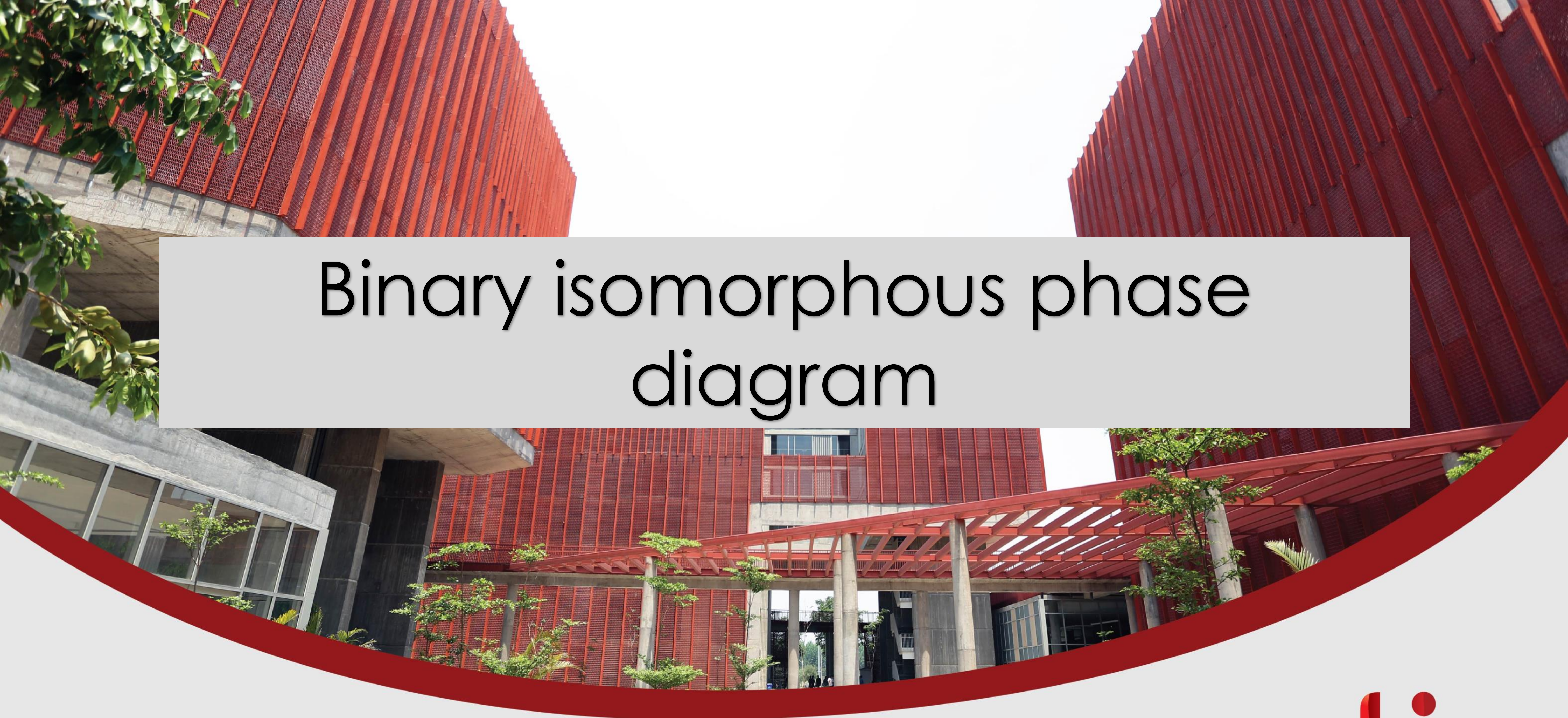

Binary isomorphous phase diagram

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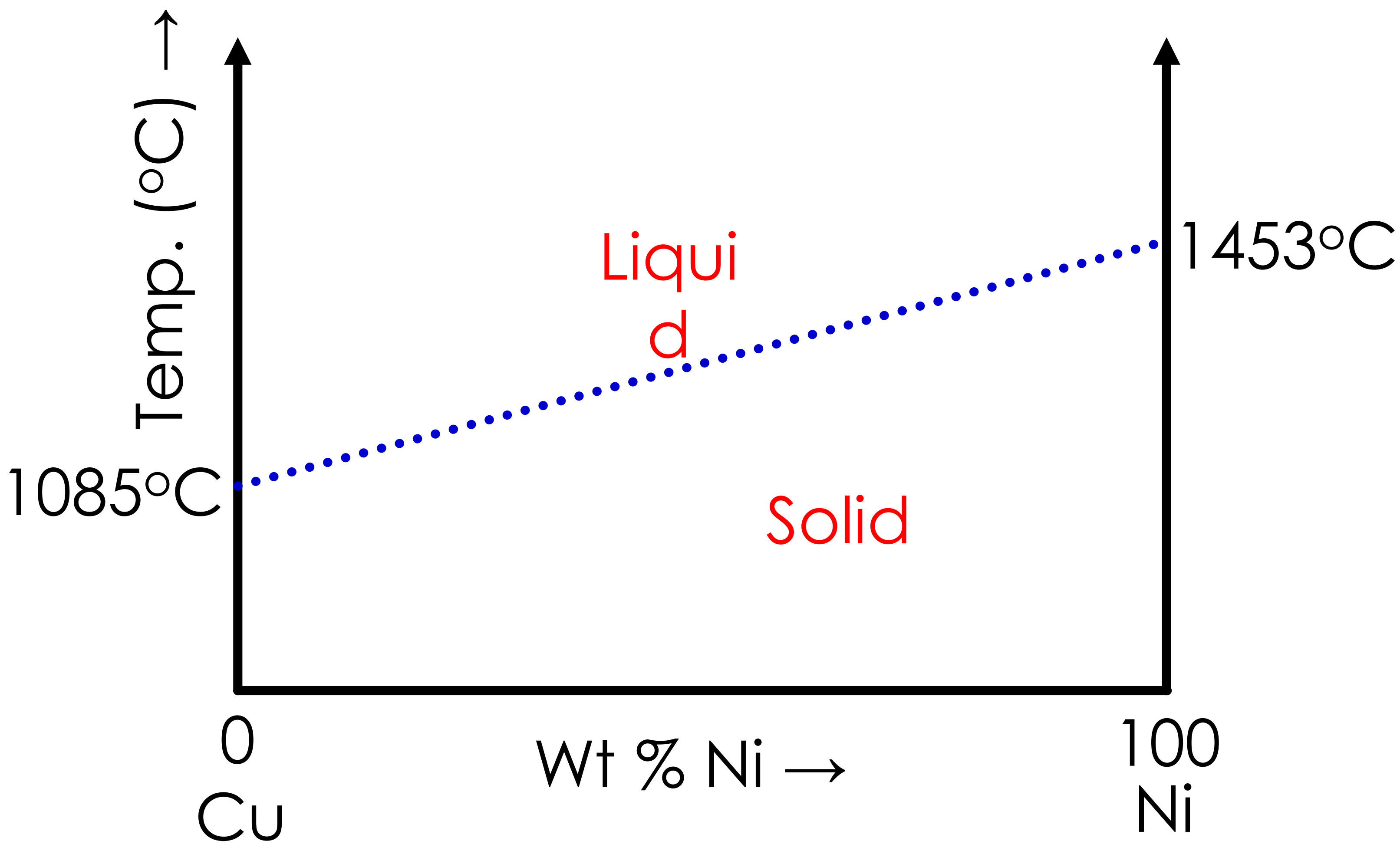
Isomorphous Binary Phase Diagram

- Two component system
- Complete solubility in liquid as well as in solid
- Also know as solid solution systems

Expect T_m of solution to lie in between T_m of two pure components



For a pure component, complete melting occurs before T_m increases (sharp phase transition)

But for multicomponent systems, there is usually a coexistence of liquid and solid.

