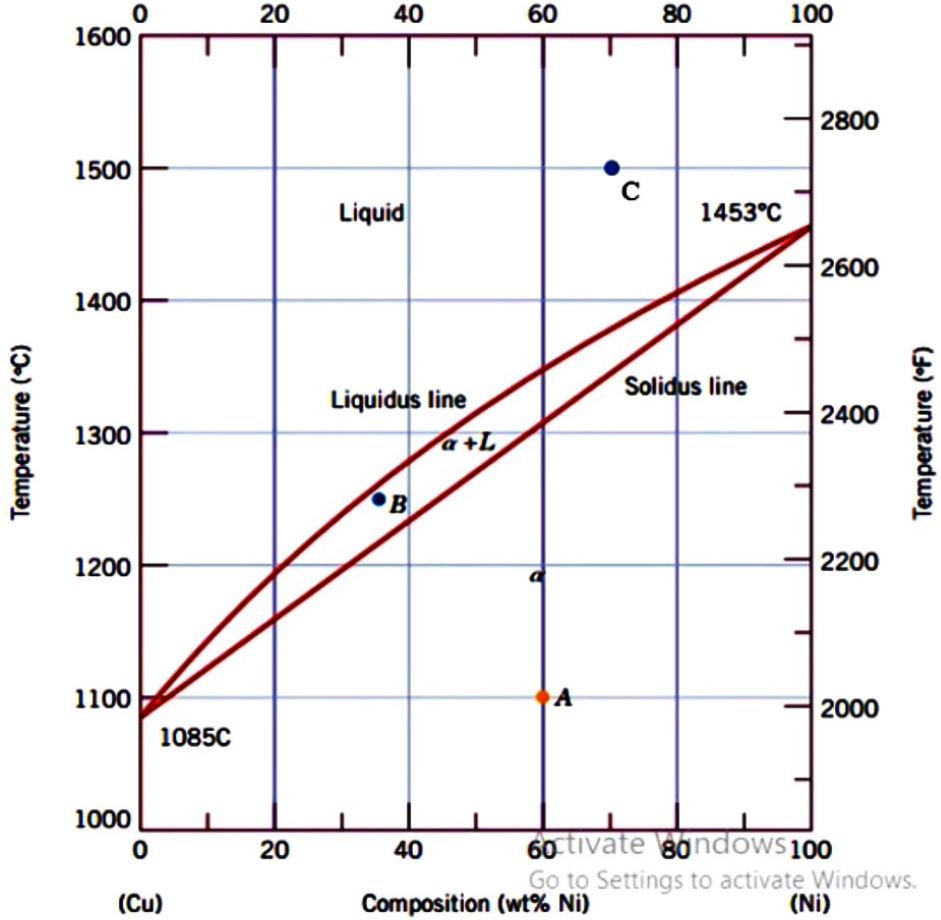
Interpretation of phase diagrams

1. Phase present

Locate this points and find the existing phases:

A	60 $Wt\%\ Ni$, 1100
B	35 $Wt\%\ Ni$, 1250
C	70 $Wt\%\ Ni$, 1500

A	α
B	L+α
C	L



Interpretation of phase diagrams

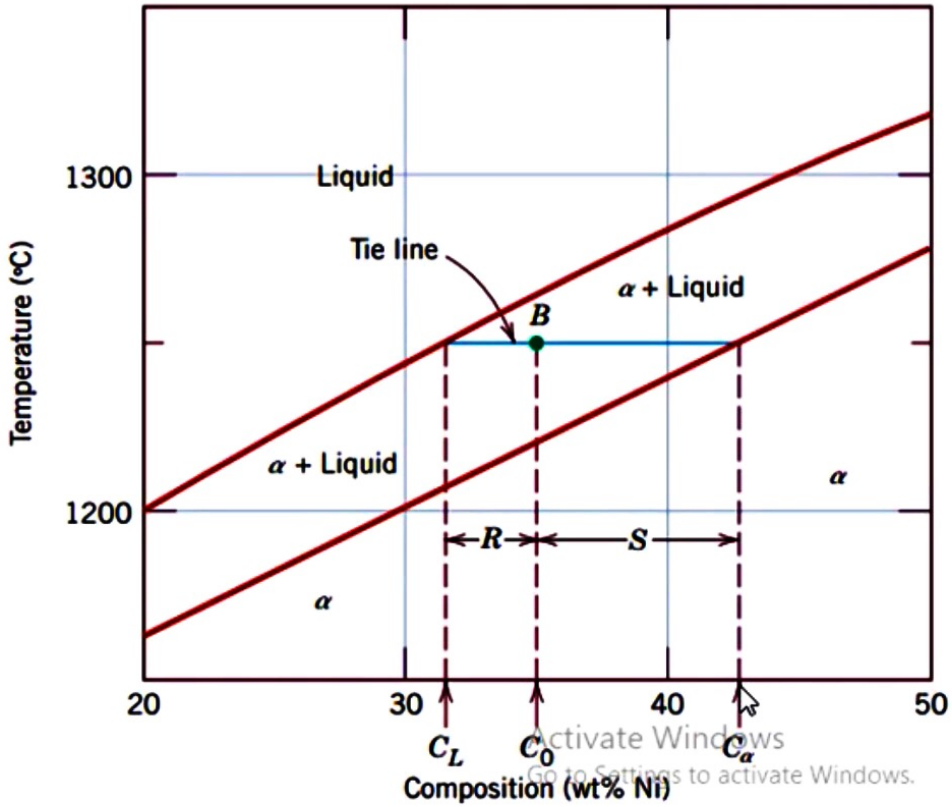
2. Phase composition

"The concentrations of the components"

- If there is only single phase, then the procedure is simple. Just drop a vertical line from the point over the composition axis and read the concentration.

