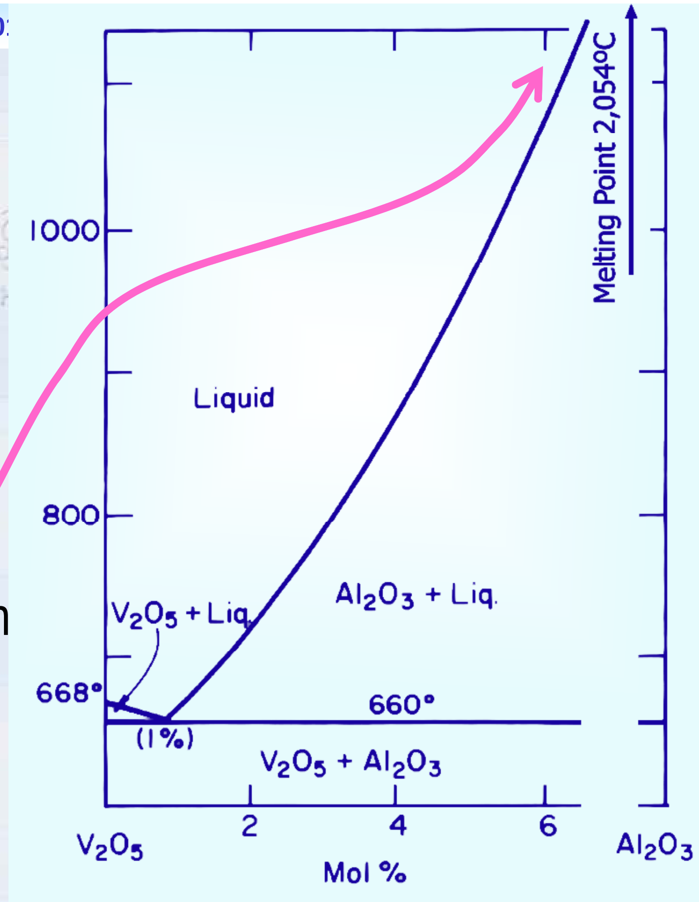
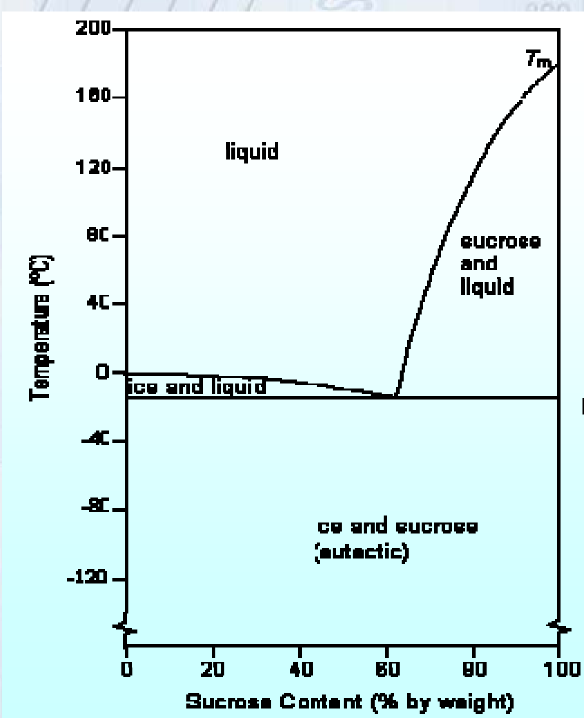
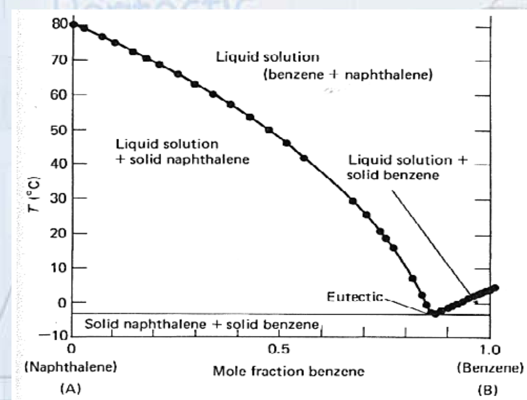
Application to other eutectic systems: V_2O_5-Al_2O_3 phase diagram

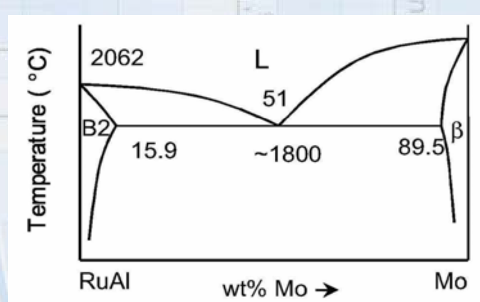
Alumina is used in high temperature applications.
So, what would happen if it is contaminated with vanadia?