Criteria for formation of Solid Solutions

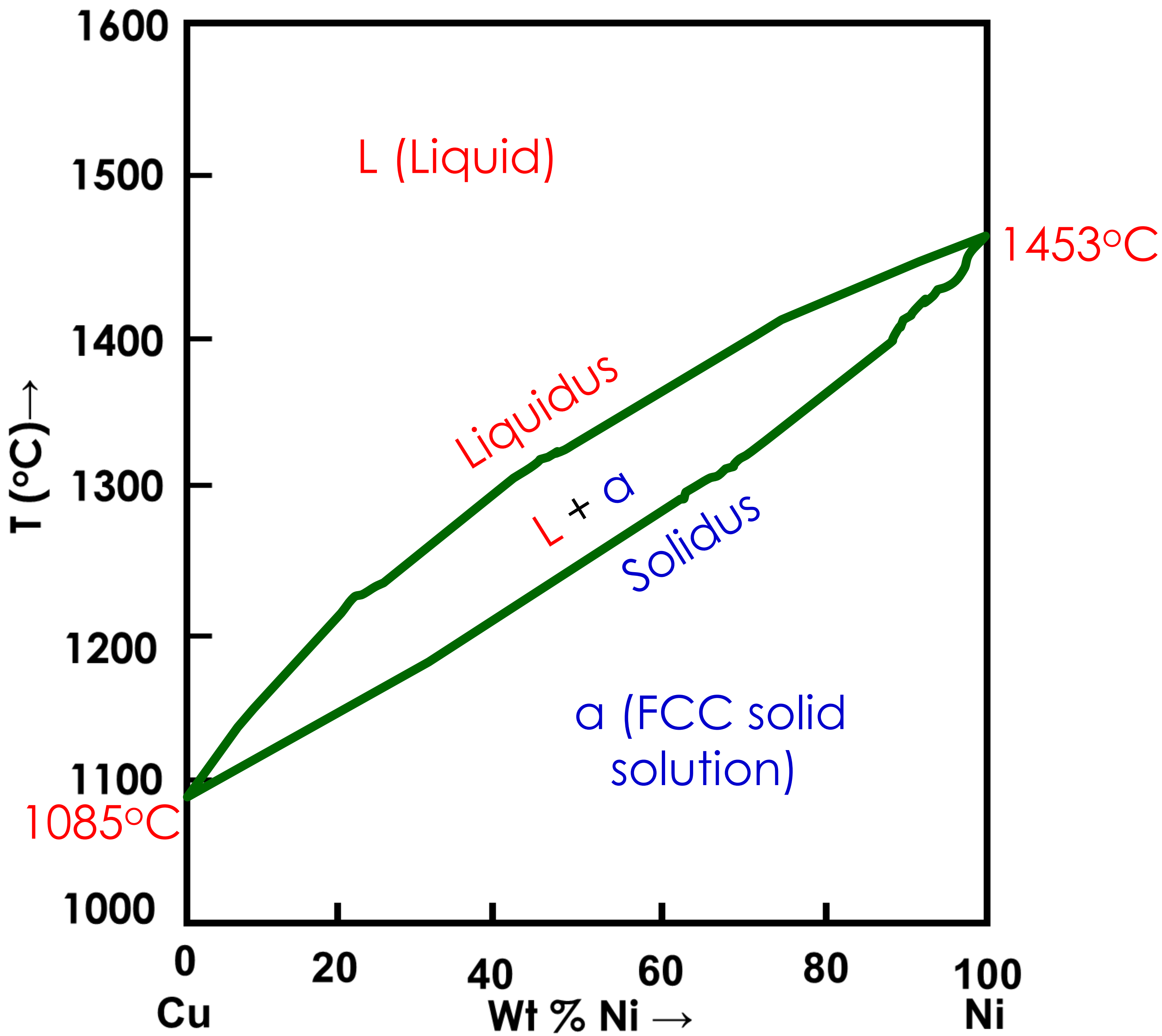
W. Hume–Rothery rules

- Both elements/compound should have the same crystal structure
- Atomic size difference less than 15% (atomic/ionic radii similar)
- Less difference in electronegativity values
- Same valency

Ni and Cu are totally soluble in one another for all proportions.

