MLL 100

Introduction to Materials Science and Engineering

Lecture-12 (February 01, 2022)

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What have we learnt in Lecture-11?

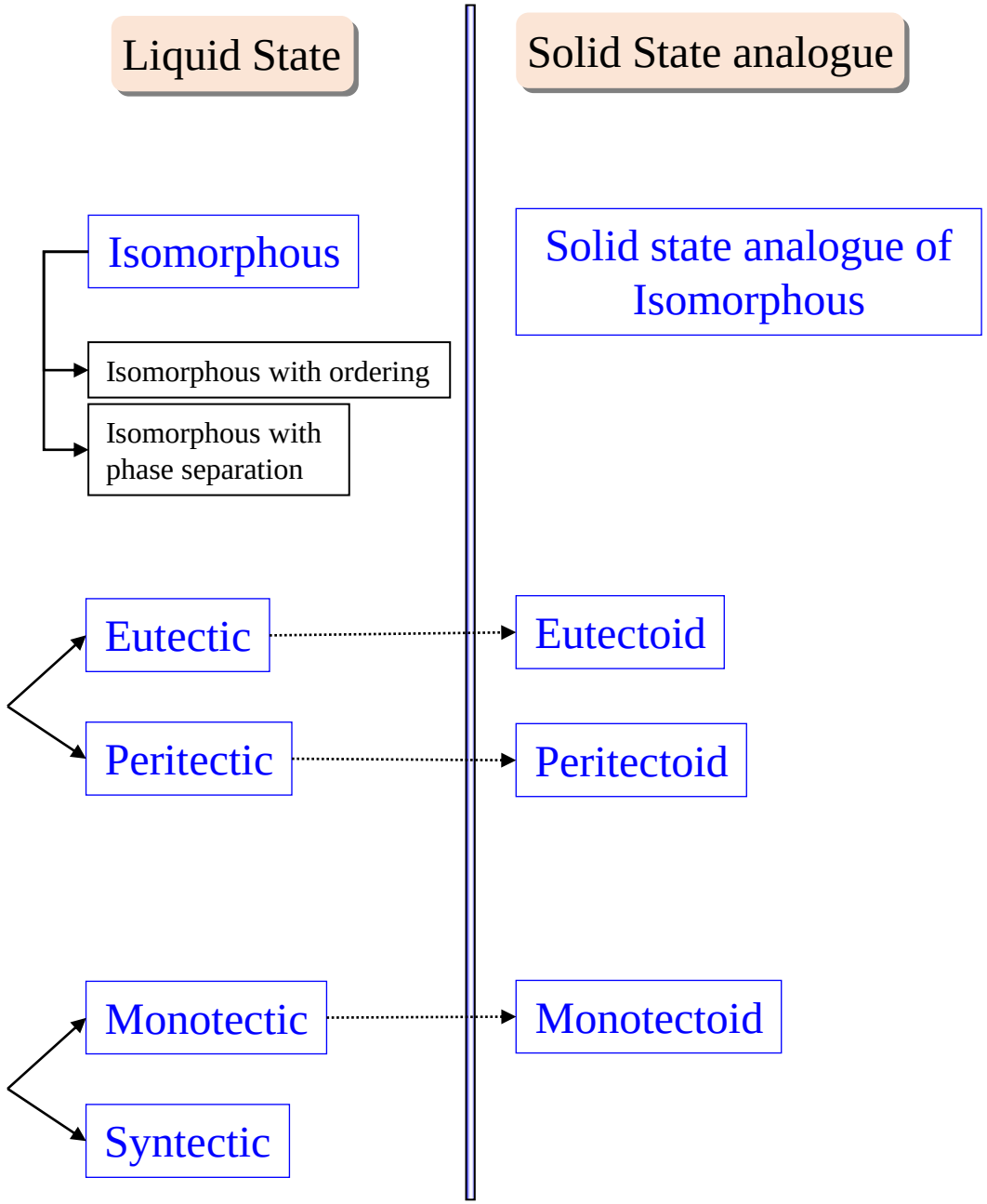
- Cooling curve
- Microstructure
- Solidification of an alloy in an isomorphous system
- Solid solution
- Hume Rothery rule

Possible scenarios in a binary phase diagram

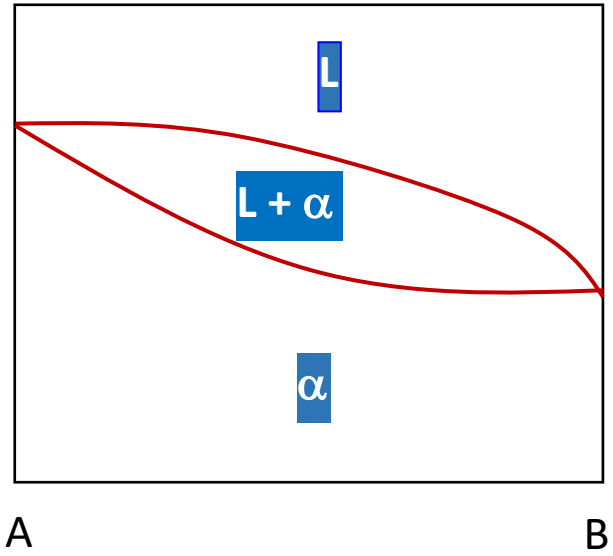
- **Complete solubility in both liquid and solid states**

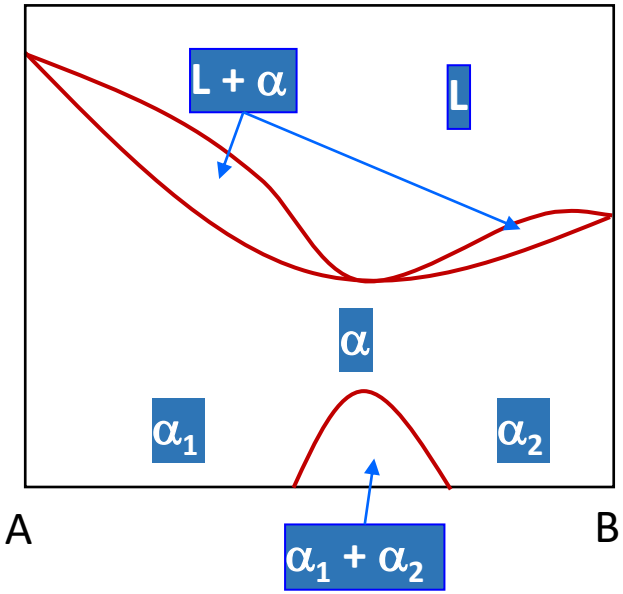
- **Complete Solubility in liquid state, but limited solubility in the solid state**