- In two phase regions: follow the procedure below

1. A tie line is constructed.
2. Determine the intersections with each boundary.
3. Perpendiculars are dropped from these intersections to the horizontal composition axis, from which the composition of each of the respective phases is read.



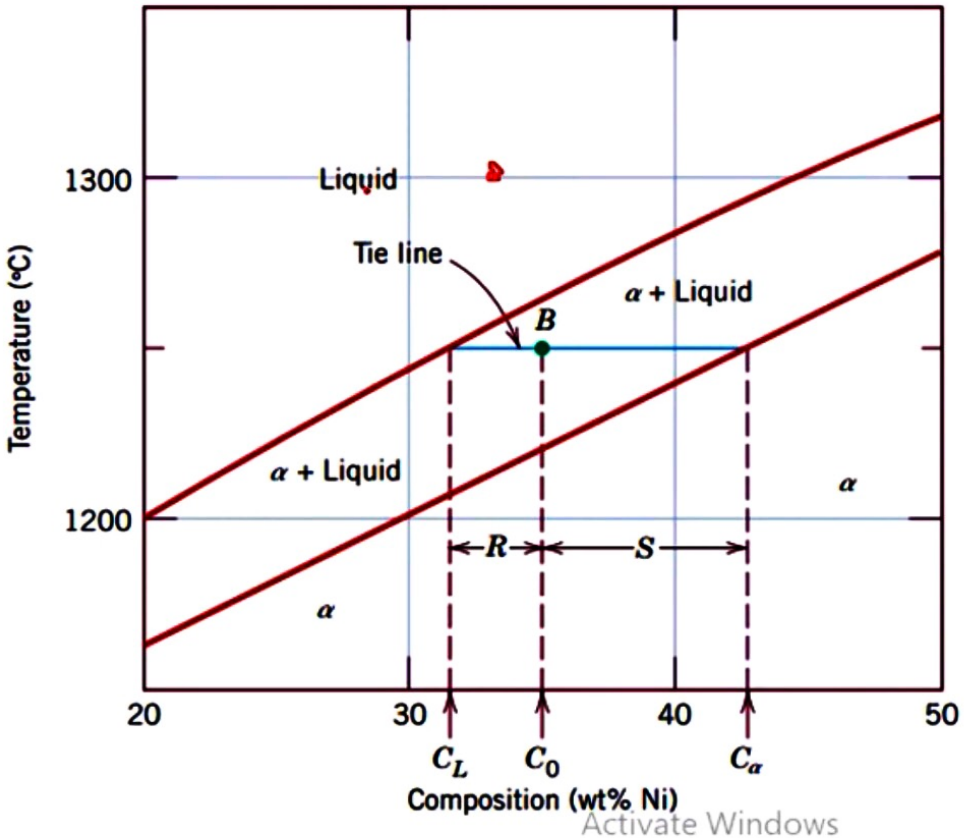
Binary phase diagram

3. Phase amounts

- If there is only single phase, then the alloy is composed completely from this phase.

- In two phase regions: follow the procedure below (lever rule)

1. A tie line is constructed.
2. The overall composition is located on tie line.
3. Drop the intersections and the overall composition over the composition axis to determine Co, Cl and Cα.
4. Use the following formula to determine each phase amount.