	Crystal Structure	electroneg	*r* (nm)
Ni	FCC	1.9	0.1246
Cu	FCC	1.8	0.1278

Isomorphous Binary Phase Diagram



What can we learn from this phase diagram?

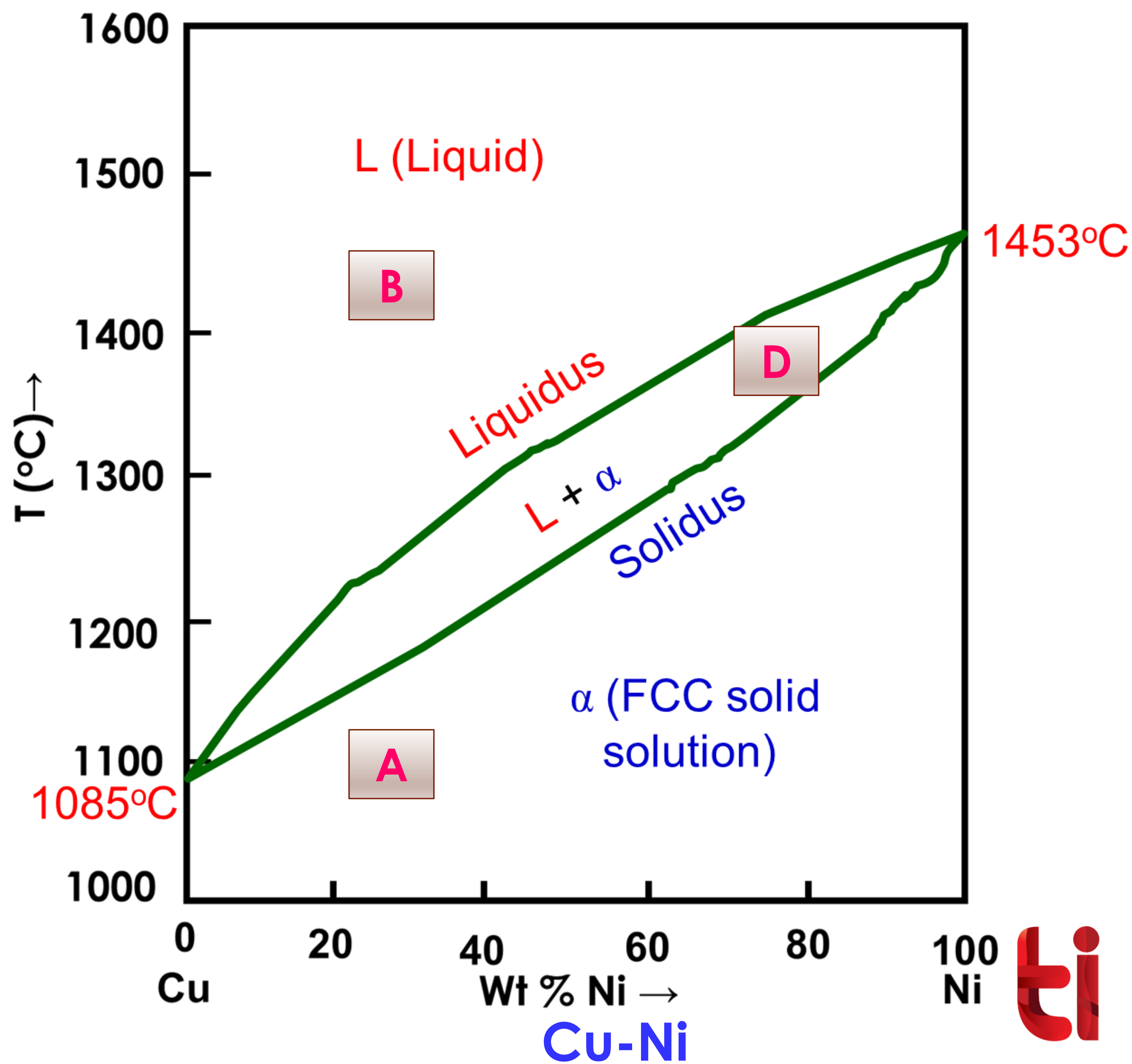
1. Phase(s) present
2. Composition of those phases
3. Amount of the phases

Solidus - Temperature where alloy is completely solid. Above this line, liquefaction begins.