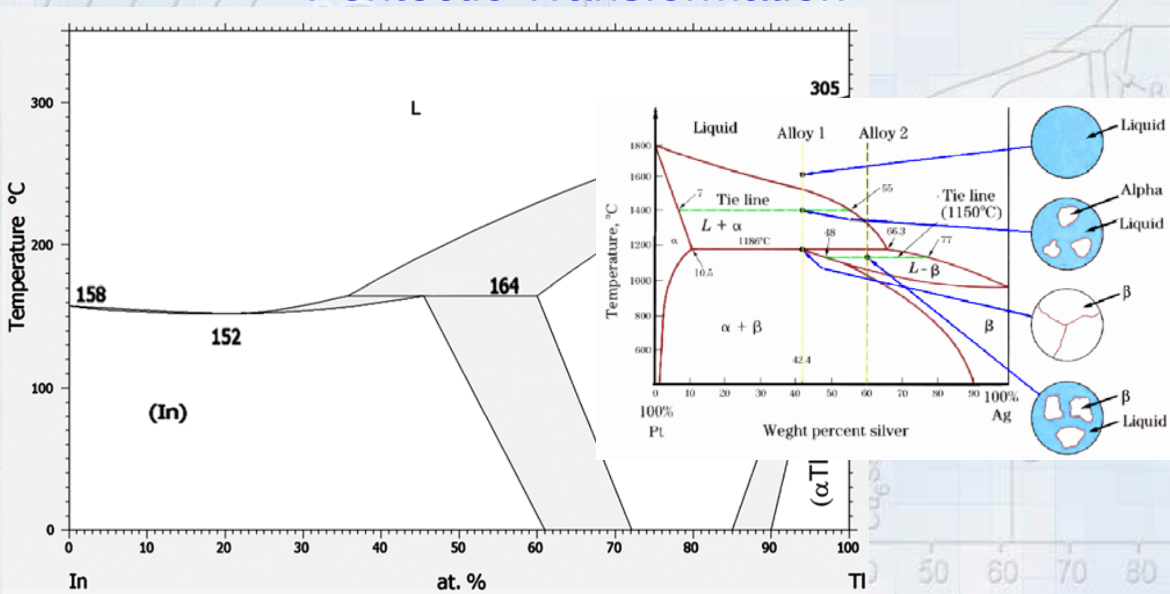
Other examples







Peritectic Transformation

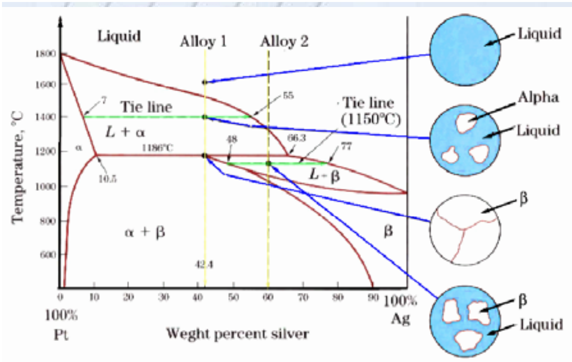


Please take note of the In-Tl diagram and then apply that explanation to the Pt-Ag one.

Peritectic Transformation (cont.)

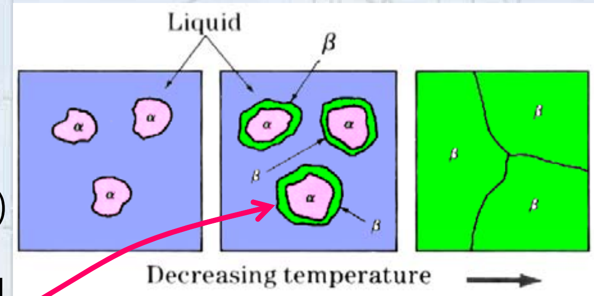
- Peritectic reactions are special cases of invariant or isothermal reactions (F = 0)
- Peritectic reactions can be described with the following formula:

$$\text{Liquid} + \text{Solid 1} \leftrightarrows \text{Solid 2} \quad \text{at } T = T_{per}$$



Peritectic Transformation (cont.)

Microstructural development



Note that the diffusion needs to occur through an increasingly wider layer (sheath) of β.

Also α is no longer in contact with the liquid to produce β since:

Liq. + α ↔ β

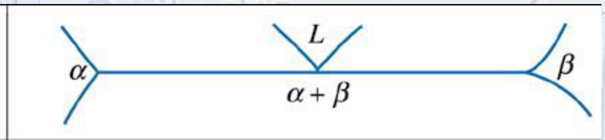
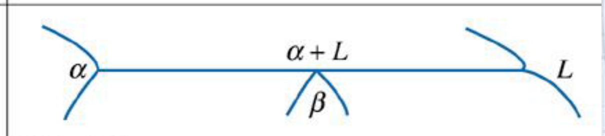
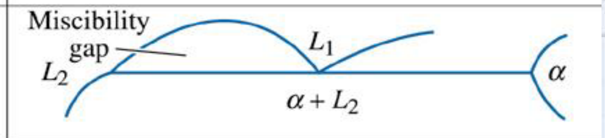
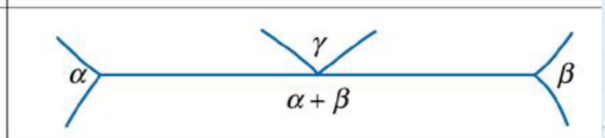
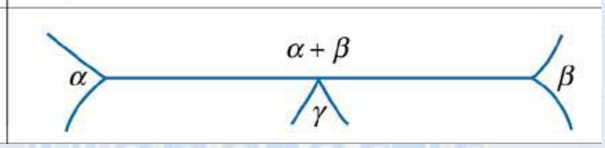
This causes this transformation to have serious kinetic problems and to end up with a metastable microstructure.

