# Module 6

## Phase diagram and diffusion in ternary and multicomponent systems

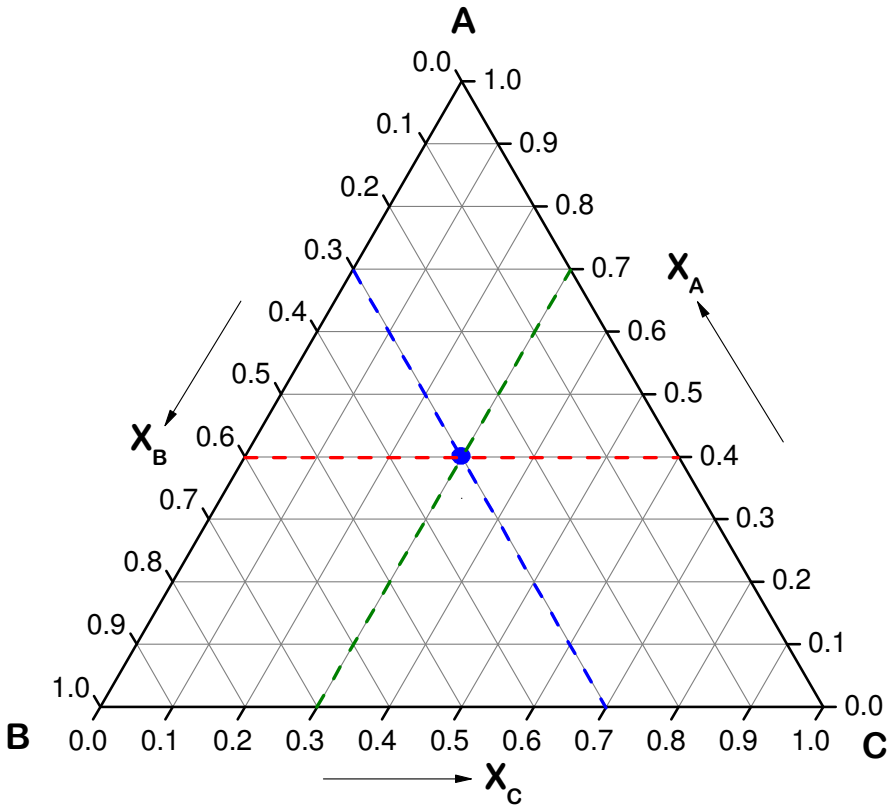
- Diffusion study in ternary and multicomponent system is rather complicated because of requirements to make quantitative analysis.

- However, materials in most of the applications have more than two elements.

- So in this chapter, first the ternary phase diagram will be discussed very briefly and then diffusion analysis will be explained.

# Ternary phase diagram

- In a ternary system, at constant pressure, there are mainly four variables to plot in a ternary diagram, compositions of three elements and temperature.
- This rather makes it very difficult to plot or read.
- So it is very common practice to show the phases at a particular temperature.
- This is shown in a Gibb's triangle, as shown in the figure below.



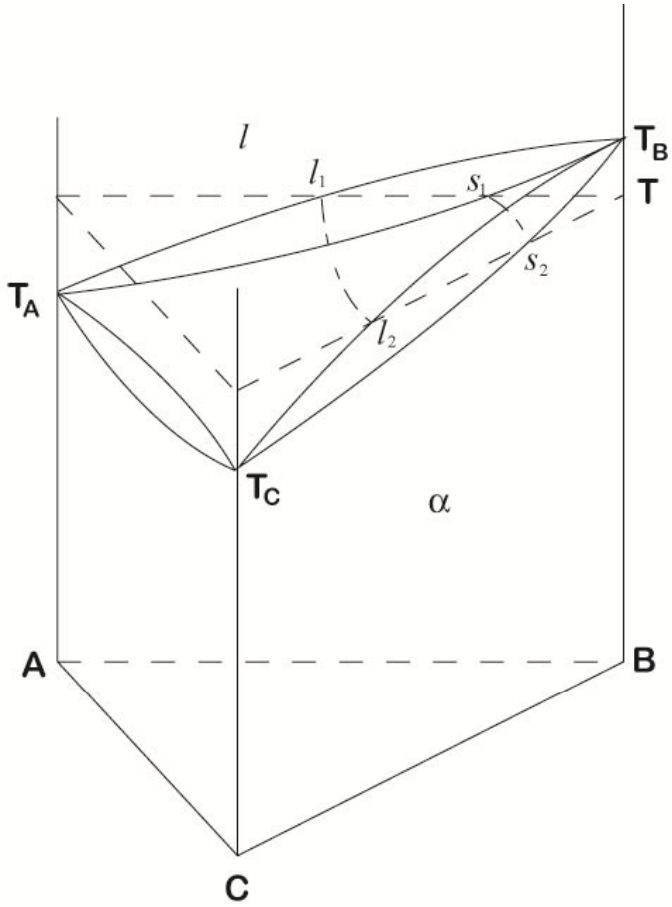
- Suppose we are interested to know the composition of a point shown by the blue dot.