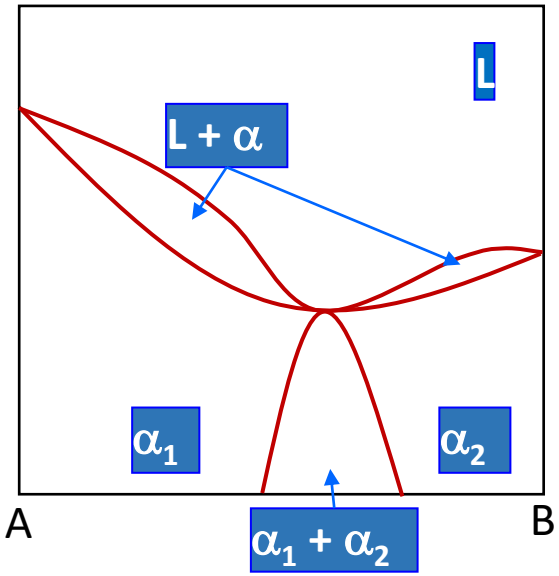
- **Limited Solubility in both liquid and solid states**

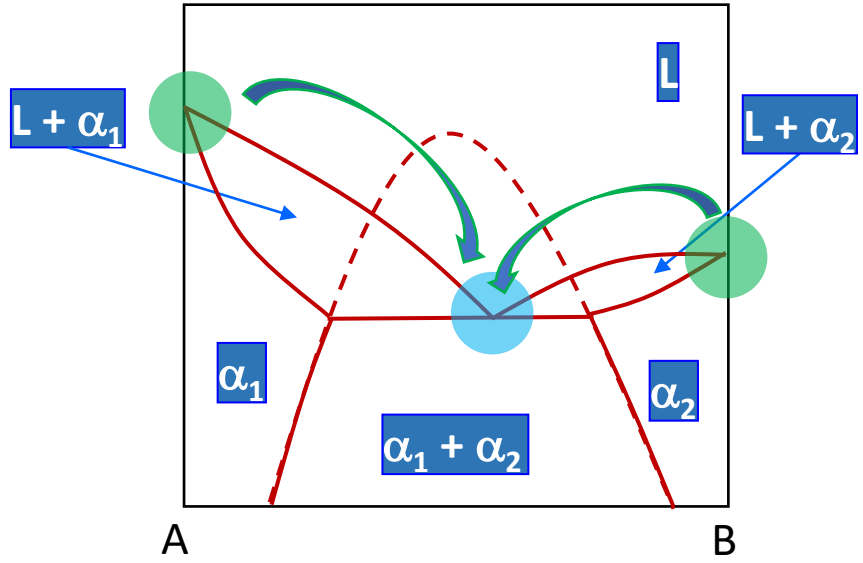


Isomorphous ⟶ Eutectic phase diagram



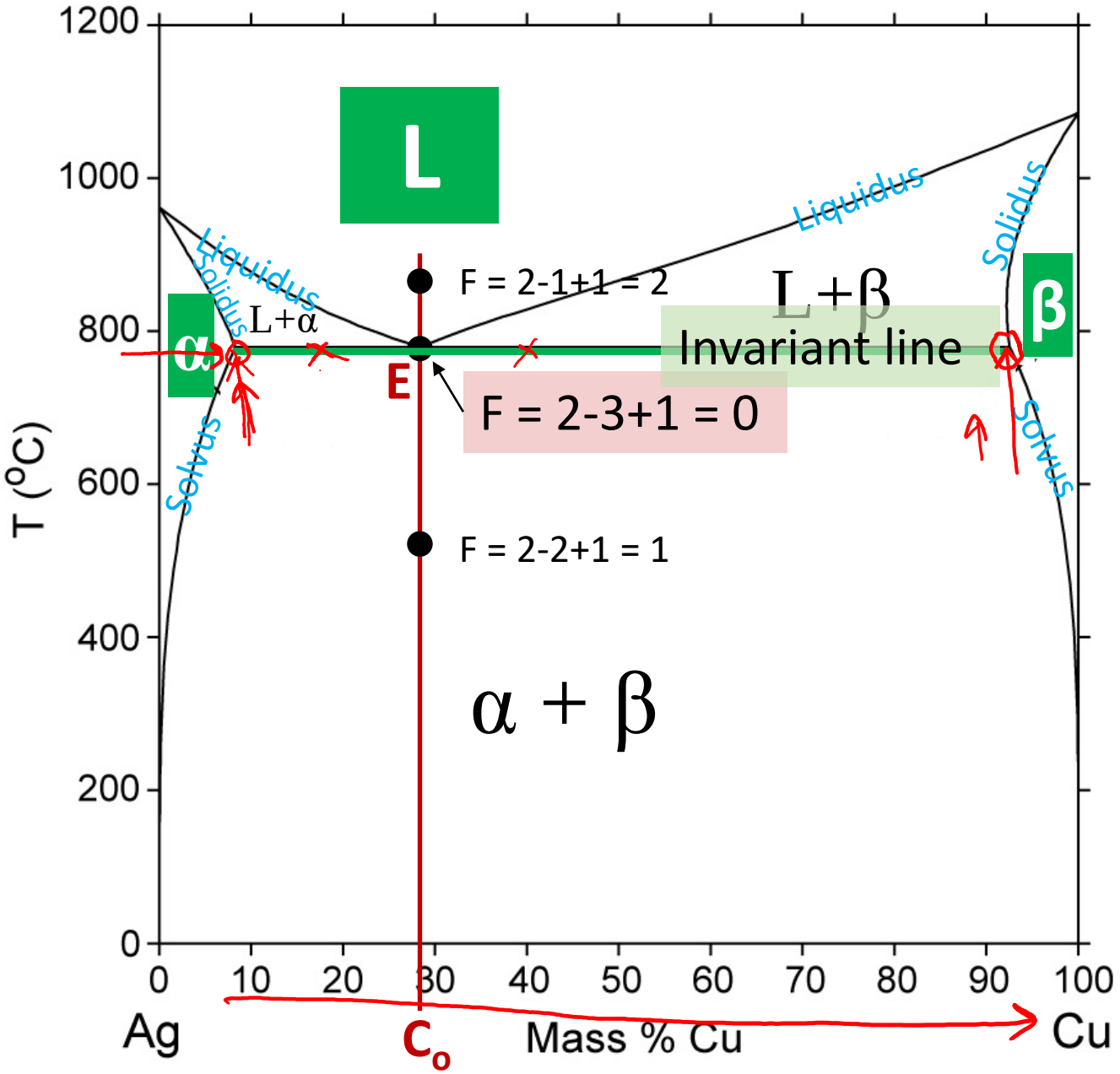






- *Eutēktos: Easily melted*
- Any homogeneous material melting or solidifying at a particular temperature which is lower than the melting point of any of the components.

