Binary Eutectic Phase Diagram

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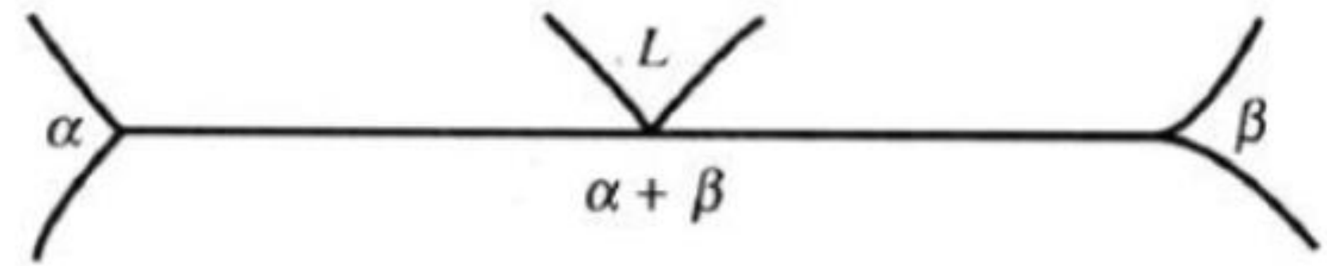
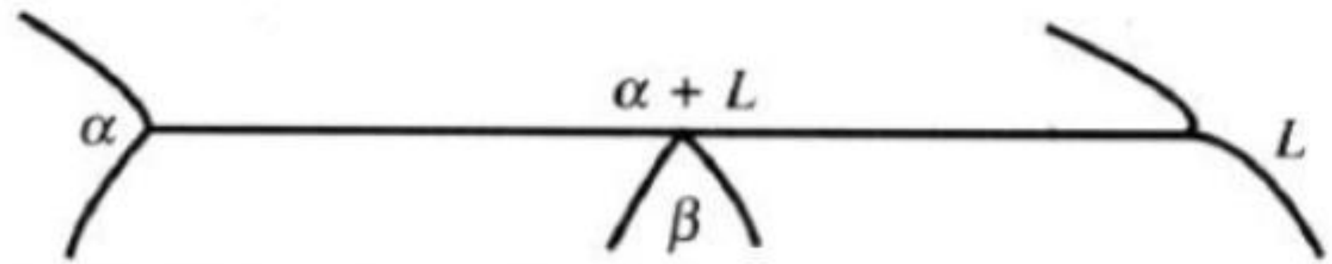
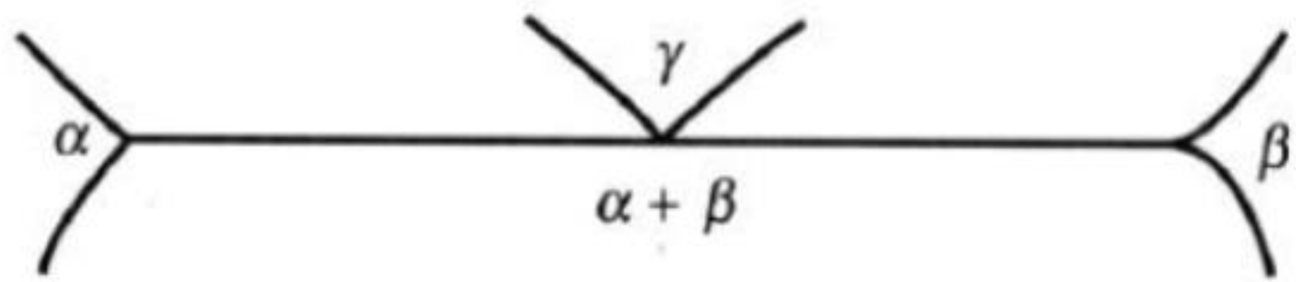
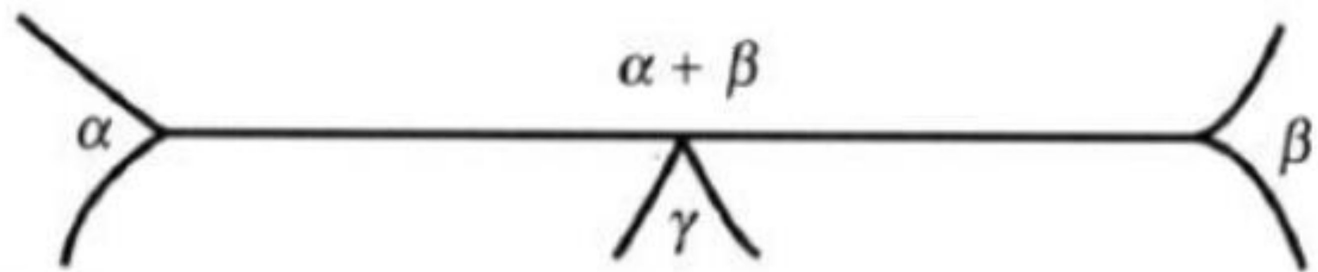
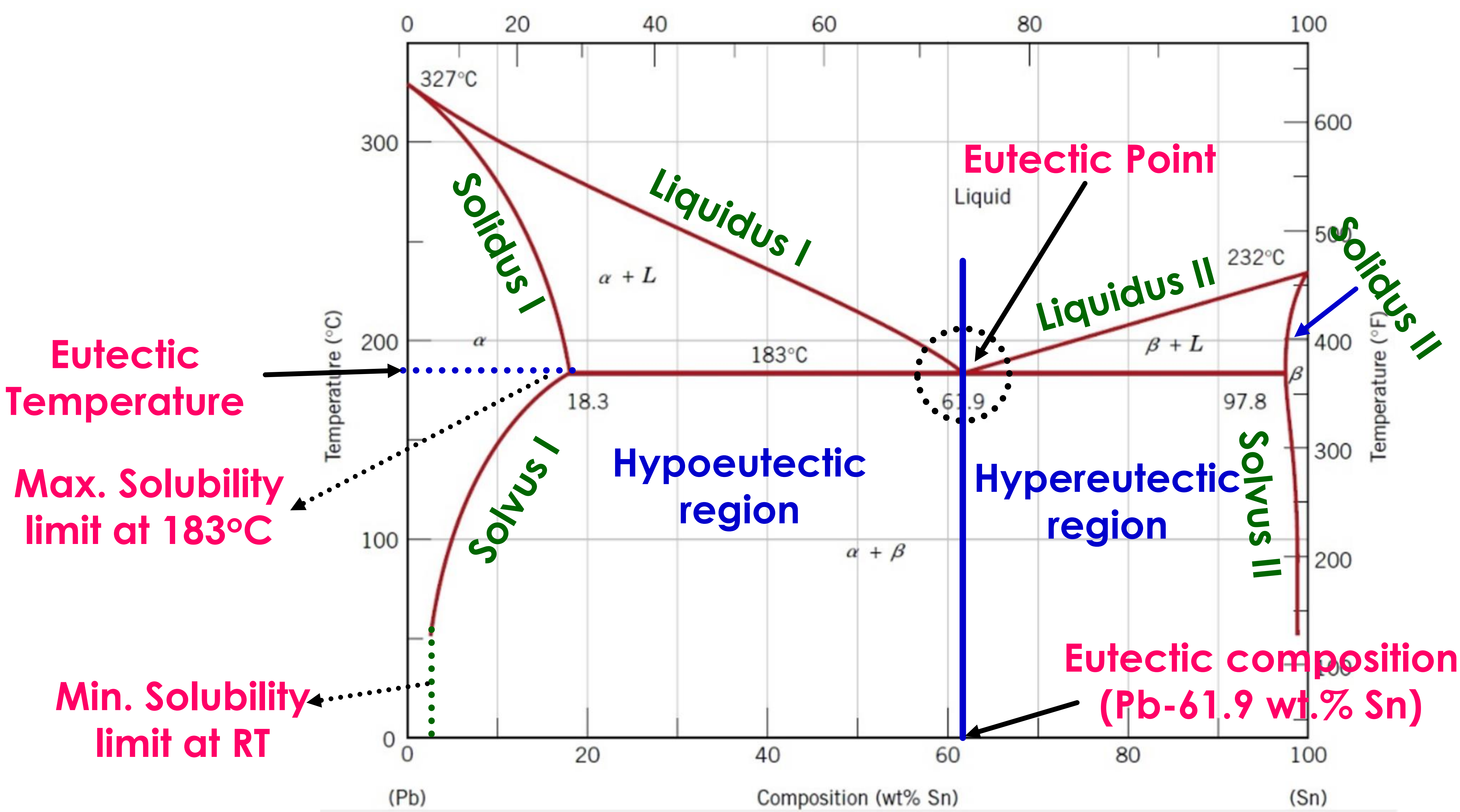
Three Phase Reactions