Invariant Transformations

- Note that both the eutectic and the peritectic transformations are characterized by isothermal transformations.
- In the cooling curves they are reflected as flat-lines (isotherm) where F = 0 (three phases coexist for that temperature and chemical compositions).
- These are instances of invariant transformations.

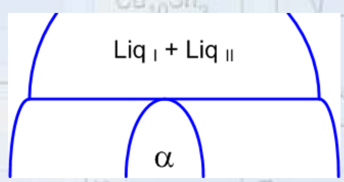
Some examples of invariant (isothermal) transformations are:

There are three points on each horizontal line and two single-phase fields at the end points

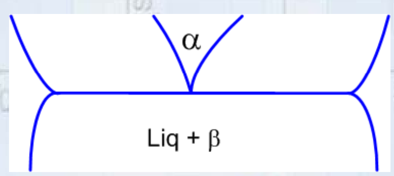
Eutectic	$L \rightarrow \alpha + \beta$	
Peritectic	$\alpha + L \rightarrow \beta$	
Monotectic	$L_1 \rightarrow L_2 + \alpha$	
Eutectoid	$\gamma \rightarrow \alpha + \beta$	
Peritectoid	$\alpha + \beta \rightarrow \gamma$	

There are several more of which only two more will be mentioned:

- Syntectic transformation:
  - Liq $_{I}$ + Liq $_{II}$ ↔ Solid



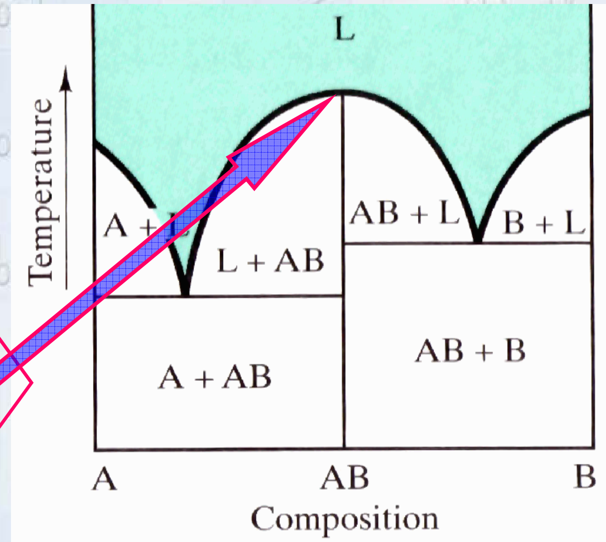
- Metatectic transformation:
  - Solid $_{I}$ ↔ Liq + Solid $_{II}$



Intermediate Phases or Compounds

Chemical compounds can form by chemical reaction between the two components of a binary system

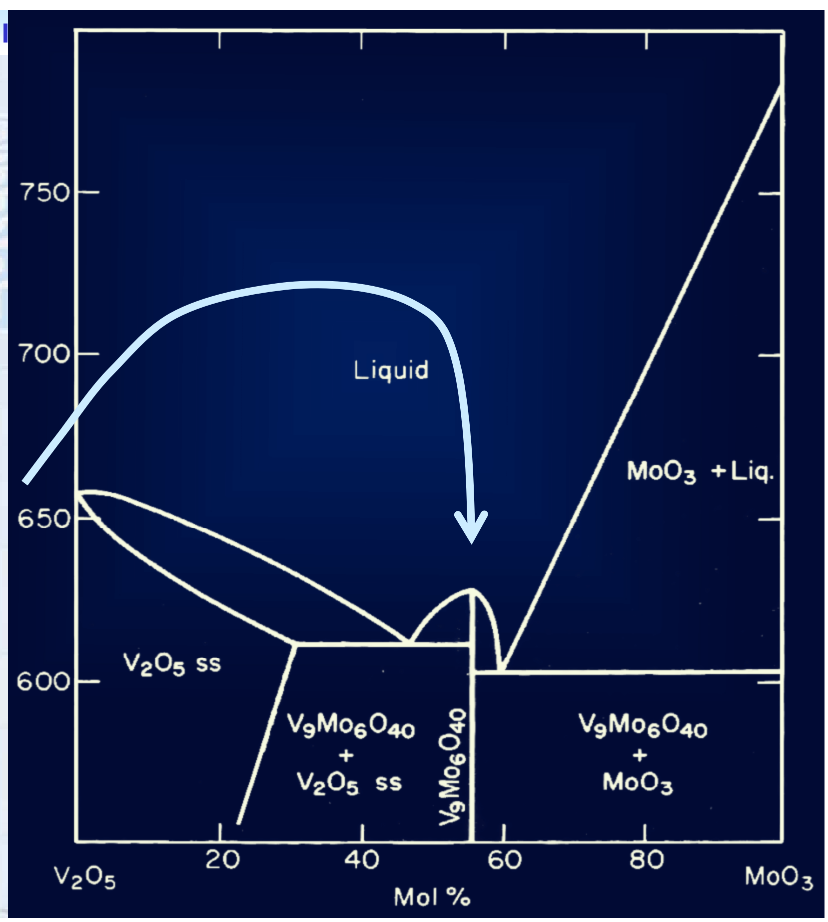
Therefore they could have a *stoichiometric* composition:
$x \cdot A + y \cdot B \leftrightarrows A_xB_y$



<u>Example:</u>
In this case x=y=1, the compound AB melts *congruently.*

Intermediate Compounds (cont.)