Eutectic phase diagram



Invariant point

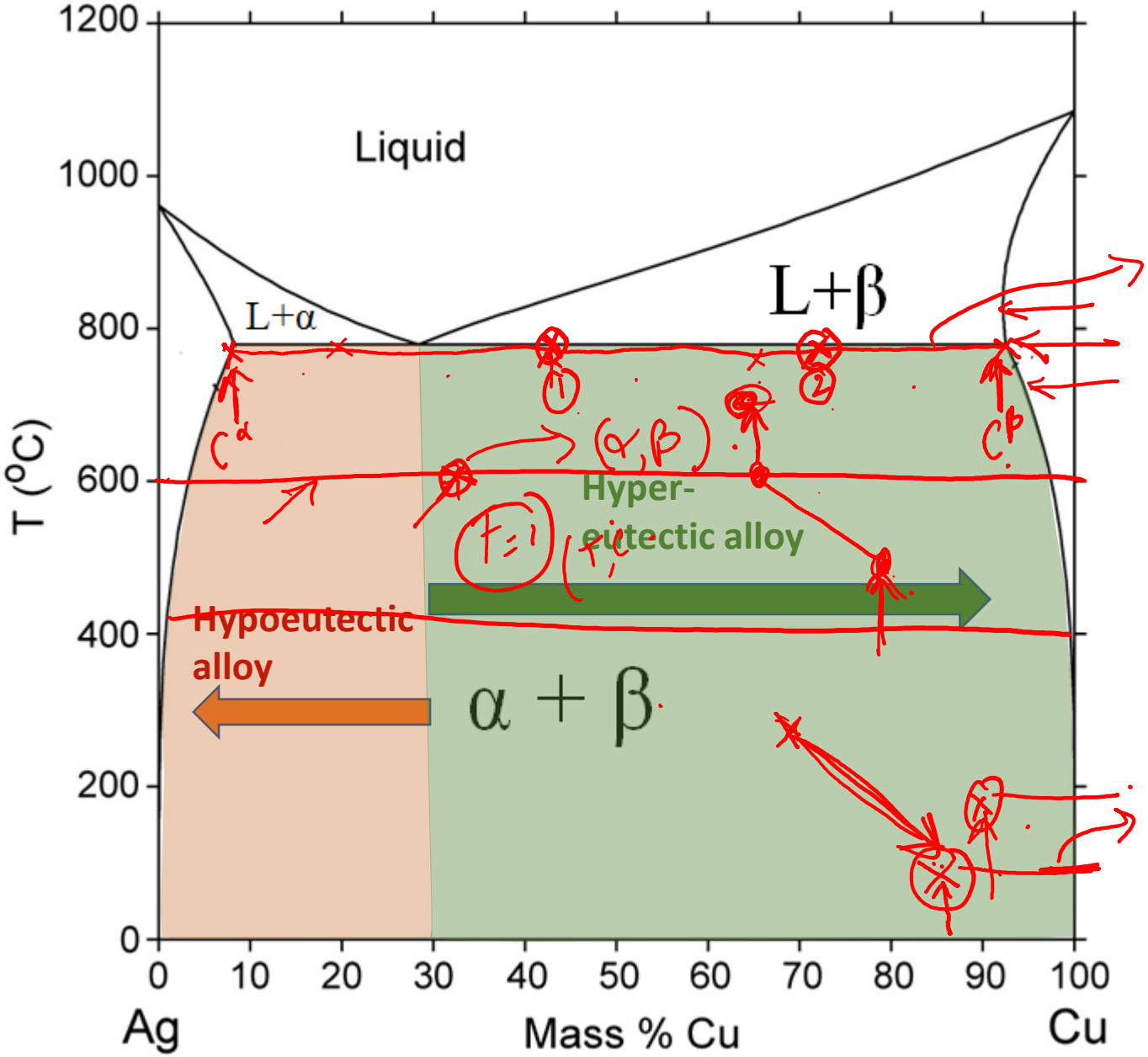
Invariant: Remains unchanged

- *Eutectic point* ('E') is an invariant point which occurs at a fixed composition and temperature for a given binary phase diagram.
- At 'E', eutectic reaction takes place:

$$L(C_o) \xrightarrow{\text{cooling}} \alpha + \beta$$

- Green line is the invariant line.
- **Solvus phase boundary**: Boundary line that divides a solid solution and a two-phase solid solution region.