Eutectic	**Cooling** → $L \rightarrow \alpha + \beta$ ← **heating**	
Peritectic	**Cooling** → $\alpha + L \rightarrow \beta$ ← **heating**	
Eutectoid	**Cooling** → $\gamma \rightarrow \alpha + \beta$ ← **heating**	
Peritectoid	**Cooling** → $\alpha + \beta \rightarrow \gamma$ ← **heating**	

Binary Eutectic Systems (easily melted)

When solid solubility is limited and the melting points of the components are not vastly different.

Pb-Sn Equilibrium Phase Diagram

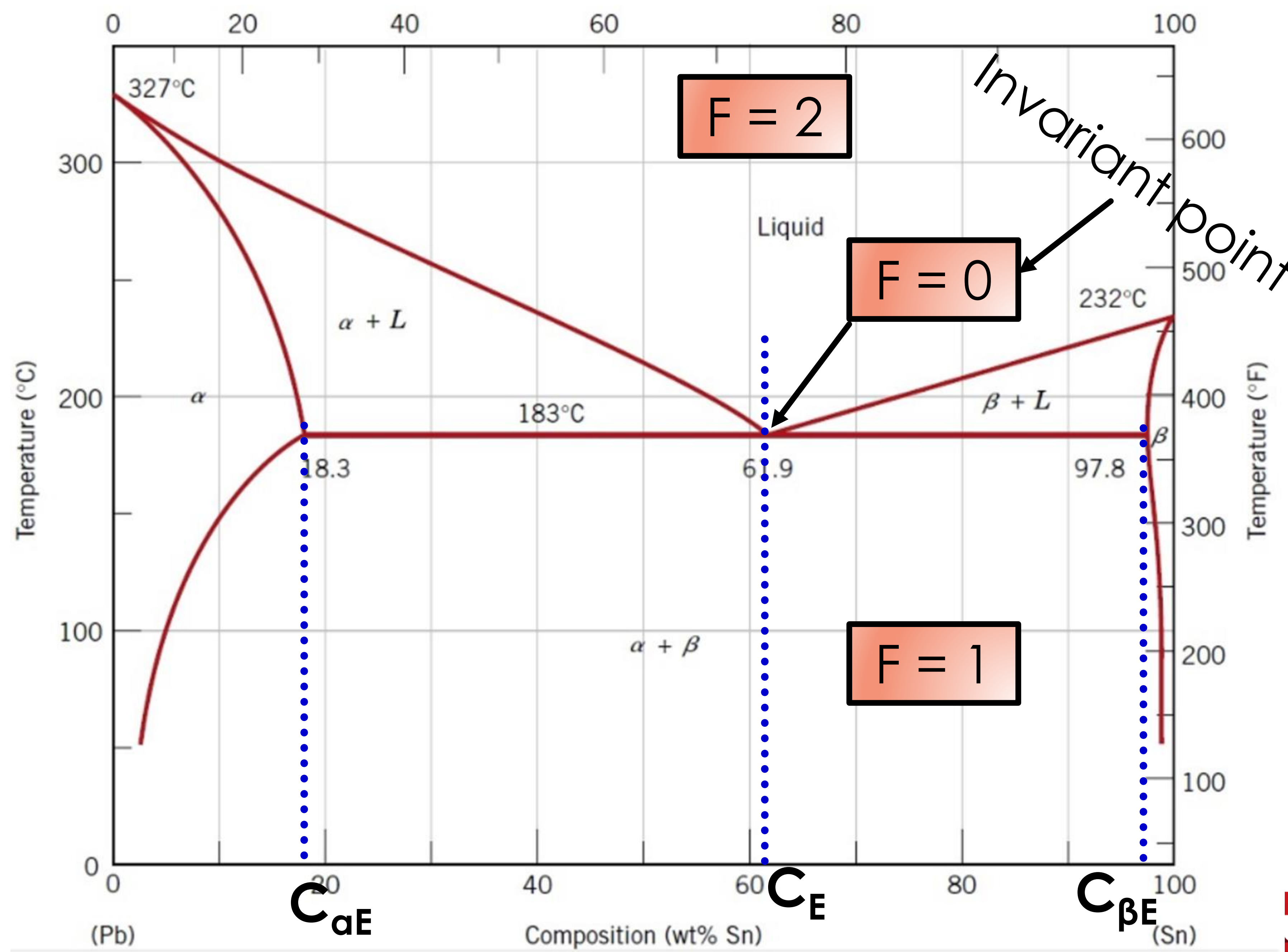


Binary Eutectic Phase Diagram

Gibbs Phase Rule $F = C - P + 1$ Pressure: 1 atm.