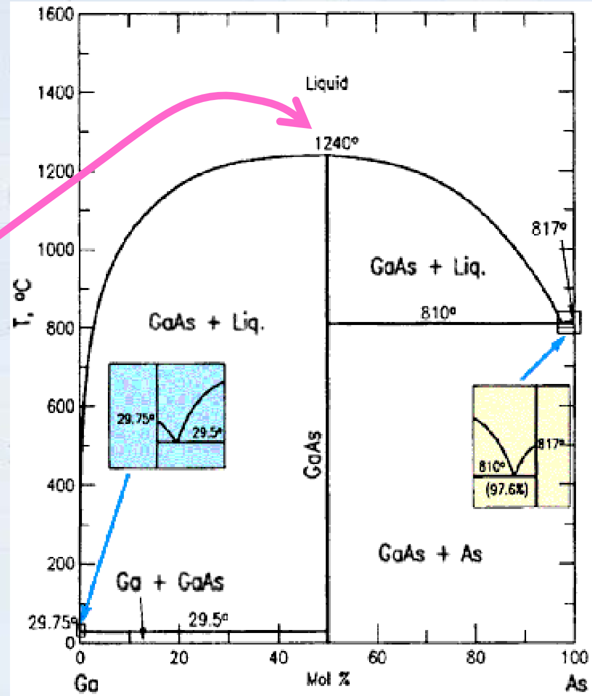
This is a real example of a phase diagram with an intermediate compound: $V_9Mo_6O_{40}$ that melts *congruently*.



Intermediate Compounds (cont.)

Another example of a phase diagram with an intermediate compound: GaAs that melts *congruently*.

Note that on both sides there are eutectic points



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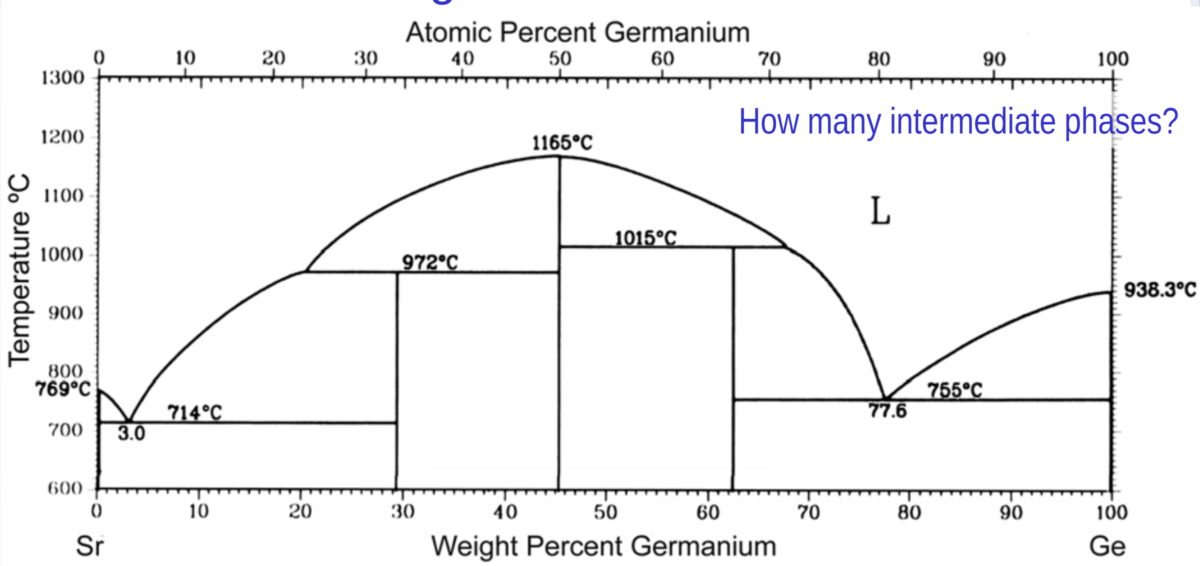
Real Phase Diagram with Intermediate Phases