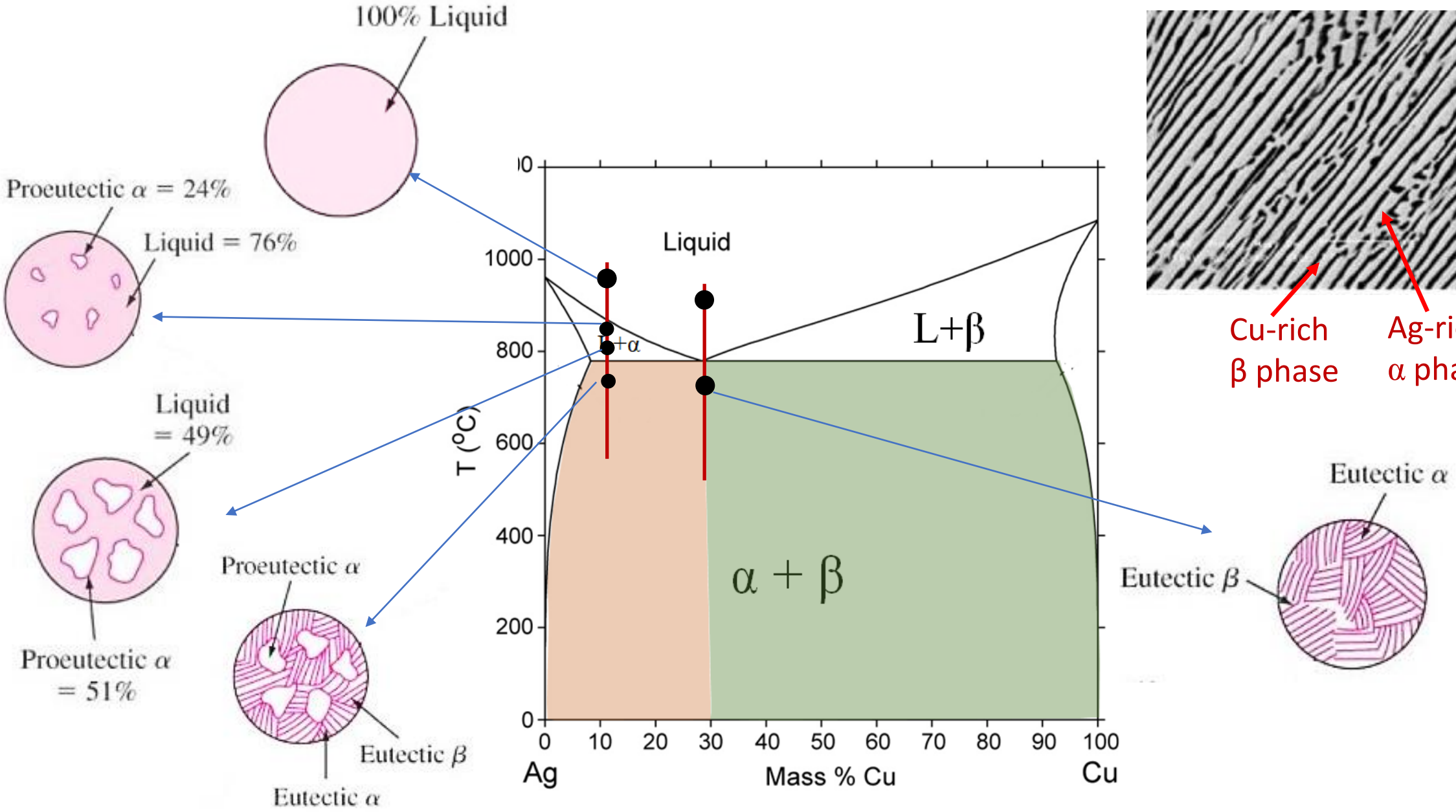
Hypo- and Hyper-eutectic alloy



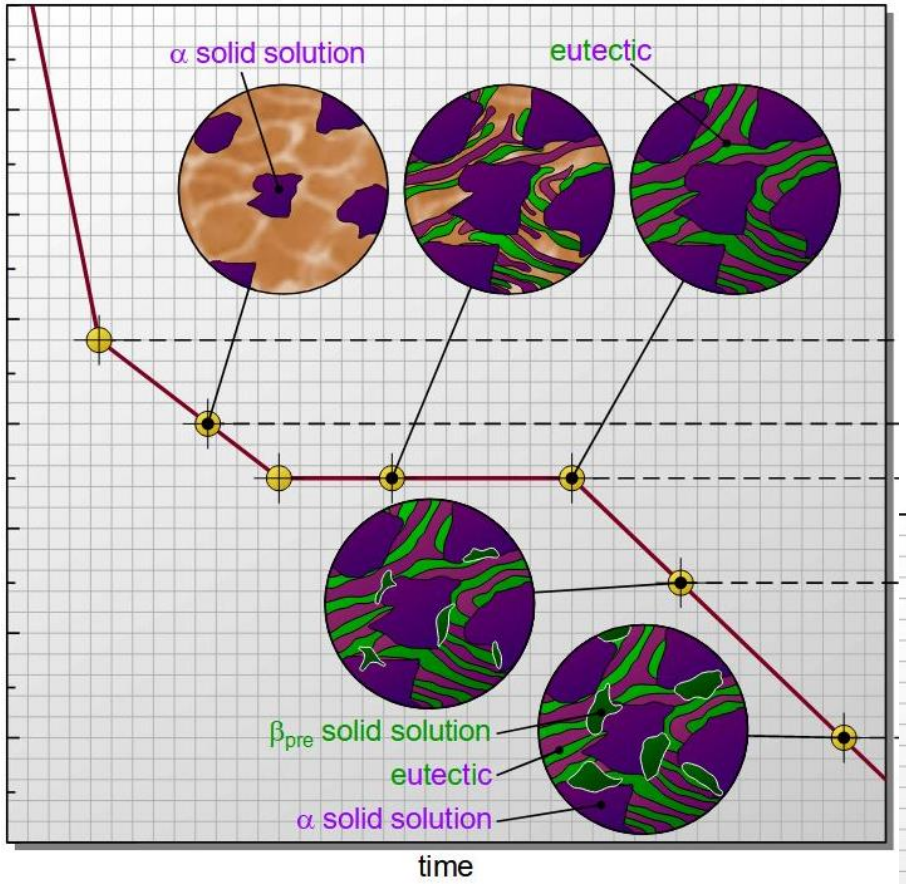
Eutectic line (T is fixed)