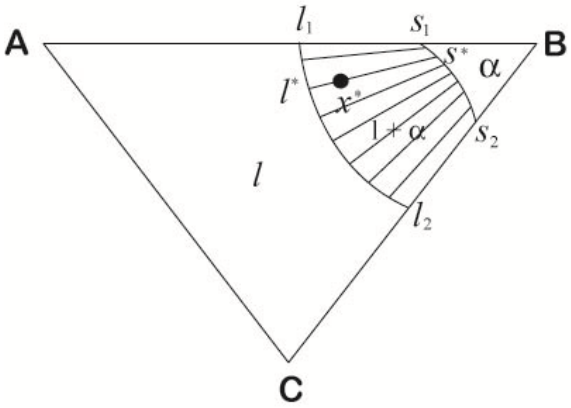
- For that we need to draw lines parallel to the binary AB, BC and CA axes passing through the point of our interest, as shown by the dotted lines.

- The line parallel to the BC (red dotted line) gives the composition of A, which is 0.4. The line parallel to AC (blue dotted line) gives the composition of B, which is 0.3. The line parallel to AB gives the composition of C, which is 0.3.

- It should be noted that $X_A + X_B + X_C = 1$.

- To understand, how the phase diagram is plotted at a constant temperature, we need first to consider the actual phase diagram and then take a section at a particular temperature of our interest. This is explained in the next slide.




- Ternary phase diagram is shown, which has basically complete solid solution over the whole composition range.

- If we are interested to know the phase diagram at temperature T, which is above the melting point of A and C, we need to take a cross section.

- This is plotted below on Gibb's triangle.

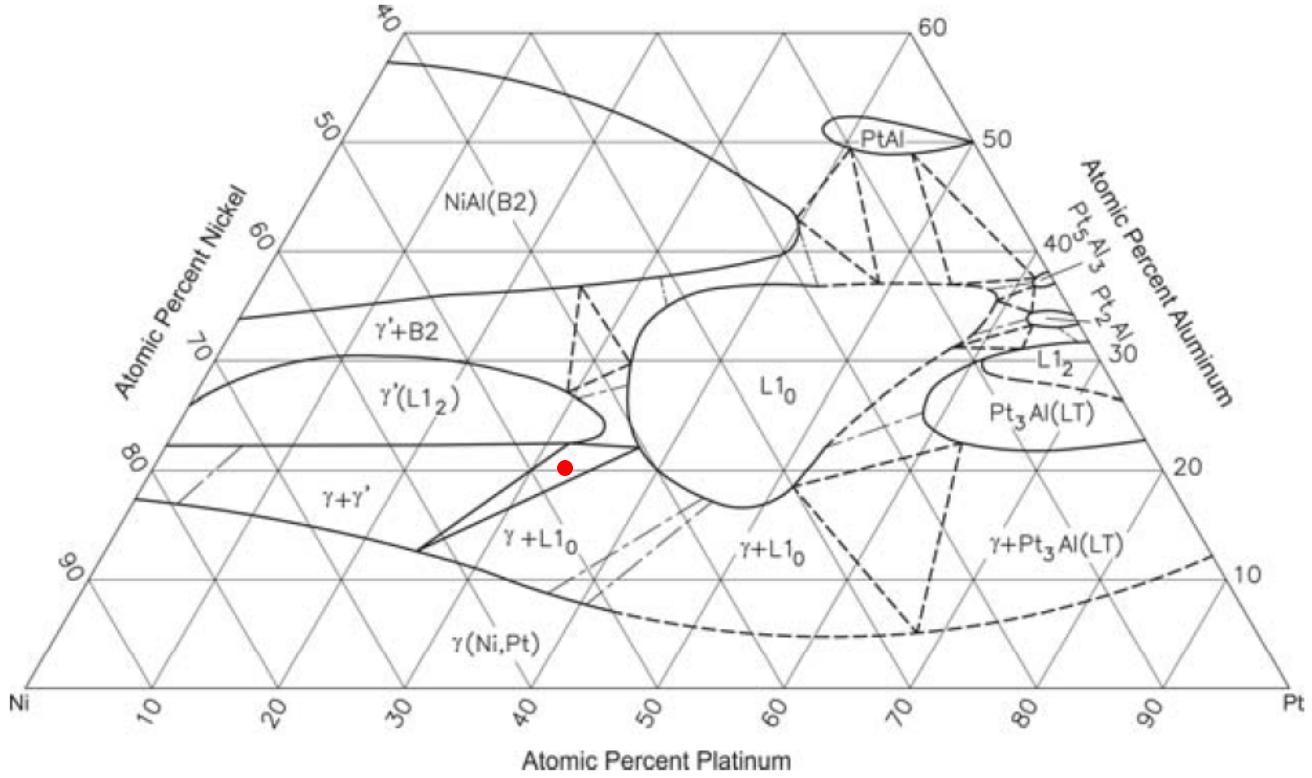
- So it has three regions, the liquid phase, mixture of the liquid and the solid phase and the solid phase.