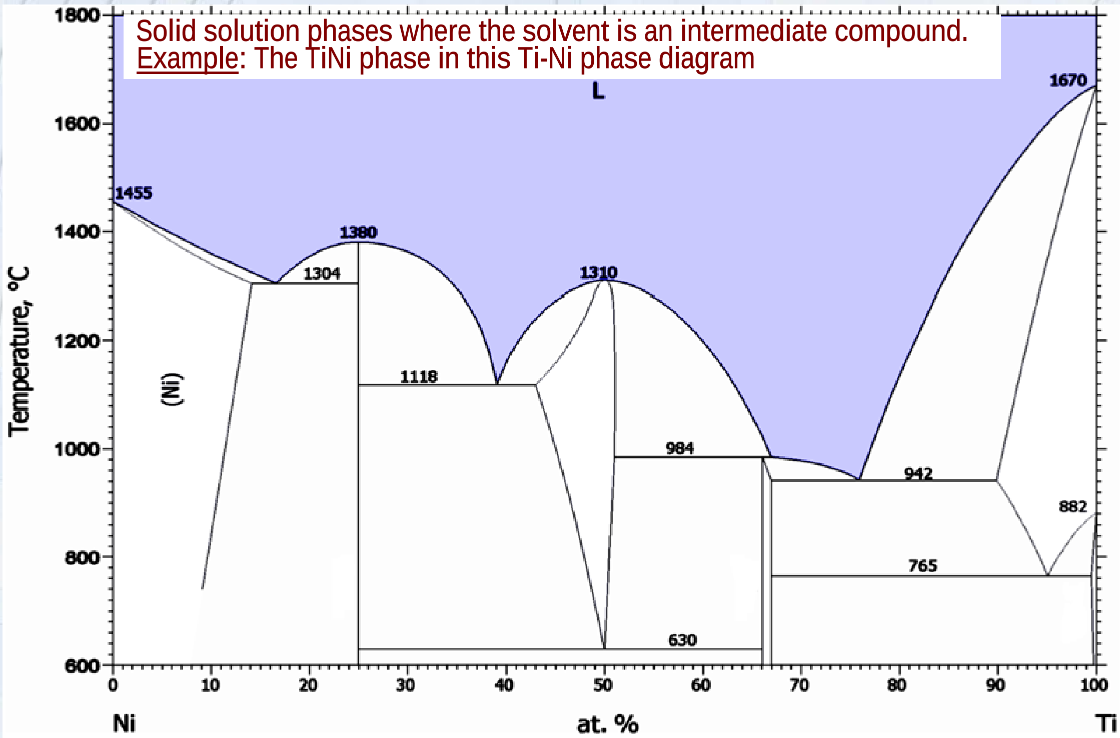


Any congruent melting point?

You can calculate the formulae of the compounds using the atomic percent scale - stoichiometric compounds -

Intermediate Phases

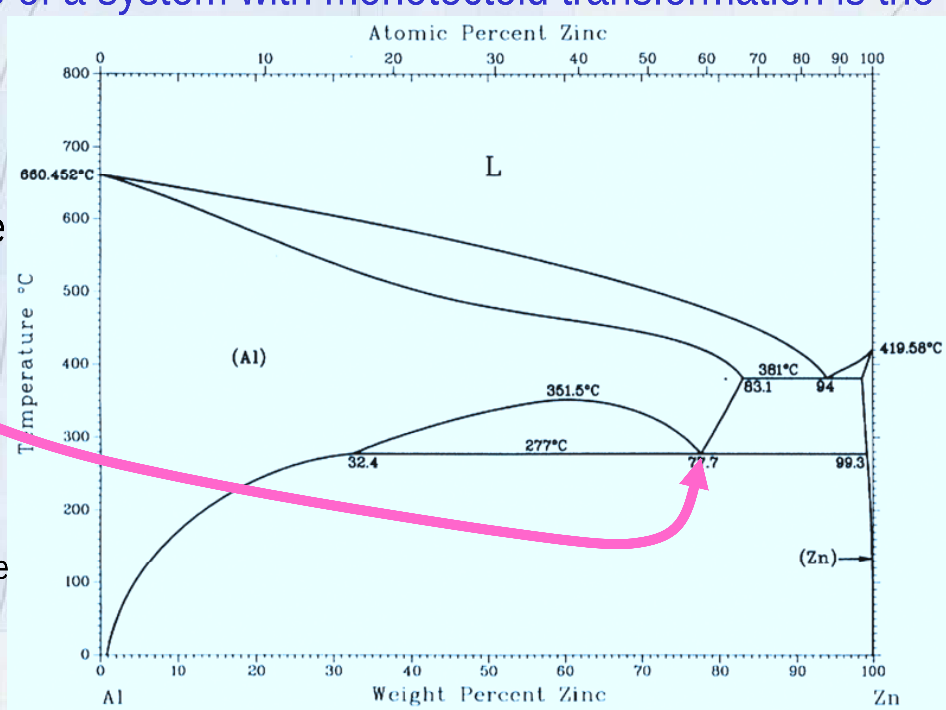
Solid solution phases where the solvent is an intermediate compound.
Example: The TiNi phase in this Ti-Ni phase diagram

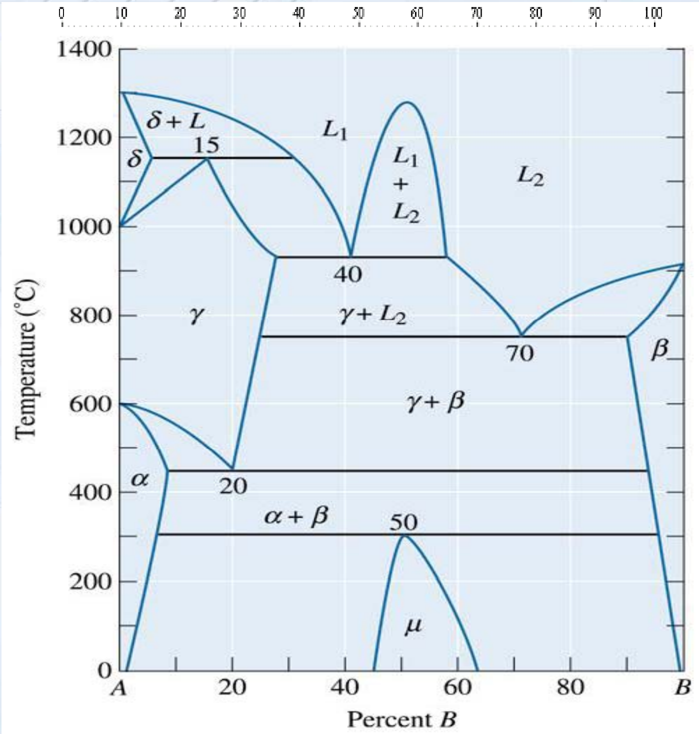


An example of a system with monotectoid transformation is the Al-Zn one

Please write down the equation for the monotectoid transformation.