Liquidus - Temperature where alloy is completely liquid. Below this line, solidification begins.

Effect of Temperature & Composition (C_o)

- Changing T can change # of phases: path A to B.
- Changing C_o can change # of phases: path B to D.



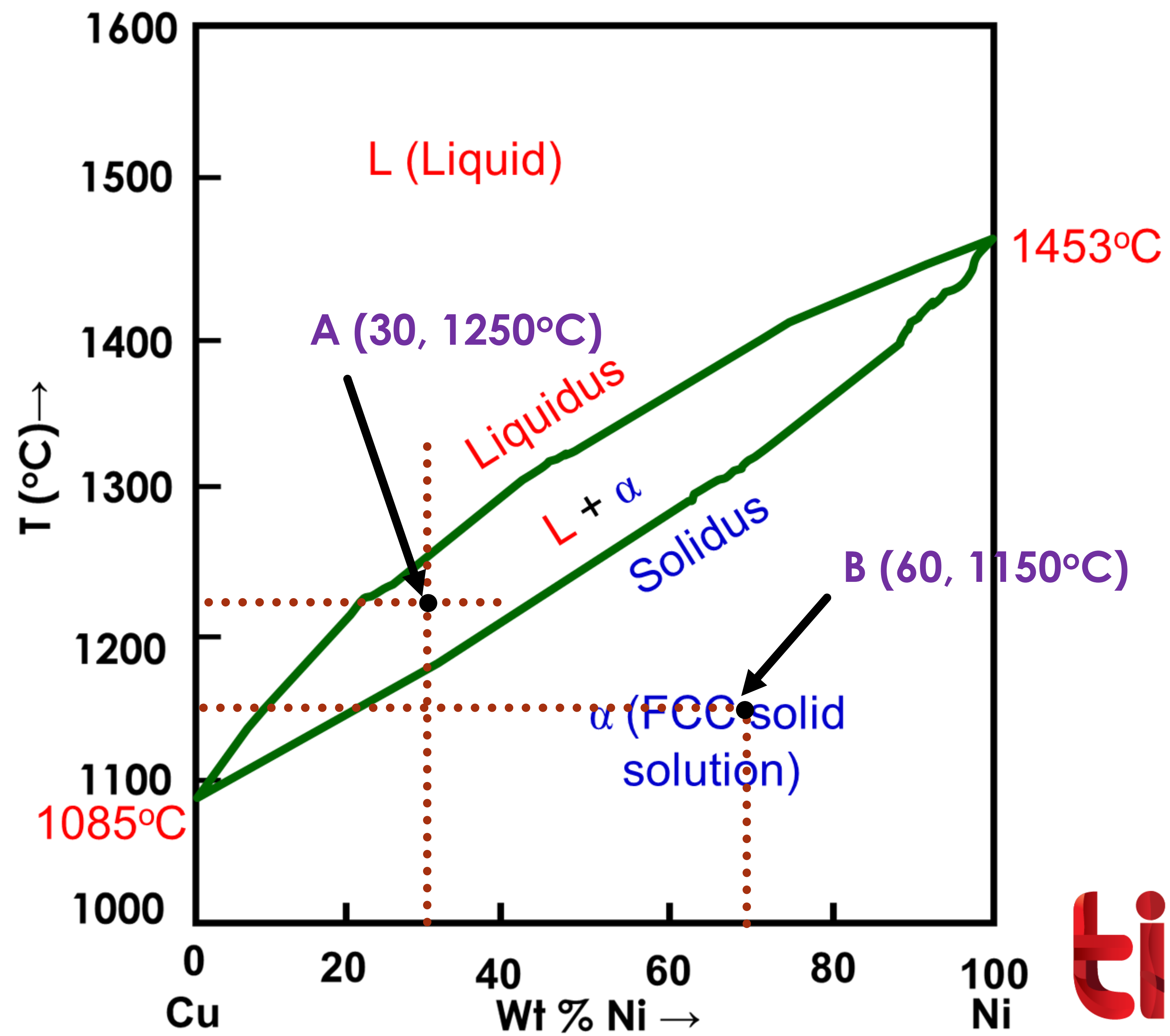
Determination of phase(s) present

- Rule 1: If we know T and Co, then we know:
  -how many phases and which phases are present.

Examples

1. At Temperature 1225 °C and C_o = 30 wt. % Ni, no of phases present: L + α. (point A in phase diagram).

2. At Temperature 1150°C and C_o = 60 wt. % Ni, no of phases present: α. (point B in phase diagram).



Composition of phases

Rule 2: If we know T and Co, then we know:-the composition of each phase.