Eutectic Reaction:

$$L\ (C_E) \underset{\text{Cool}}{\overset{\text{heat}}{\leftrightharpoons}} \alpha\ (C_{\alpha E}) + \beta\ (C_{\beta E})$$



EX 1: Pb-Sn Eutectic System

- For a 40 wt% Sn-60 wt% Pb alloy at 150°C, determine:

  -- the phases present

  Answer: α + β

  -- the phase compositions

  Answer: C_α = 11 wt% Sn

  C_β = 99 wt% Sn

  -- the relative amount of each phase

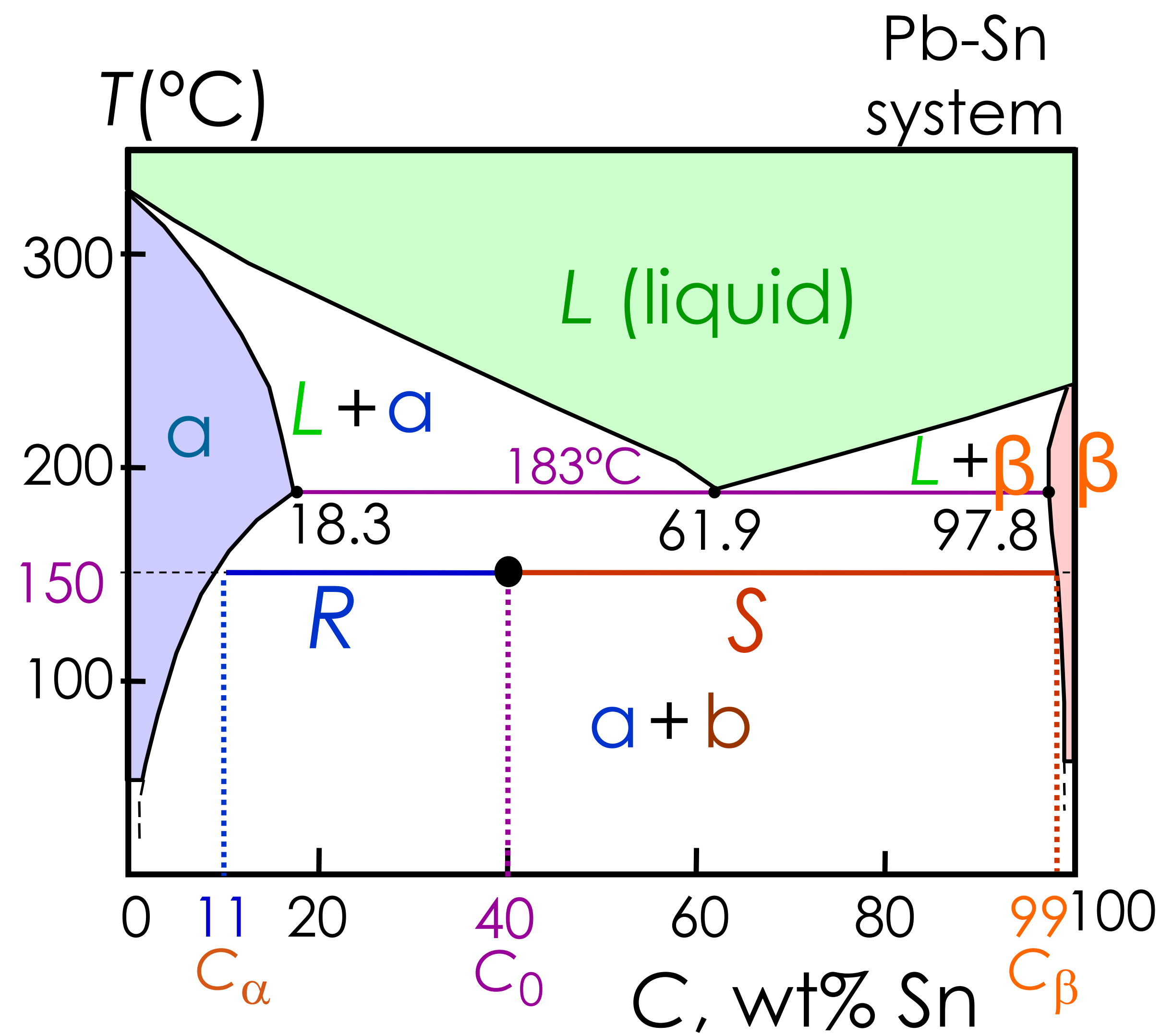
  Answer:

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

$$= \frac{99 - 40}{99 - 11} = \frac{59}{88} = 0.67$$

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

$$= \frac{40 - 11}{99 - 11} = \frac{29}{88} = 0.33$$



EX 2: Pb-Sn Eutectic System

- For a 40 wt% Sn-60 wt% Pb alloy at 220°C, determine:

  -- the phases present:

  Answer: α + *L*

  -- the phase compositions

  Answer: C_α = 17 wt% Sn
  C_L = 46 wt% Sn

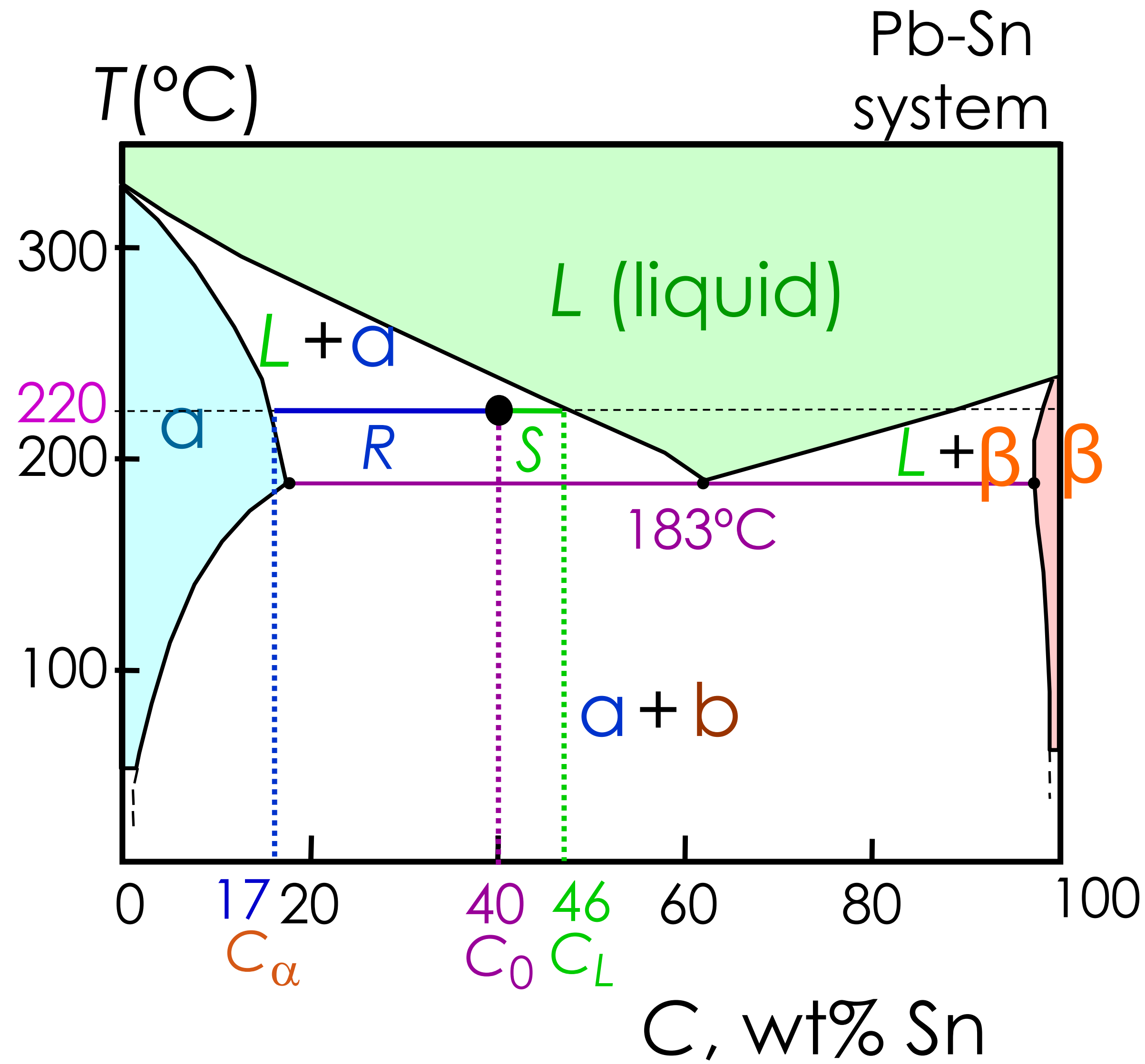
  -- the relative amount of each phase

  Answer:

$$W_\alpha = \frac{C_L - C_0}{C_L - C_\alpha} = \frac{46 - 40}{46 - 17}$$

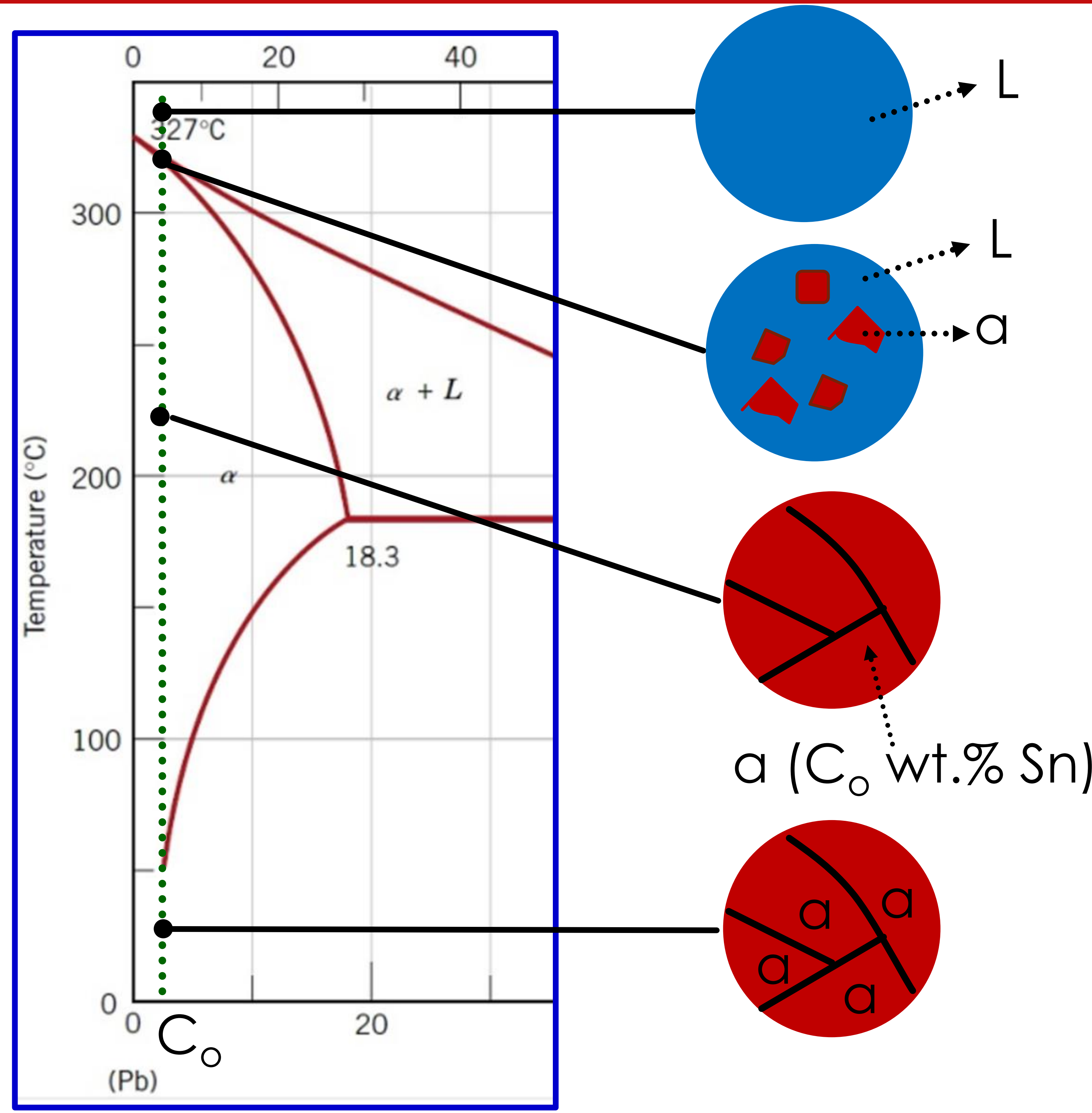
$$= \frac{6}{29} = 0.21$$

$$W_L = \frac{C_0 - C_\alpha}{C_L - C_\alpha} = \frac{23}{29} = 0.79$$



Microstructure development

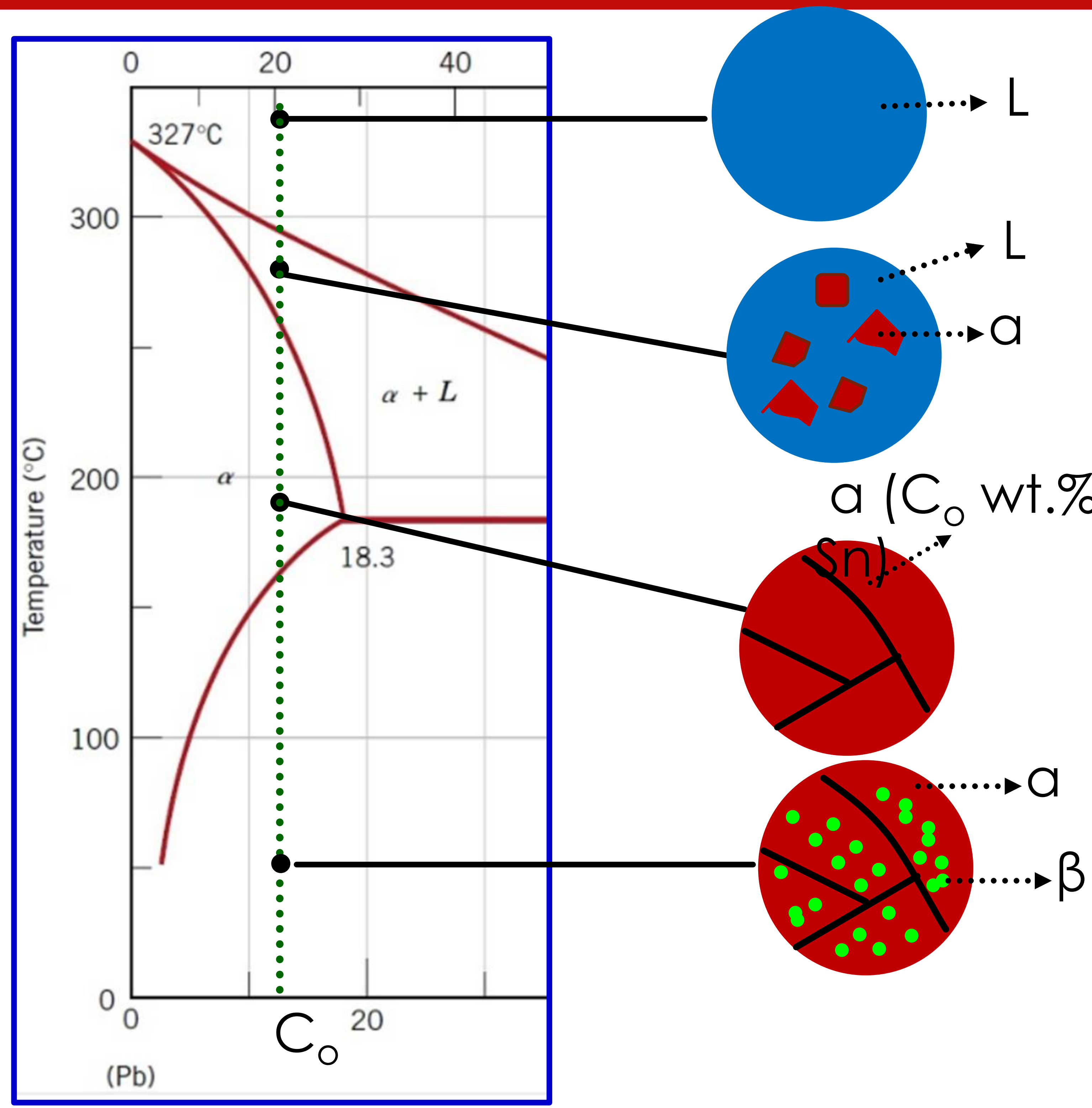
- For alloys where C_o < 2 wt% Sn
- Result at room temperature is a polycrystalline with grains of a phase having composition C_o.