Al-Zn-Mg are common aerospace structural alloys.

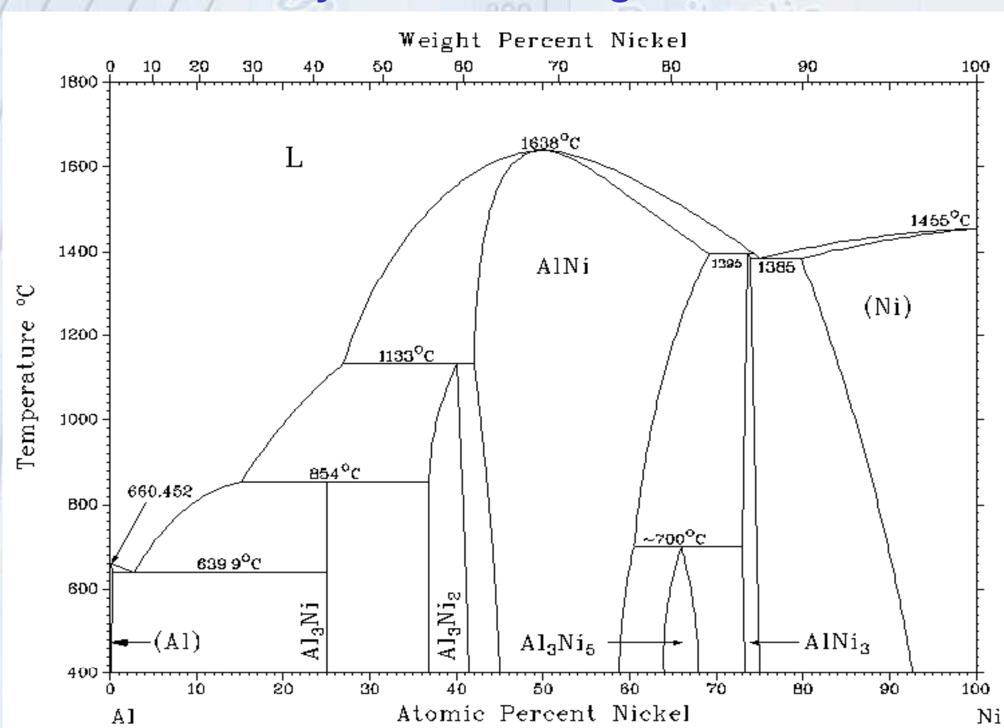


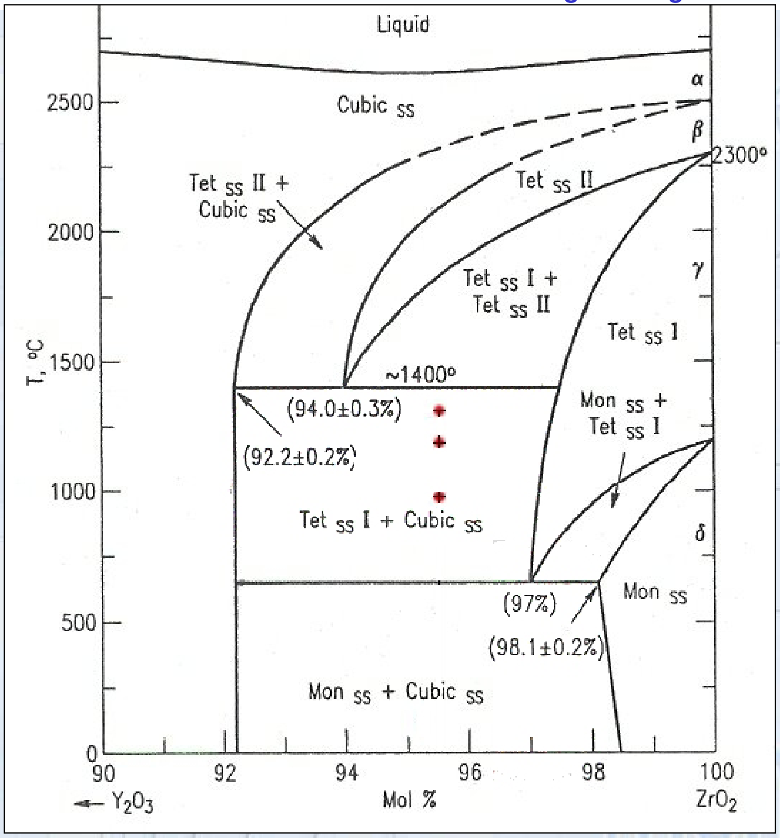


Practice:
A Hypothetical Phase Diagram

- Melting points of A and B
- Is A or B a polymorphic element?
- Number and type of invariant (isothermal) reactions.
- For the following alloys, the relative amount of phases present and their chemical composition:
  - –30%B - 70%A @ 100ºC
  - –40%B - 60%A @ 650ºC
  - –40%B - 60%A @ 1000ºC
  - –90%B - 10%A @ 700ºC
  - –80%B - 20%A @ 300ºC