- Lines connecting the liquid and solid phase are the tie lines.

- One can determine the fraction of the liquid and solid phases based on the tie line as it is done by lever rule in binary systems.

- When phase diagram is plotted with respect to mol fractions, the ratio of moles of the solid and liquid phases, for example at x* can be written as

$$\frac{m_s}{m_l} = \frac{x^* l^*}{s^* x^*}$$



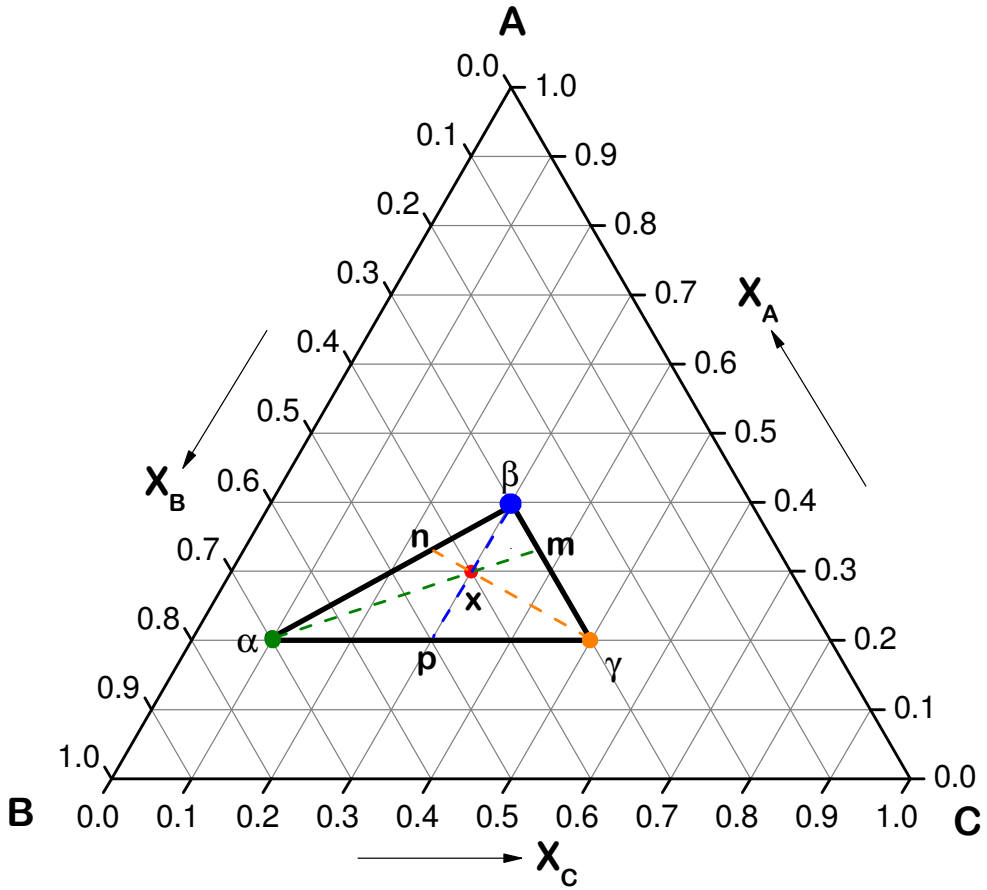

➢ **Ternary phase diagrams, although plotted at one particular temperature could be very complicated, as shown above the Ni-Pt-Al phase diagram at 1150 $^{o}$C.**

➢ **Many times dotted lines are drawn, when the phase equilibria is not confirmed or if there is any doubt.**

➢ **As shown by the red dot there can be three phase equilibrium in the ternary system.**

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➢ **Lever rule in a ternary system in three phase equilibrium region**




➢ **Suppose three phases α, β and γ are in equilibrium and we want to find the relative amounts in mole fractions of these phases at composition x.**

➢ **First we need to draw straight line connecting the phase and the composition of our interest. Following mole fractions of different phases can be calculated following**

$$m_\alpha = \frac{xm}{\alpha m} \qquad m_\beta = \frac{xp}{p\beta} \qquad m_\gamma = \frac{xn}{\gamma n}$$