(C^{α}, C^{β}) → ①, ②

Microstructural evolution of hypoeutectic alloy and eutectic alloy

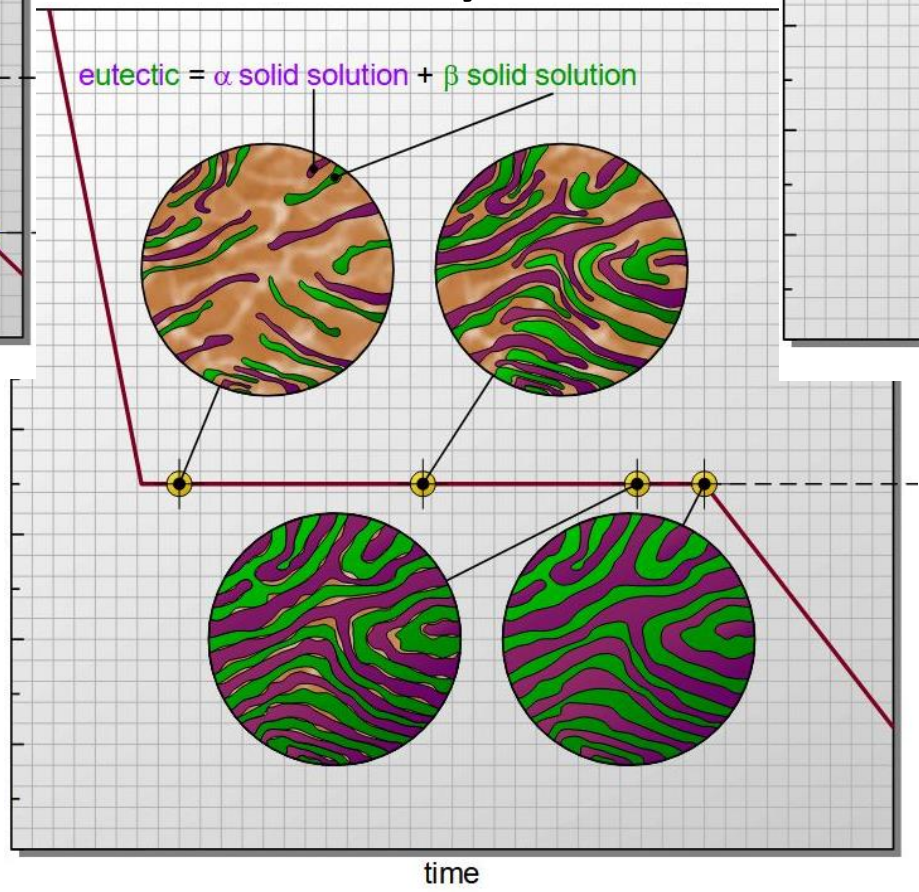


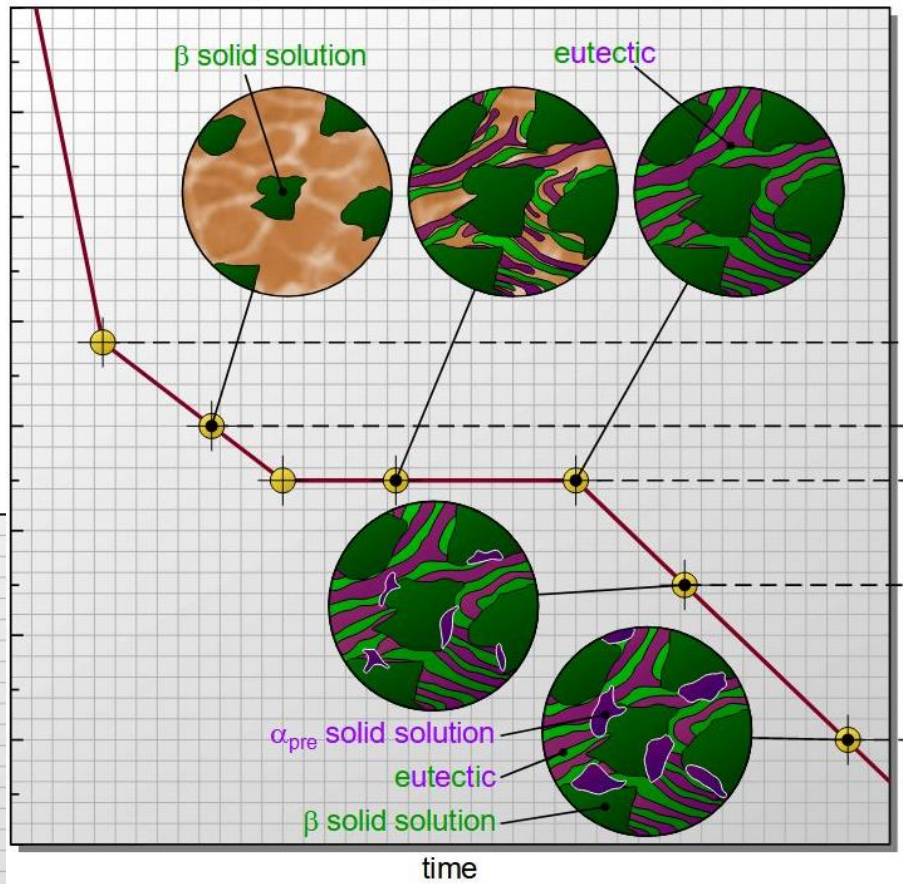
Cooling curve



Solidification of a hypoeutectic alloy

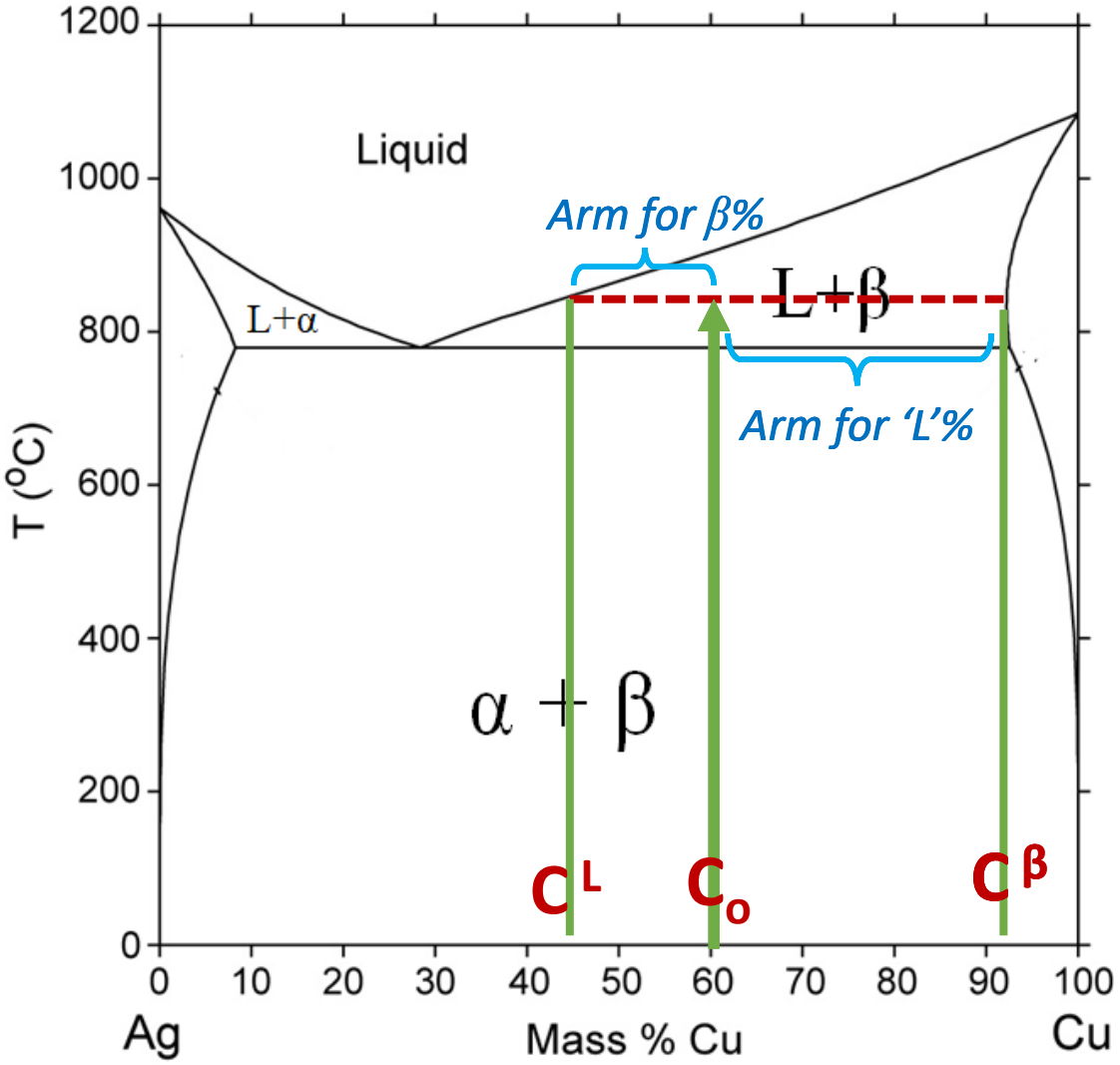
Solidification of an eutectic alloy





Solidification of a hypereutectic alloy

What are the fractions of 'L' and 'β' phases present at T = 830 °C for an alloy with composition of C_o?