Example

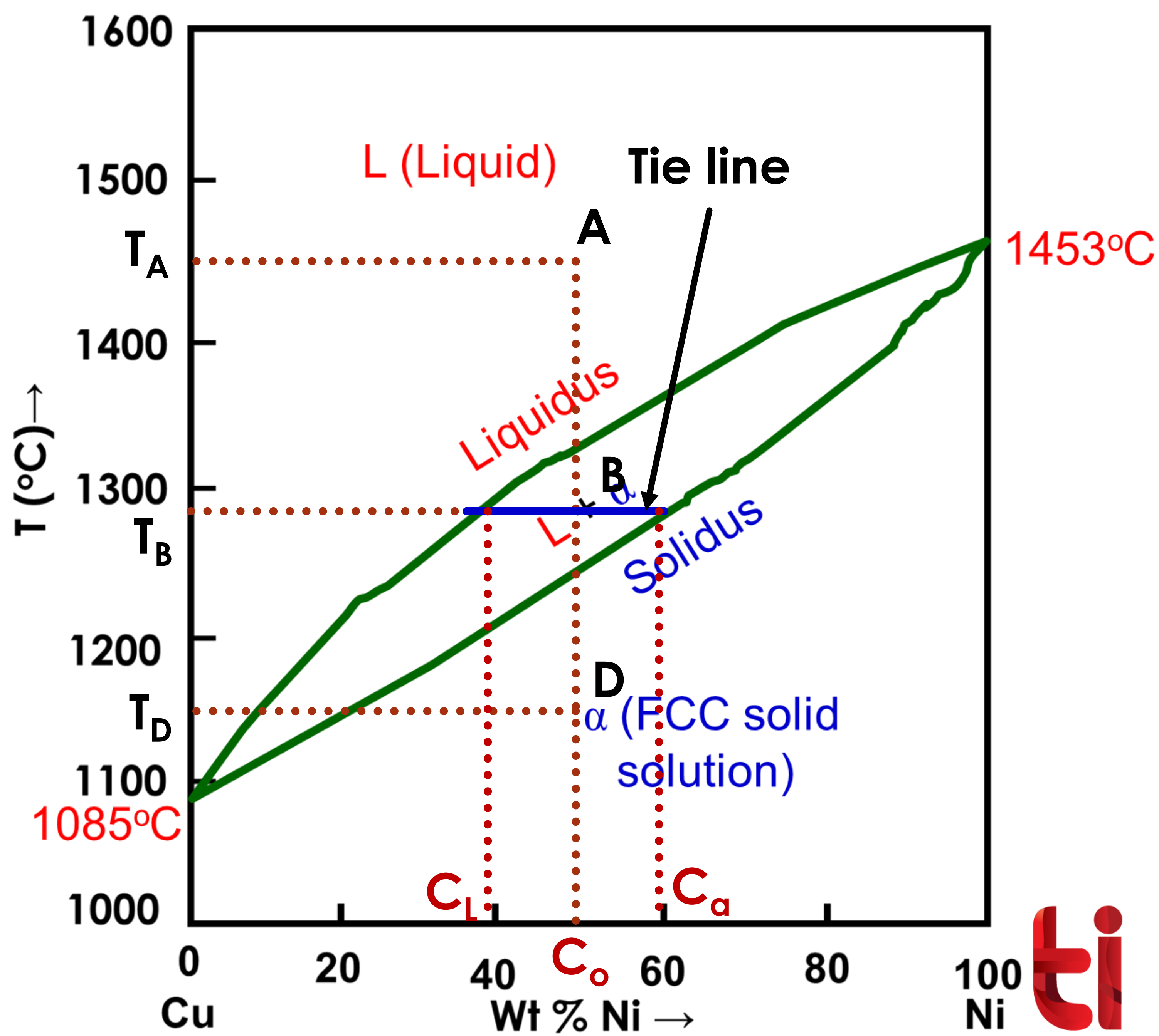
Alloy composition (C_o)= Cu 50 wt. % Ni

1. At temperature T_A = 1450°C, only liquid phase is present and $C_L = C_o$(=50 wt.% Ni).

2. At temperature T_B = 1275°C, Both α and L present, C_L = 40 wt. % Ni and C_α = 60 wt. % Ni. Use tie line to identity these composition.

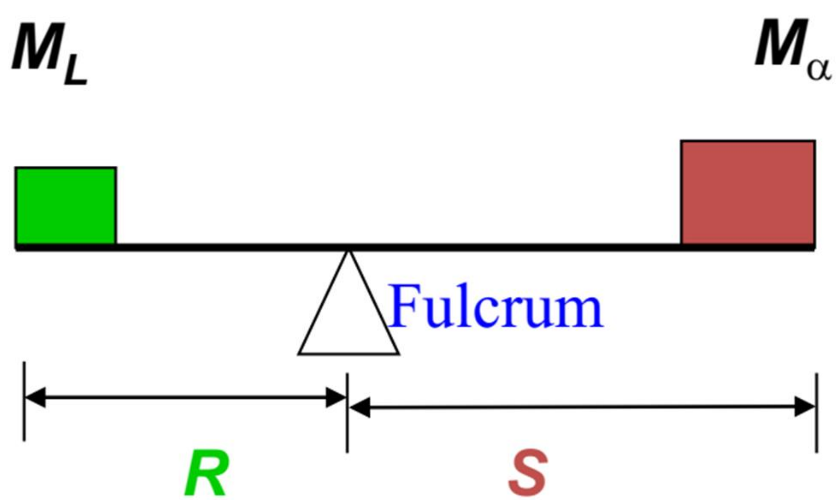
3. At temperature T_D = 1190°C, only solid (α) present $C_\alpha = C_o$ (= 50 wt. %Ni)

A tie line is constructed across the two-phase region at the temperature of the alloy