Al-Ni Binary Phase Diagram for Practice



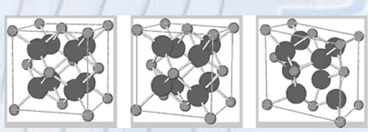


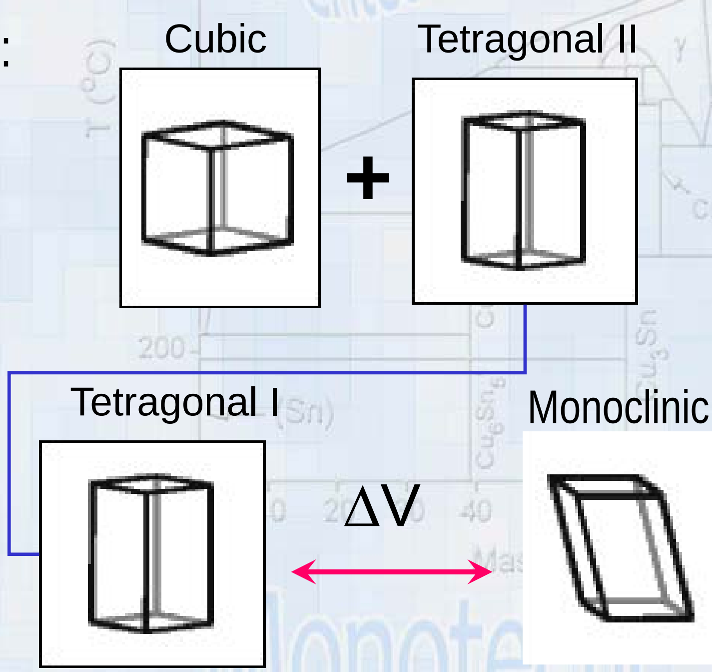
Let's apply these concepts to "real materials:"

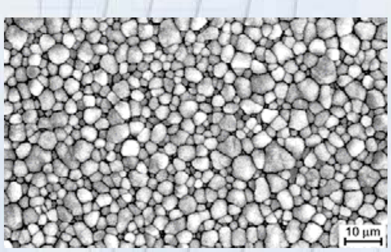
Yttria-stabilized zirconia is another tough ceramic that we already talked about.

Calcia- or yttria-modified zirconia undergo several phase transformations during cooling.

In the case of YSZ:



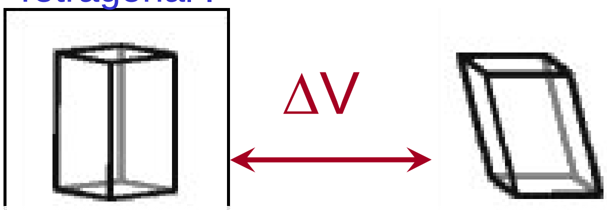




This is the stress-induced transformation in toughened zirconia

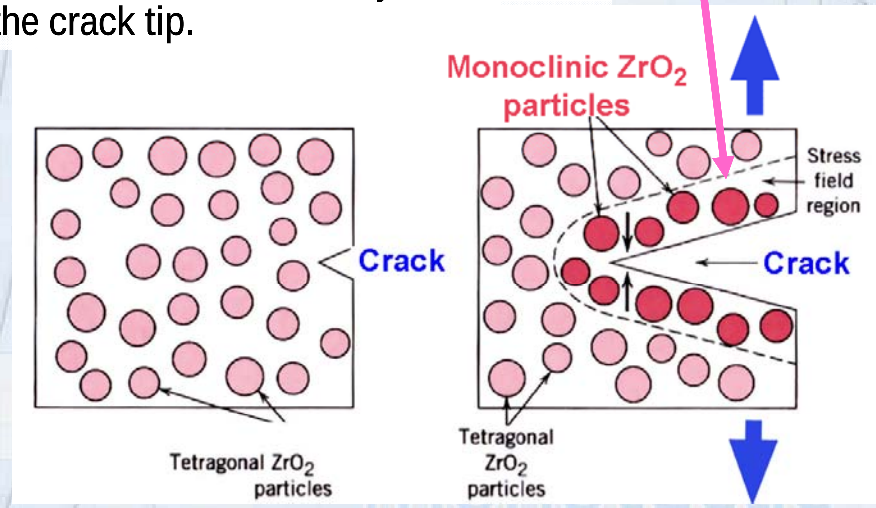
Tetragonal I

Monoclinic



This is a phase with larger specific volume:

The phase transformation is induced by the stress field ahead of the crack tip.