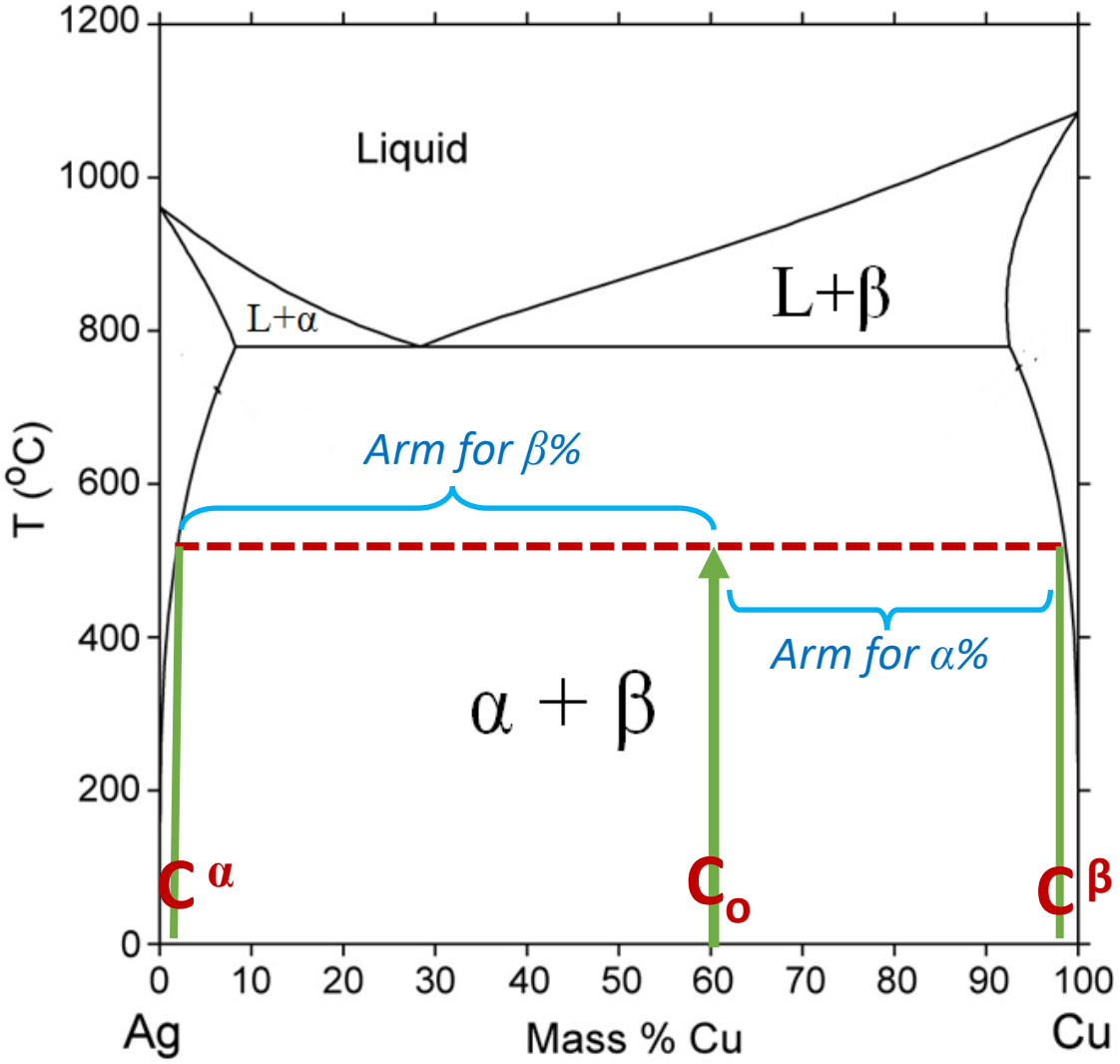
$$f_\beta = \frac{(C_o - C^L)}{(C^\beta - C^L)}$$

$$f_\beta = \frac{(60 - 45)}{(92 - 45)}$$

$$f_\beta = 32\%$$

$$f_L = 68\%$$

What are the fractions of ‘α’ and ‘β’ phases present at T = 530 °C for an alloy with composition of C_o?



$$f_\beta = \frac{(C_o - C^\alpha)}{(C^\beta - C^\alpha)}$$

$$f_\beta = \frac{(60 - 2)}{(98 - 2)}$$

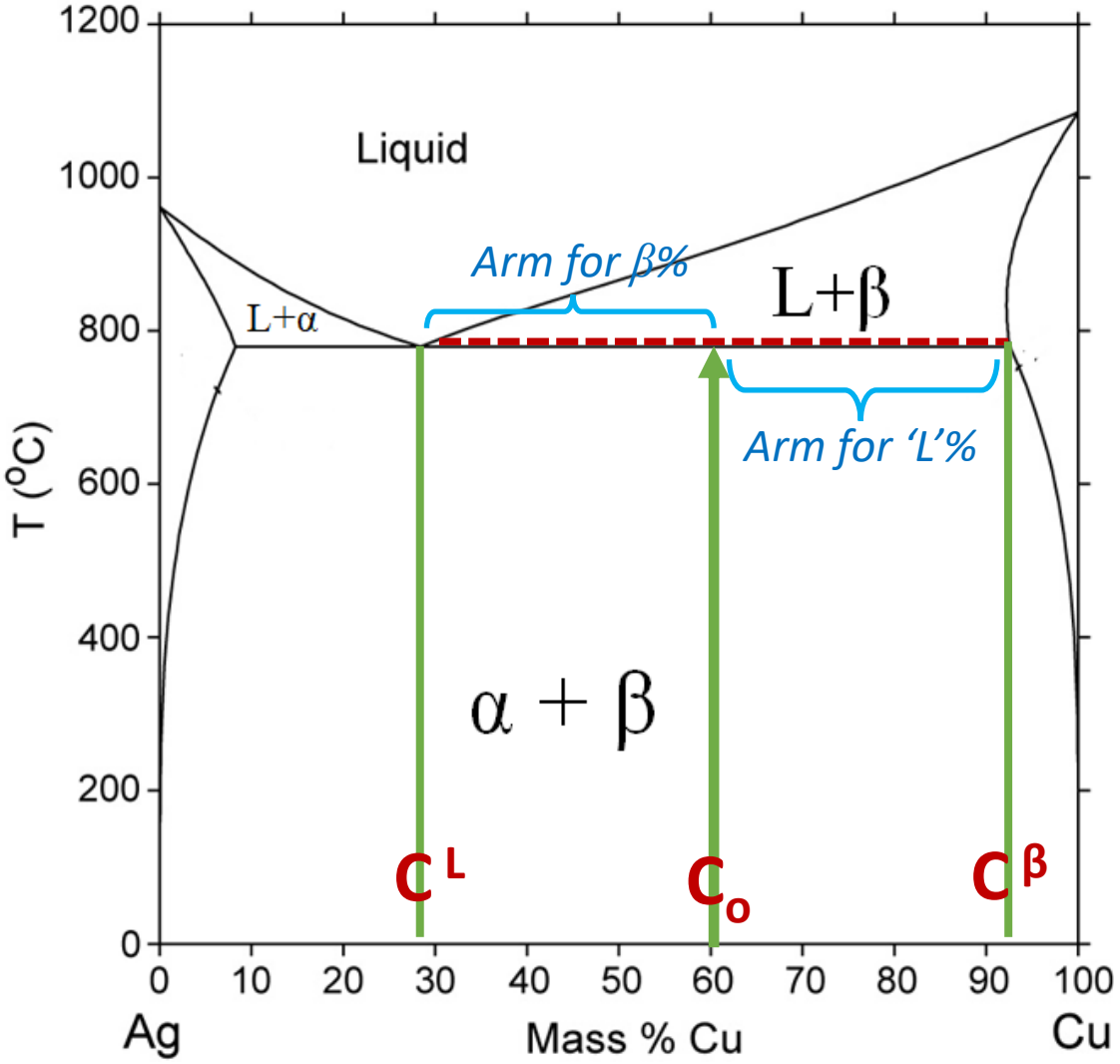
$$f_\beta = 60.4\%$$

$$f_\alpha = \frac{(C^\beta - C_o)}{(C^\beta - C^\alpha)}$$

$$f_\alpha = \frac{(98 - 60)}{(98 - 2)}$$

$$f_\alpha = 39.6\%$$

What are the fractions of 'L' and 'pro-eutectic β' phases present at the eutectic temperature for an alloy with composition of C_o?