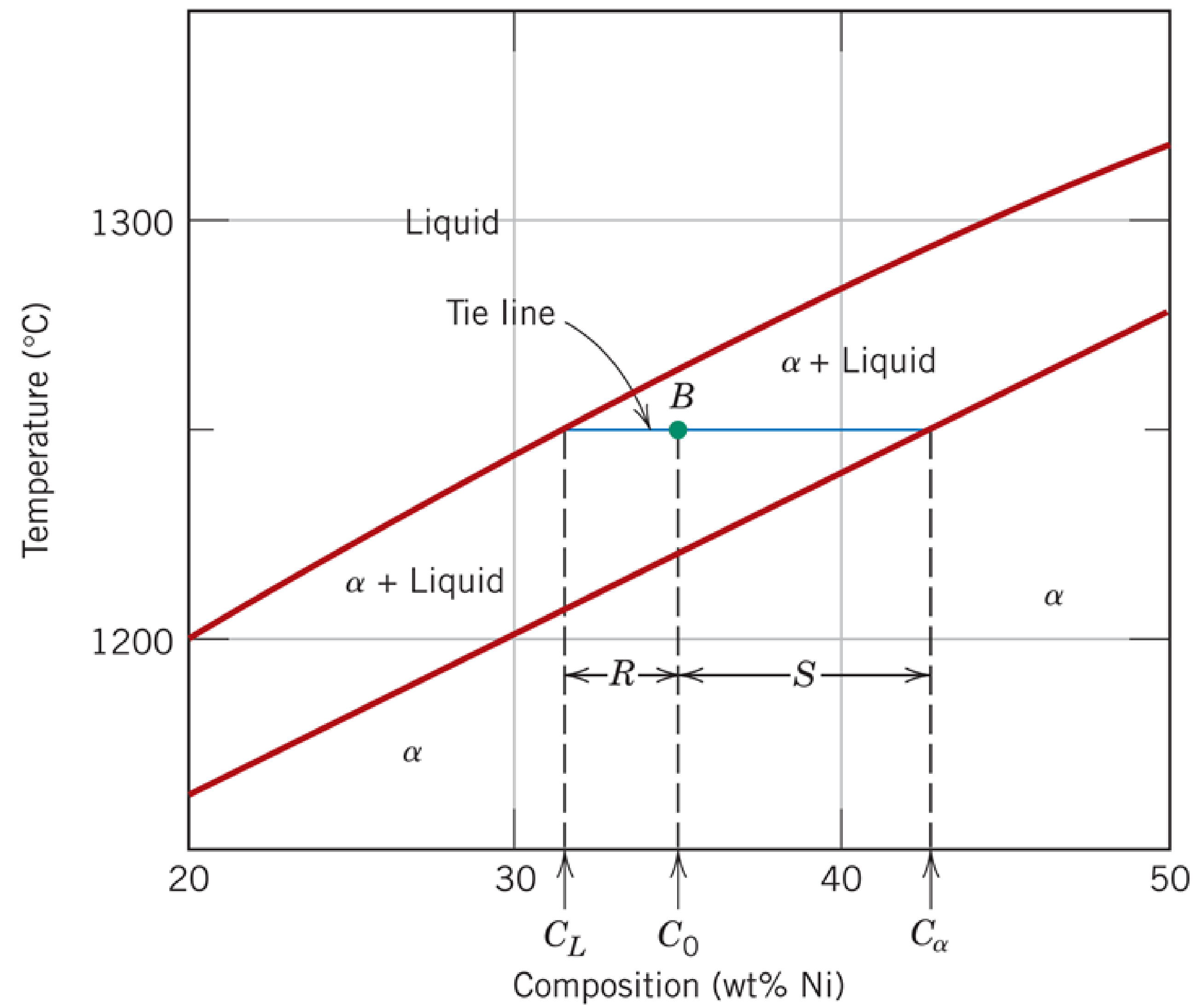
The Lever Rule

The lever rule derived from mass balance gives the relative amounts of the co-existing phases. It is derived as Tie line treated as lever arm, with the fulcrum as the overall composition.



Mass fractions be represented by W_L and W_α for the respective phases.

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



Interpretation of Phase Diagram

C_o = 35wt.% Ni, C_α = 42.5 wt.% Ni, and C_L = 31.5 wt.% Ni

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

$$W_L = \frac{42.5 - 35}{42.5 - 31.5} = 0.68$$

$$W_\alpha = \frac{35 - 31.5}{42.5 - 31.5} = 0.32$$

For an alloy consisting of α and β phases, the volume fraction of the α phase, V_α,