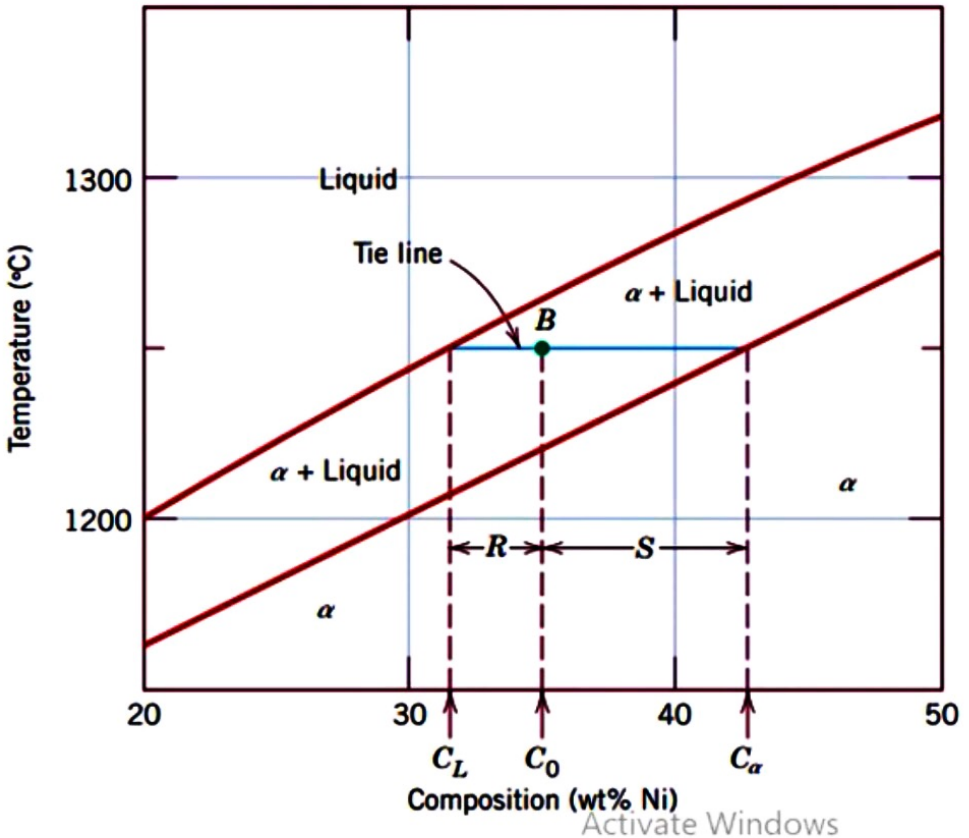
Binary phase diagram

For liquid phase

$$W_L = \frac{S}{R+S} \qquad W_L = \frac{C_\alpha - C_0}{C_\alpha - C_L}$$

For solid phase

$$W_\alpha = \frac{R}{R+S} \qquad = \frac{C_0 - C_L}{C_\alpha - C_L}$$



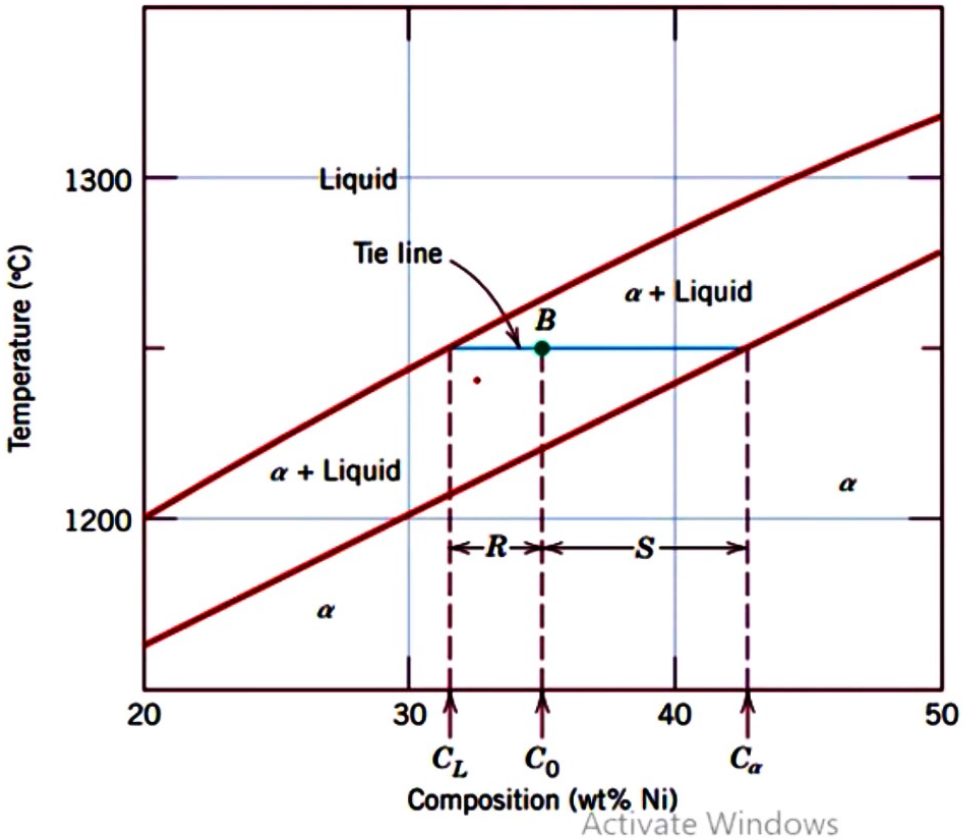
Binary phase diagram

Example

$C_L = 31.5\,;\; C_o = 35\,;\; C_\alpha = 42.5$

$$C_l = \frac{C_\alpha - C_o}{C_\alpha - C_l} = \frac{42.5 - 35}{42.5 - 31.5} = 0.68$$

$$C_\alpha = \frac{C_o - C_l}{C_\alpha - C_l} = \frac{35 - 31.5}{42.5 - 31.5} = 0.32$$



Development of microstructure