$$f_\beta = \frac{(C_o - C^L)}{(C^\beta - C^L)}$$

$$f_\beta = \frac{(60 - 28)}{(92 - 28)}$$

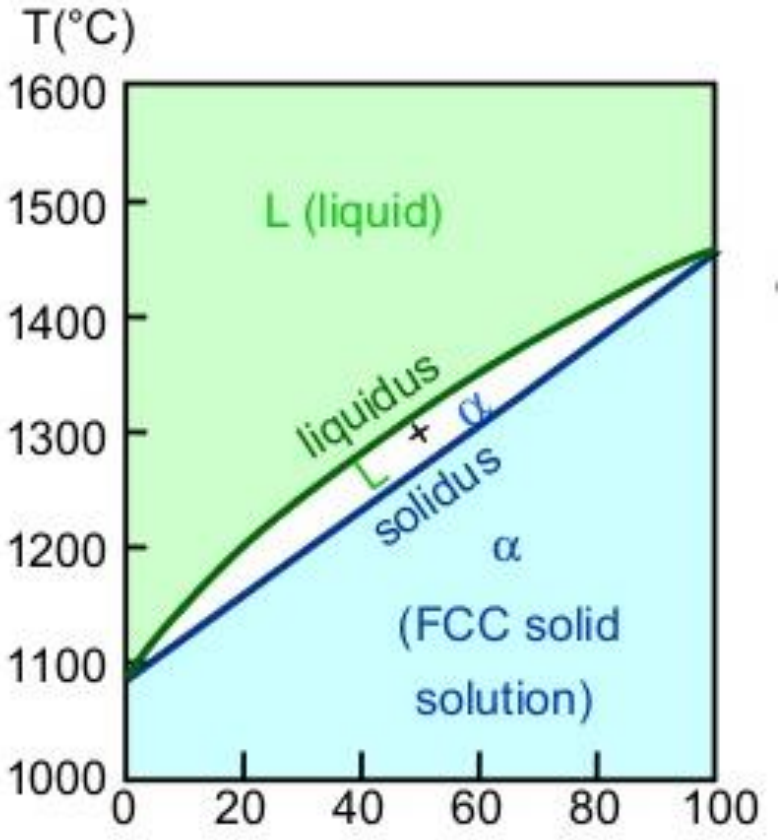
$$f_\beta = 50\%$$

$$f_L = \frac{(C^\beta - C_o)}{(C^\beta - C^L)}$$

$$f_L = \frac{(92 - 60)}{(92 - 28)}$$

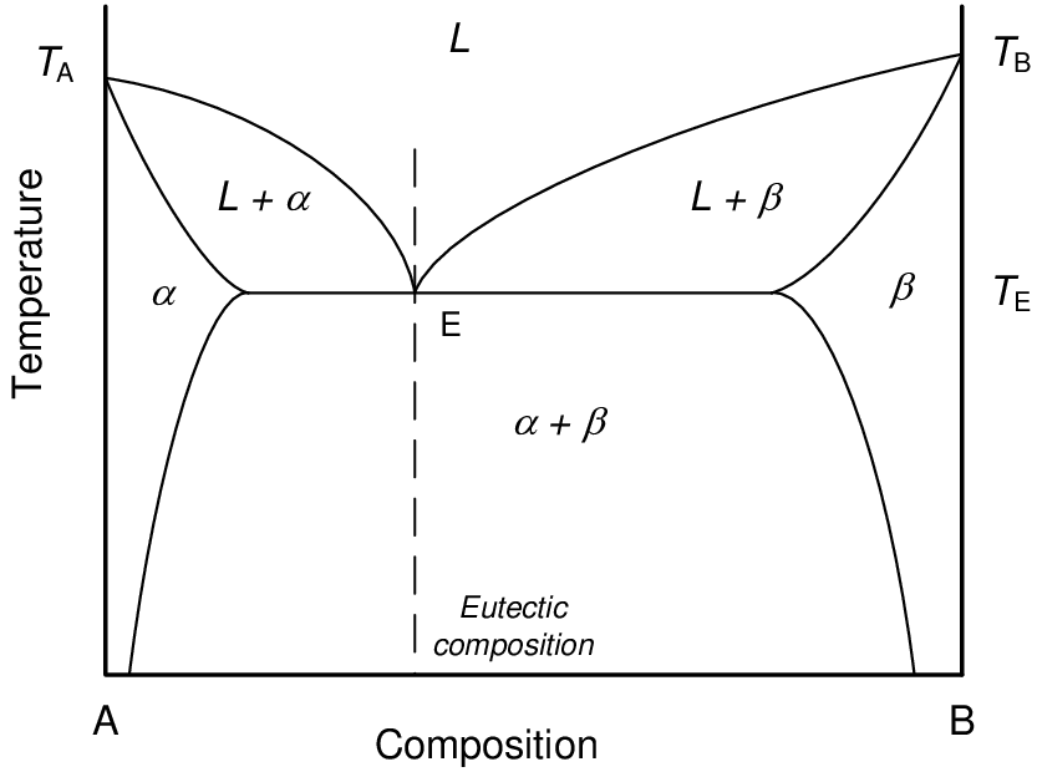
$$f_L = 50\%$$

Isomorphous

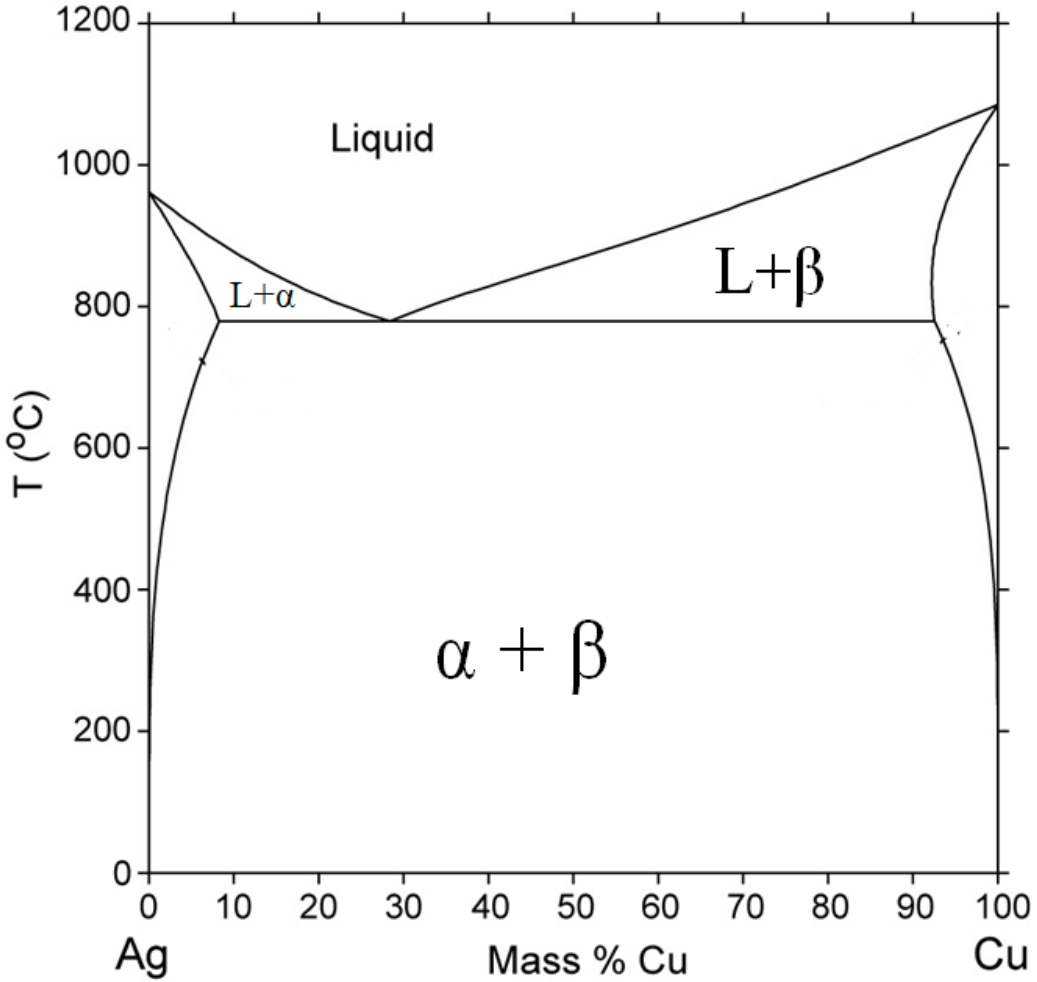