is defined as

$$V_\alpha = \frac{V_\alpha}{V_\alpha + V_\beta}$$

$$V_\alpha + V_\beta = 1$$

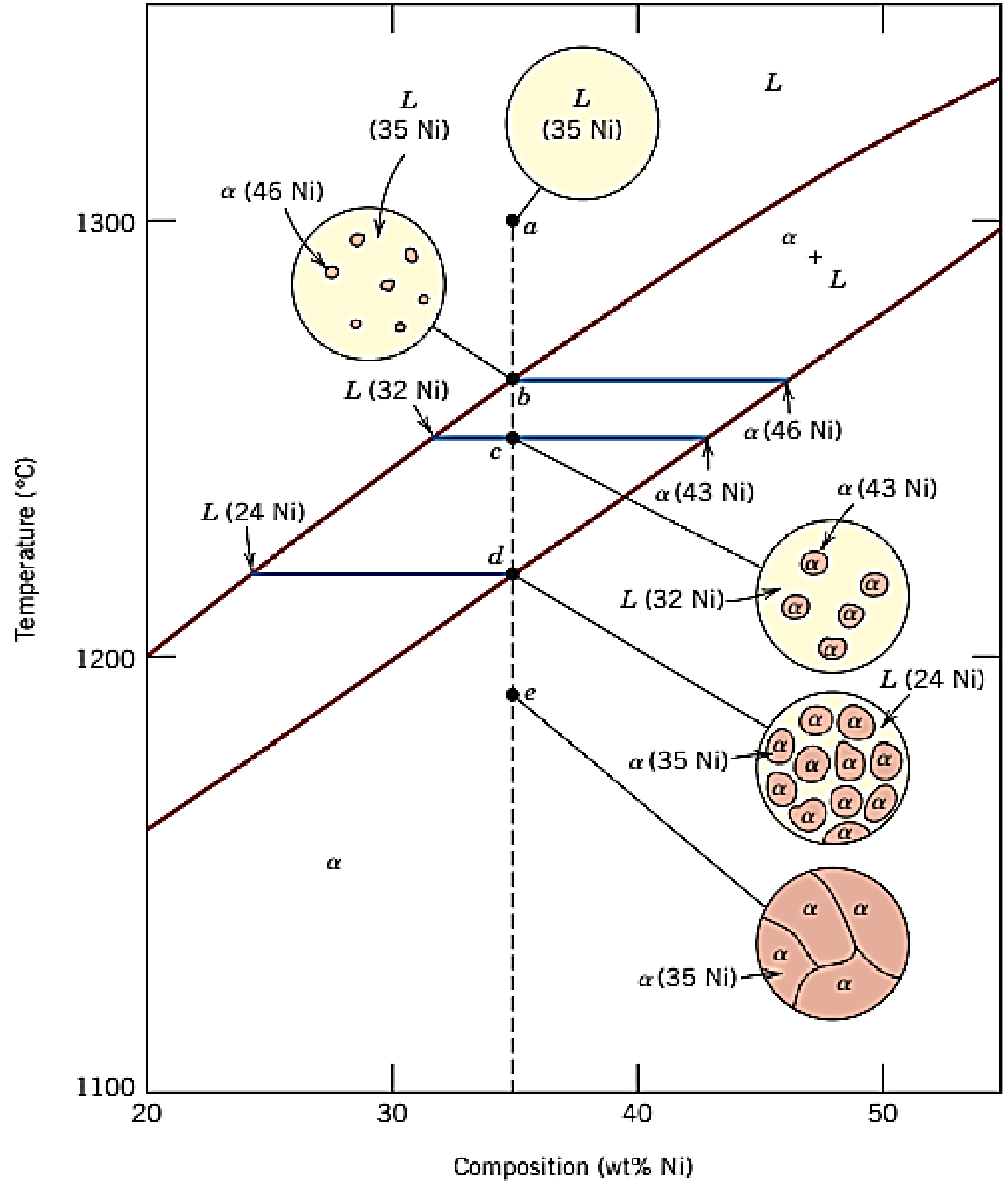
α phase volume fraction-dependence on volumes of α and β phases

Development of microstructure

Microstructures will vary on the cooling rate (i.e. processing conditions)

Equilibrium Cooling

1. Very slow cooling to allow phase equilibrium to be maintained during the cooling process.
2. Colling rate << diffusion time.