Microstructure development

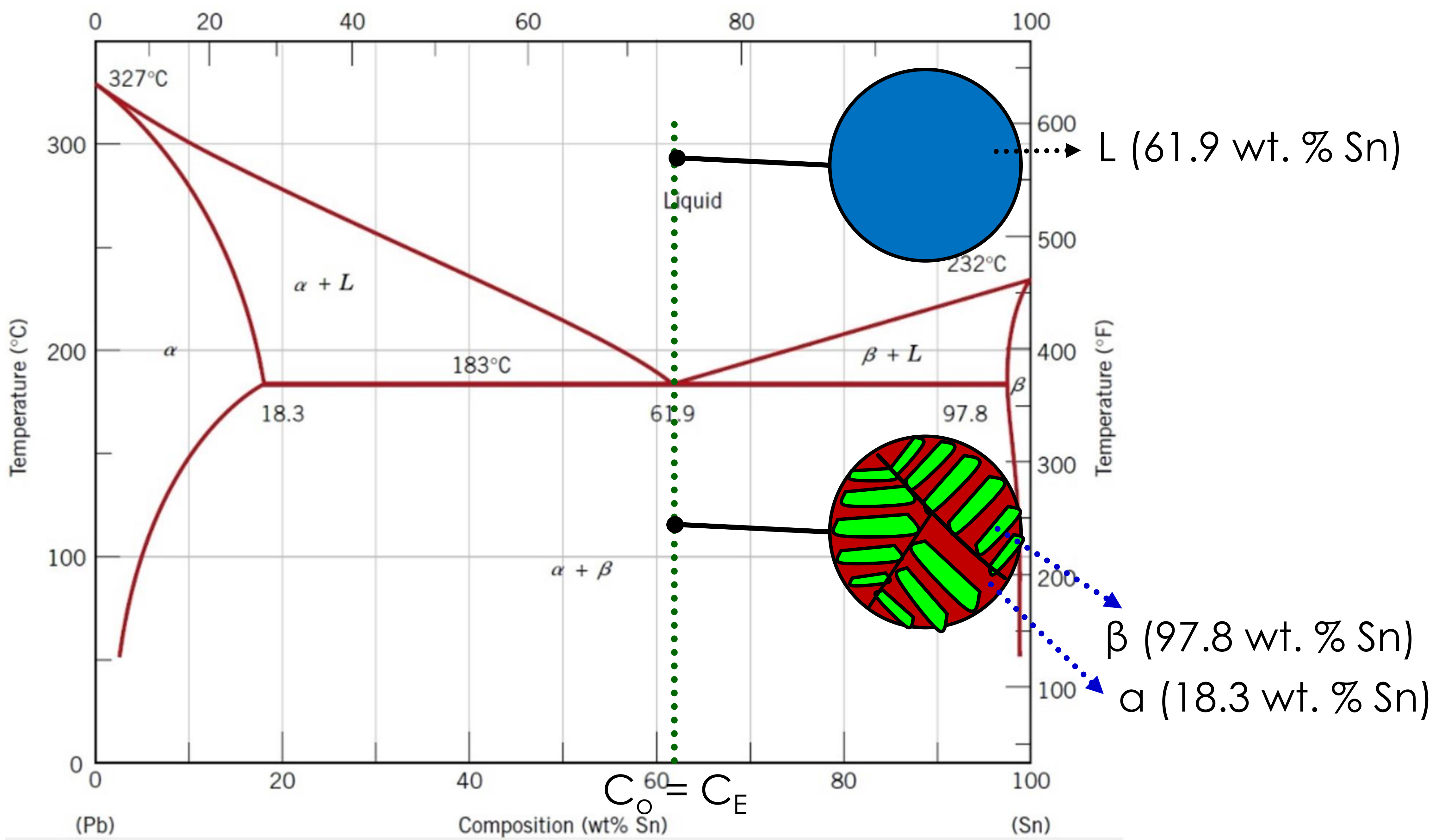
- 2 wt% Sn < C_o < 18.3 wt% Sn

- Results in polycrystalline microstructure with α grains and small β-phase particles at lower temperatures.



Microstructure development

- $C_o = C_E$
- Results in a eutectic microstructure with alternating layers of α and β crystals.

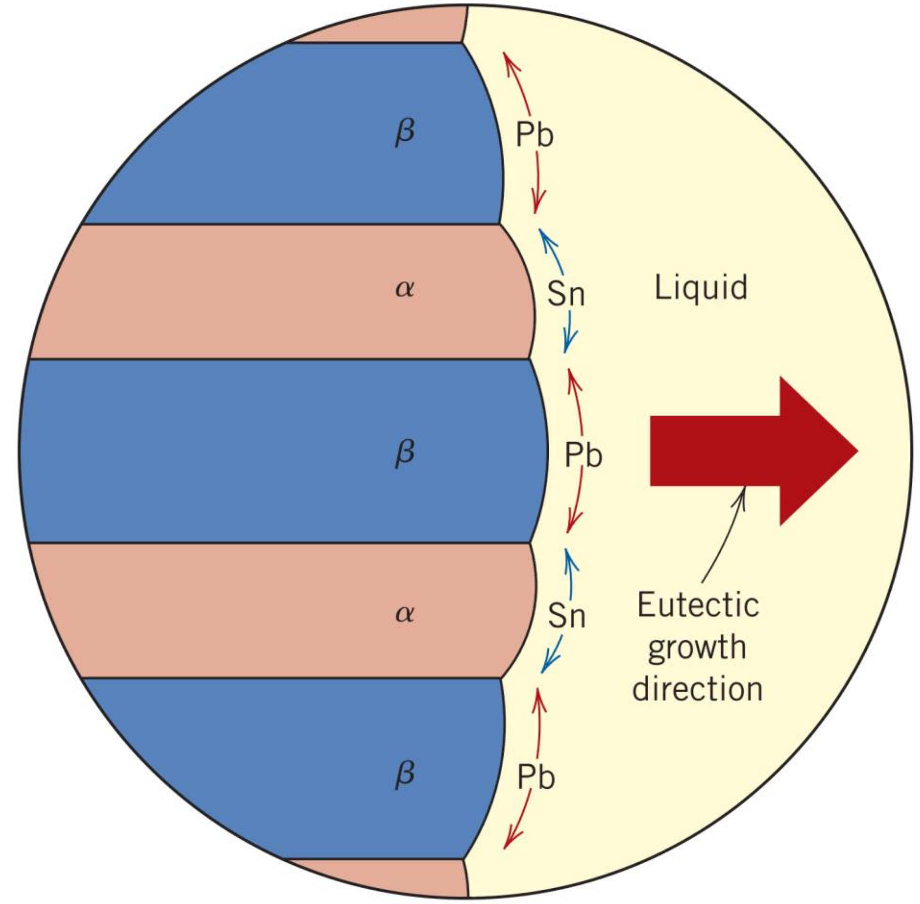


$$L(61.9\,\text{wt\% Sn}) \underset{\text{heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \alpha(18.3\,\text{wt\% Sn}) + \beta(97.8\,\text{wt\% Sn})$$

Lamellar Eutectic Microstructure

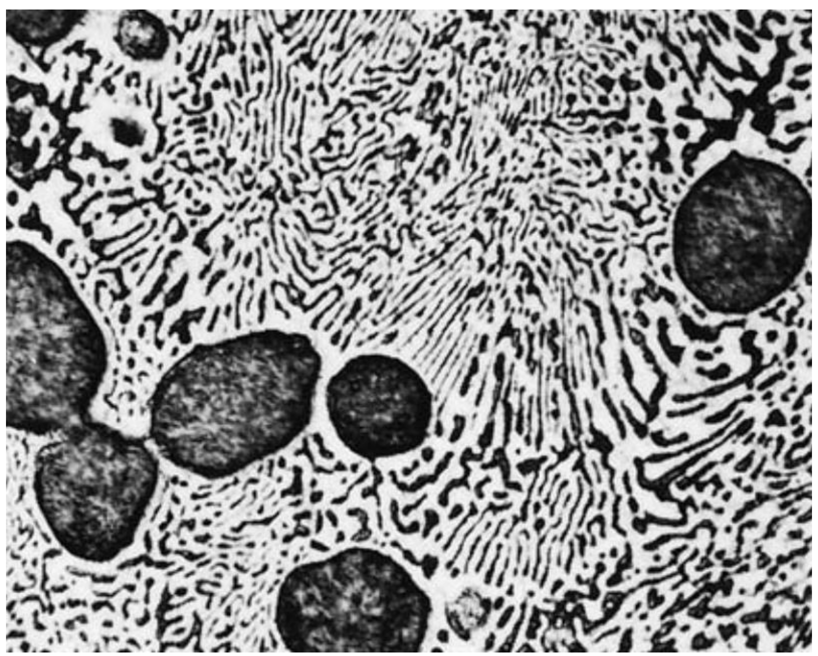
- A 2-phase microstructure resulting from the solidification of a liquid having the eutectic composition where the phases exist as a lamellae that alternate with one another.