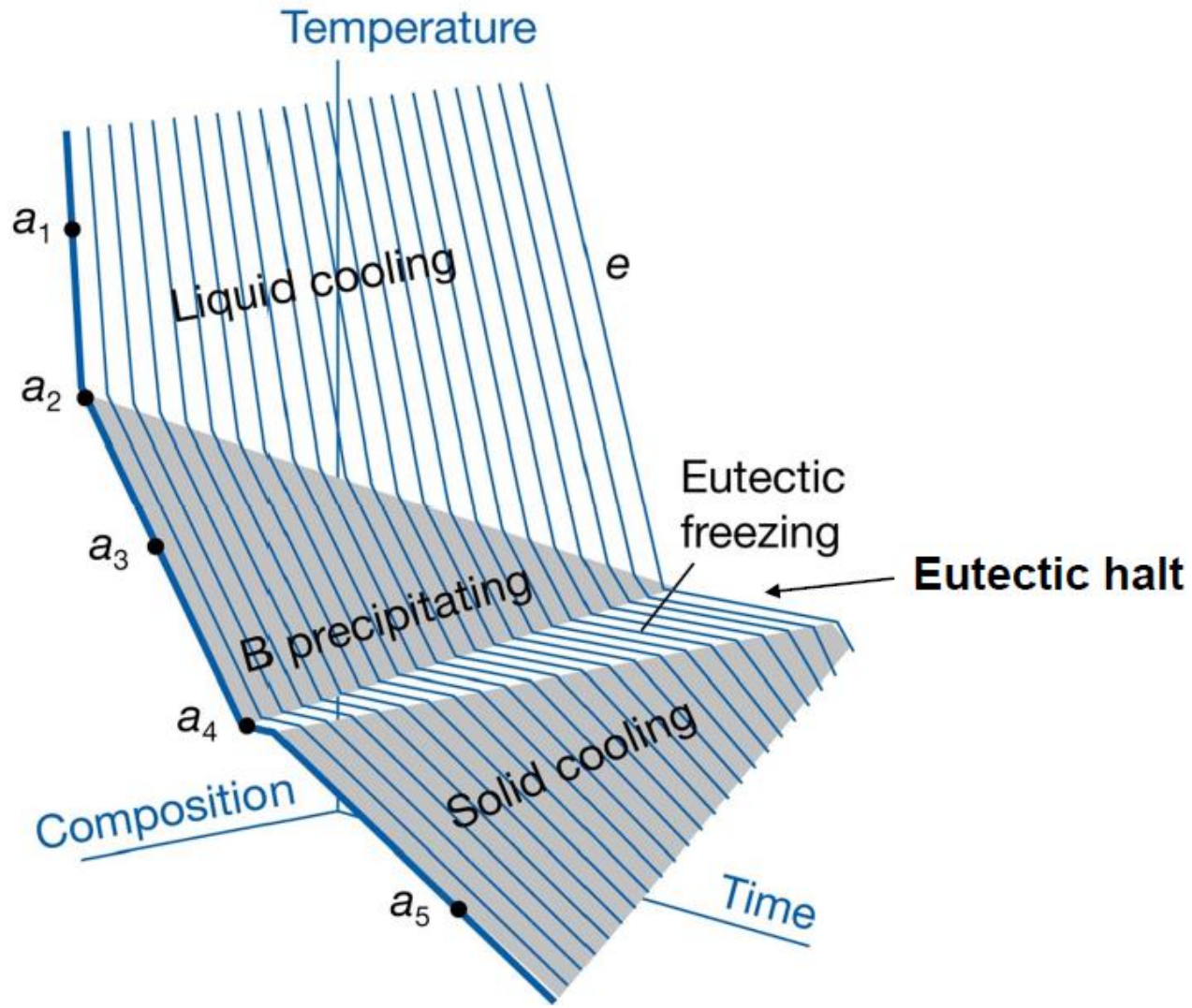
$$L \xrightarrow{\text{cooling}} S$$

Eutectic



$$L \xrightarrow{\text{cooling}} S_1 + S_2$$


1200
1000
800
600
400
200
0
T (°C)
Liquid
L+α
L+β
α + β
0
10
20
30
40
50
60
70
80
90
100
Ag
Mass % Cu
Cu


Temperature
a_1
a_2
a_3
a_4
a_5
Liquid cooling
e
Eutectic freezing
Eutectic halt
B precipitating
Solid cooling
Composition
Time