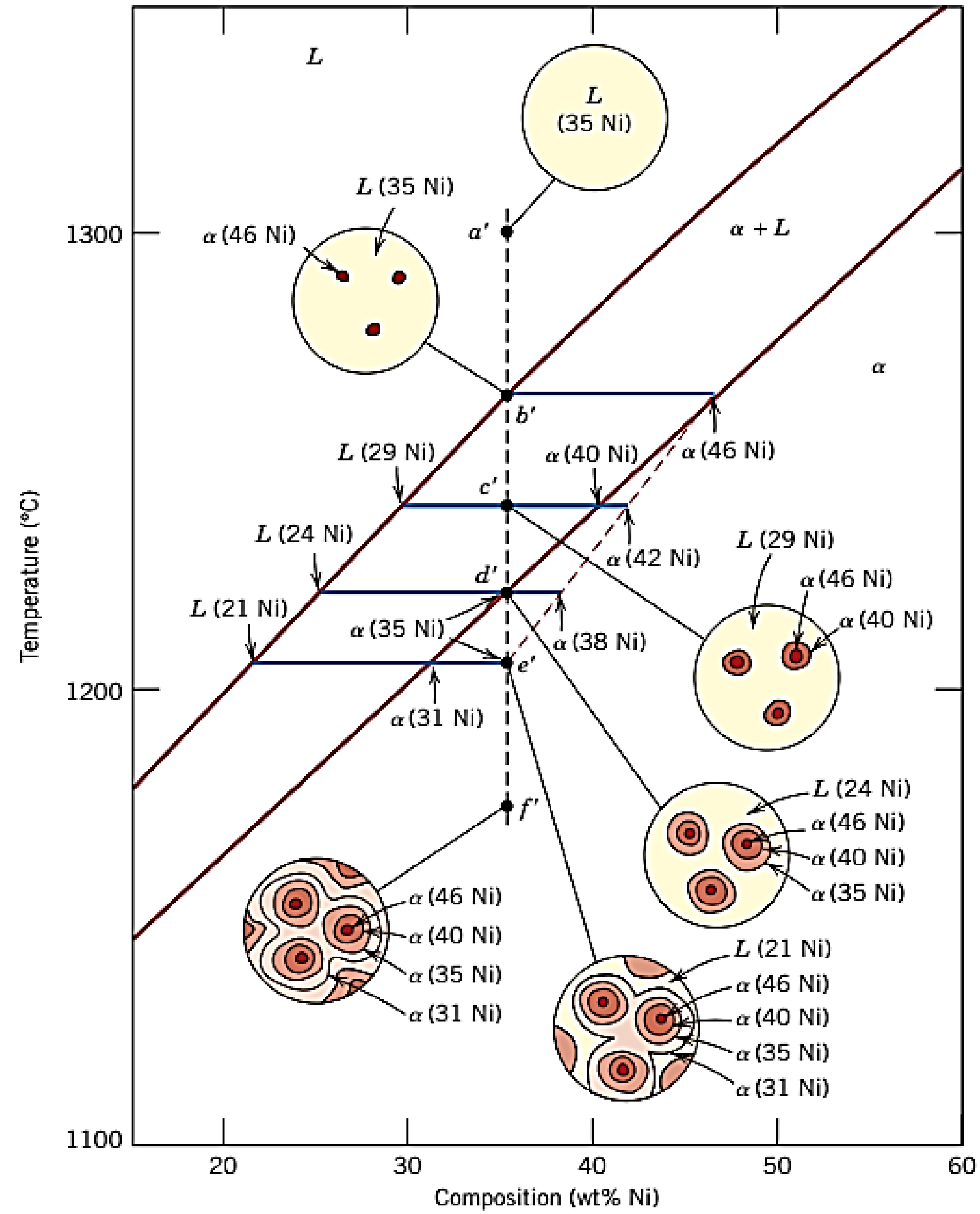


Development of microstructure in isomorphous alloys

Non-equilibrium Cooling

1. Fast cooling does not allow to allow phase equilibrium to be maintained during the cooling process.
2. Colling rate >> diffusion time.

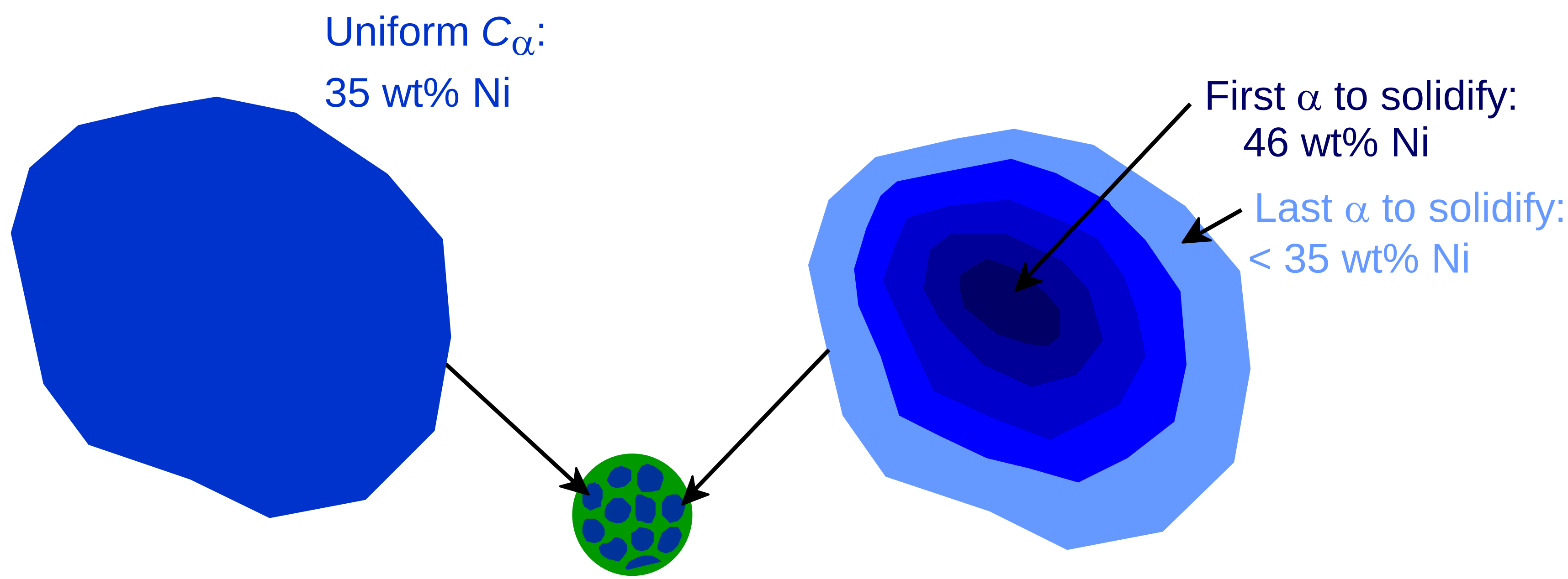
The centre of each grain, which is the first part to freeze, is rich in the high-melting element (e.g., nickel for this Cu–Ni system), whereas the concentration of the low-melting element increases with position from this region to the grain boundary. This is termed a cored structure, and gives rise to less than the optimal properties.



Development of microstructure

- C_α changes as we solidify.
- Cu-Ni case: First α to solidify has C_α = 46 wt% Ni.
  Last α to solidify has C_α = 35 wt% Ni.

- Slow rate of cooling:
  Equilibrium structure
- Fast rate of cooling:
  Cored structure



Summary

1. Phase diagrams are useful tools to determine:
   -- the number and types of phases present,
   -- the composition of each phase,
   -- and the weight fraction of each phase given the temperature and composition of the system.
2. Isomorphous phase diagrams has same structure and same morphology without any solubility limit.
3. The microstructure of an alloy depends on
   -- its composition, and
   -- whether or not cooling rate allows for maintenance of equilibrium.