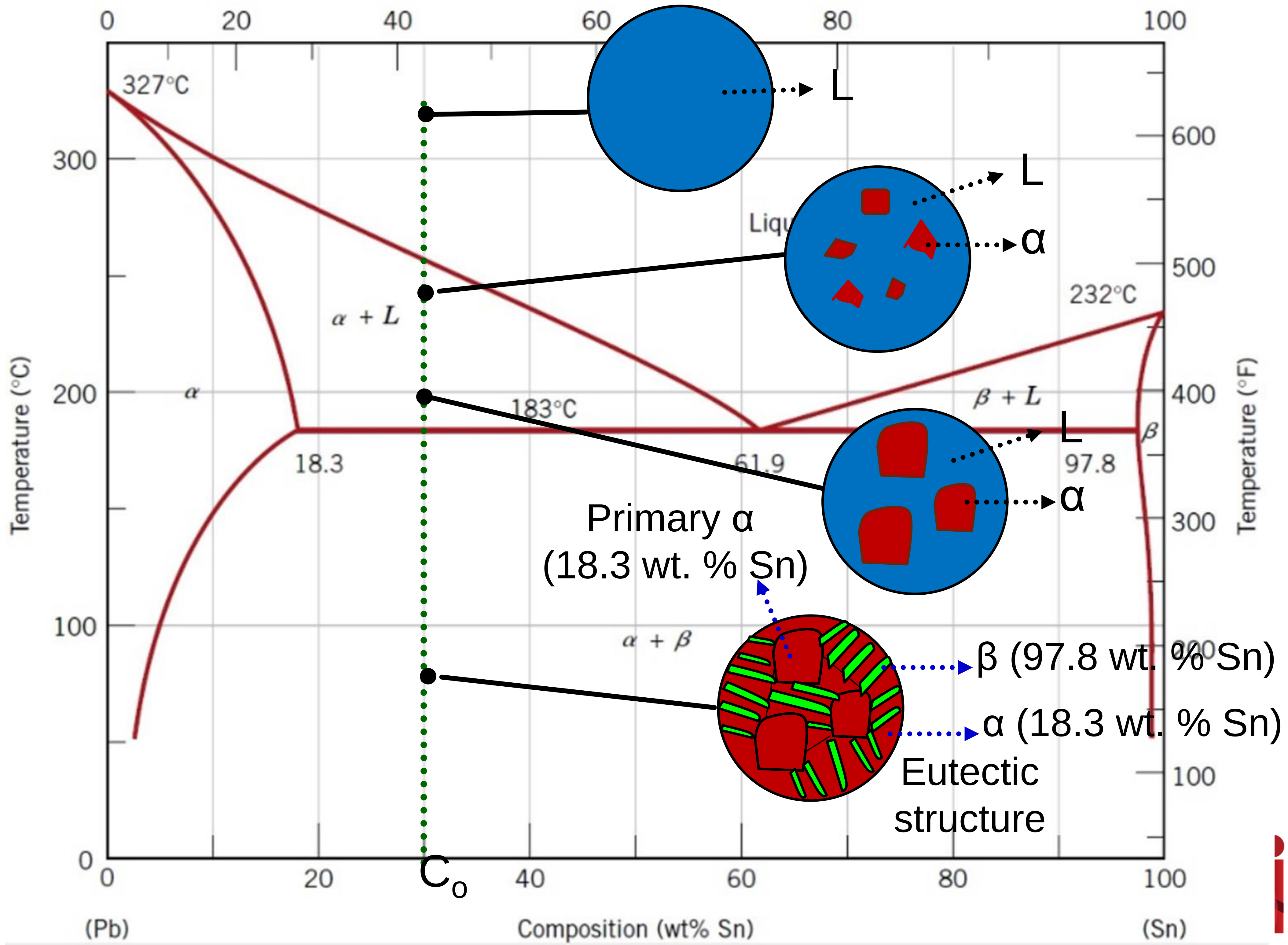
- Formation of eutectic layered microstructure in the Pb-Sn system during solidification at the eutectic composition. Compositions of a and β phases are very different. Solidification involves redistribution of Pb and Sn atoms by atomic diffusion.



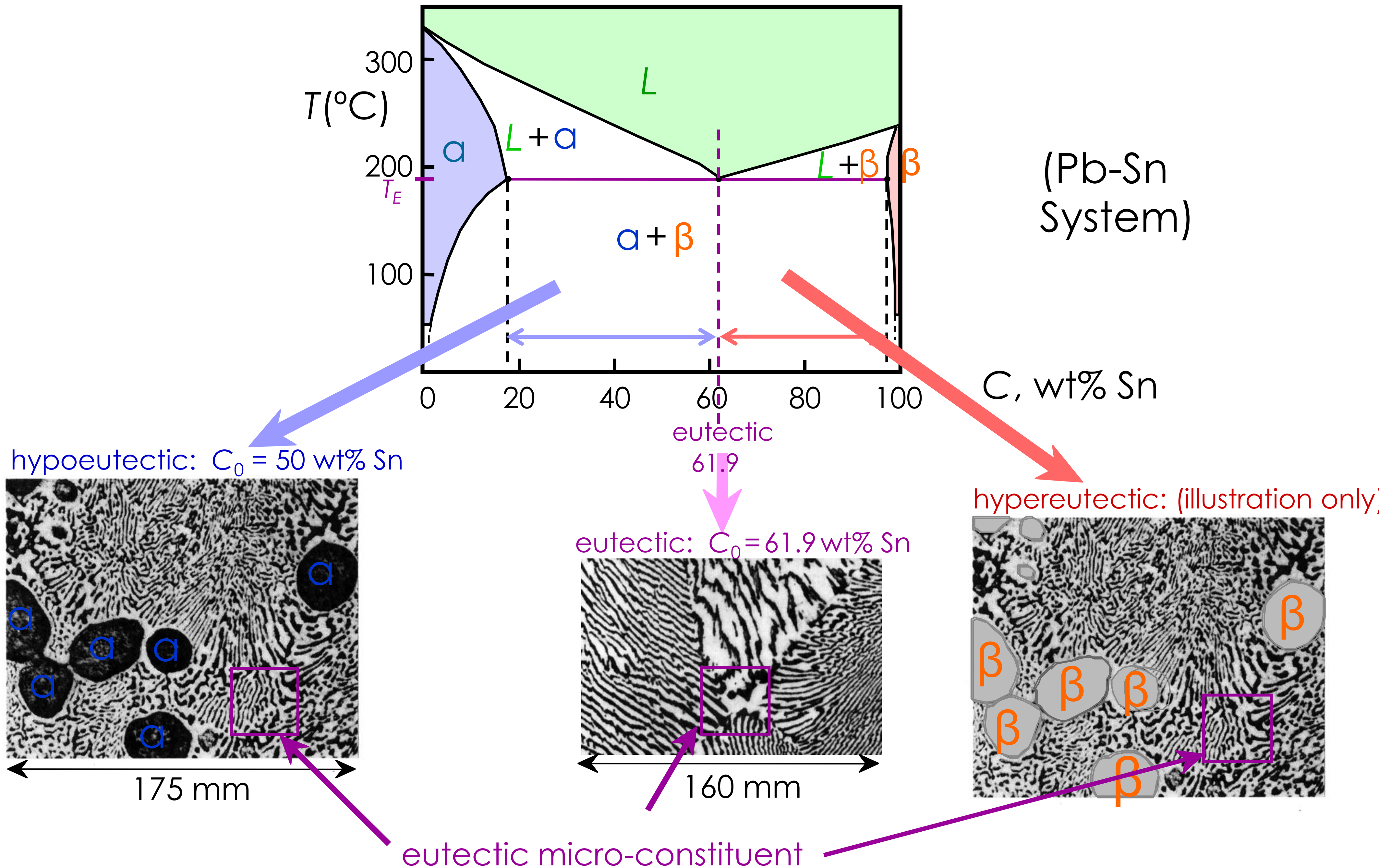
Microstructure development

- C_o = 30 wt. % Sn
- Microstructure consists of primary a phase and an eutectic structure between a and β phases



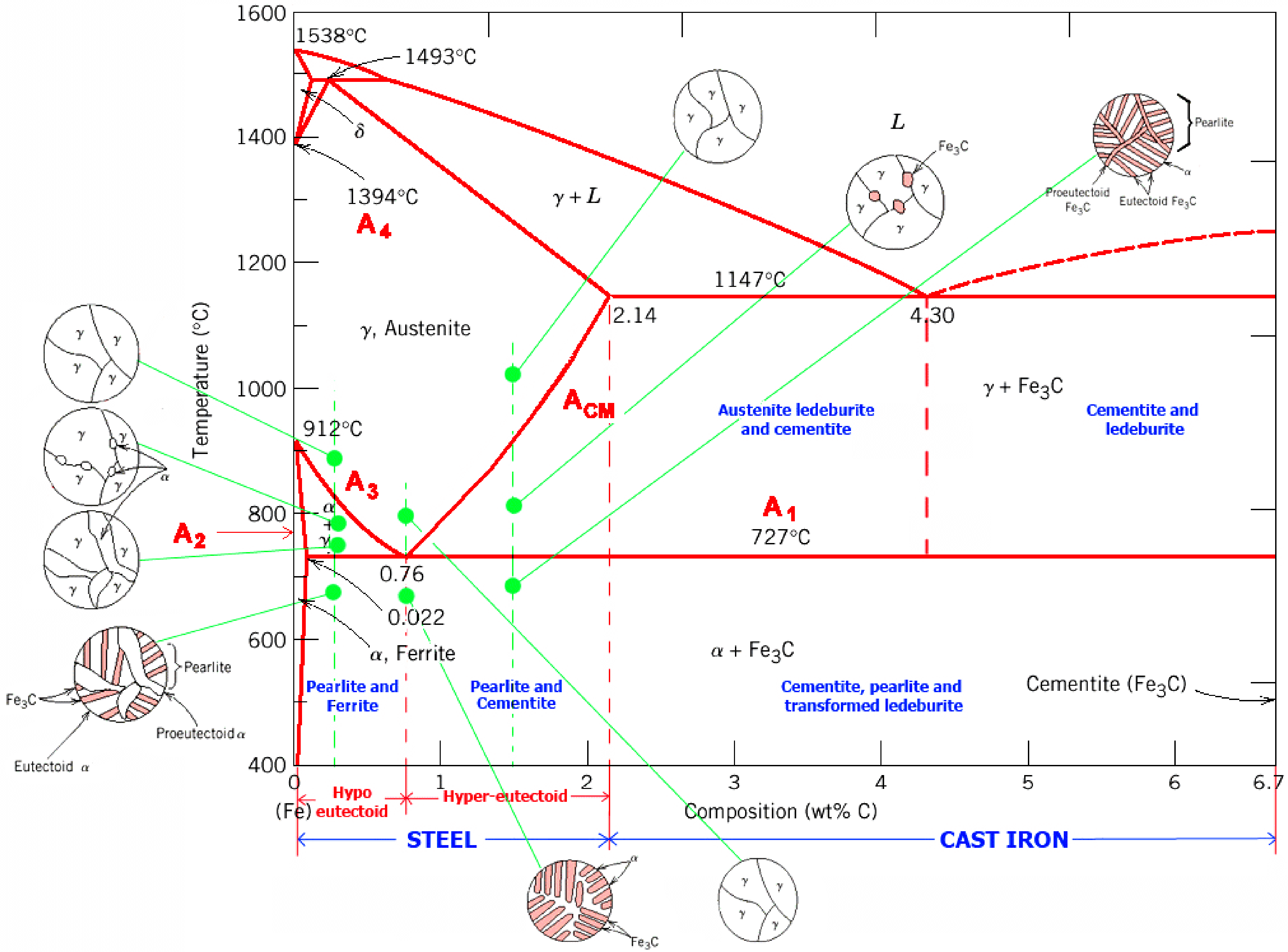


Hypoeutectic & Hypereutectic



Iron-Carbon Phase Diagram

Identify the different reactions in this phase diagram



Summary

1. Binary eutectic phase diagram have a composition where it behaves like a metal called as eutectic composition.

2. Lamellar structure forms at the eutectic composition and below eutectic temperature.

3. Below and above the eutectic composition, the microstructure has primary or proeutectic alpha or beta phase also.