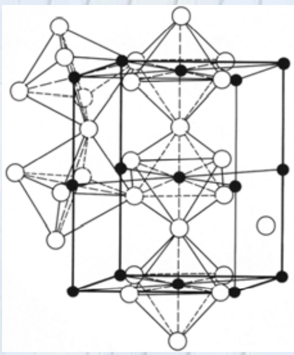


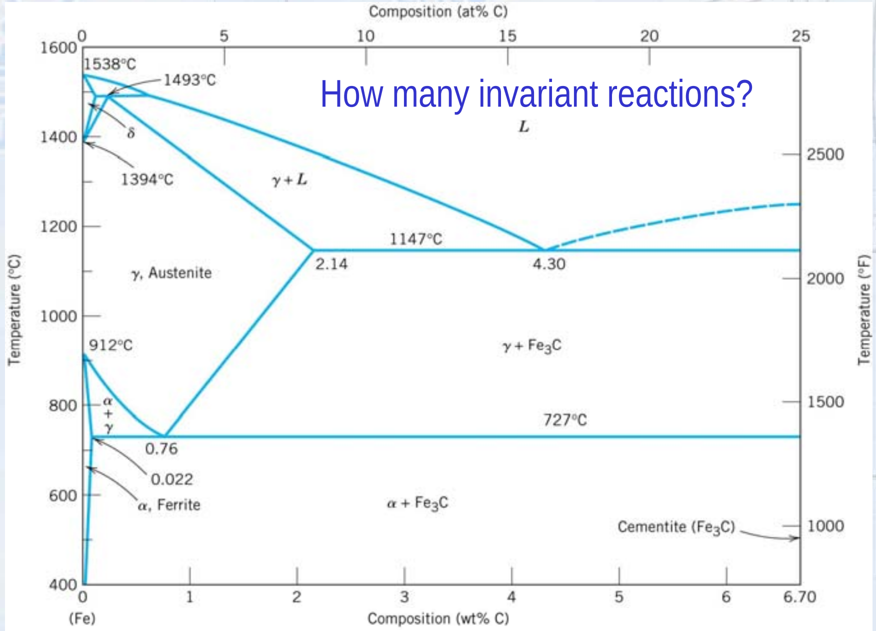
Chapter 12

Dispersion Strengthening by Phase Transformations and Heat Treatment

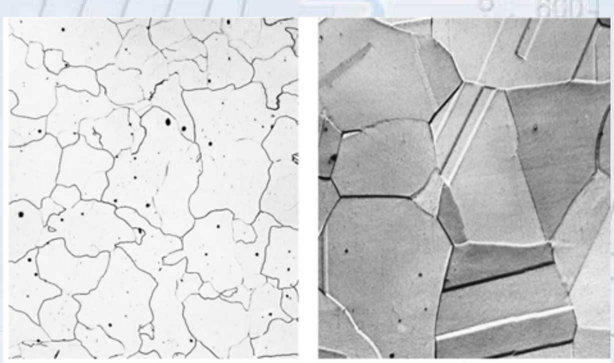
Now we'll apply all our phase diagram knowledge to the Fe-C *metastable* phase diagram:

There are 4 solid phases:
3 Fe solid solutions: δ, γ, α
and cementite Fe_3C

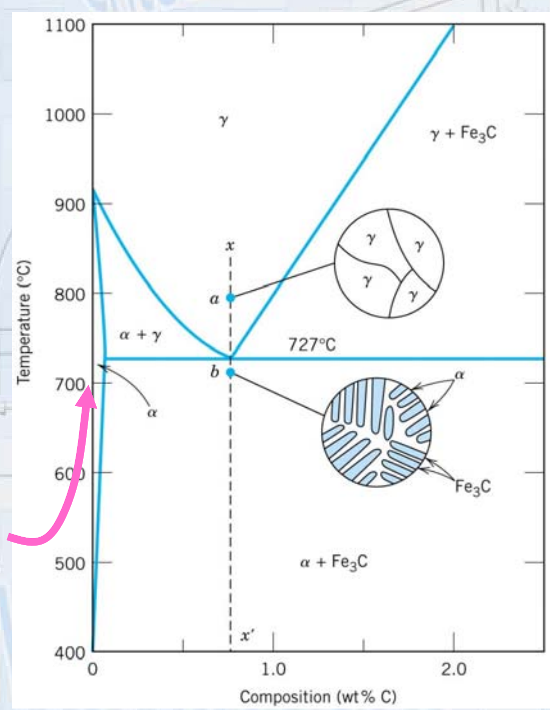




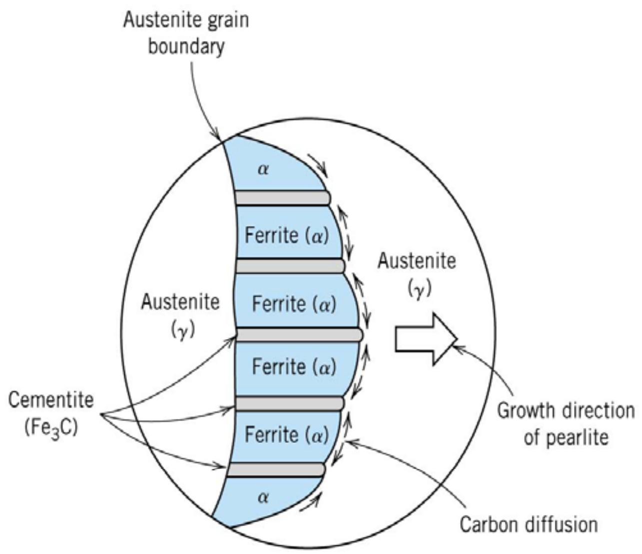
How does the microstructure develop in pure iron?

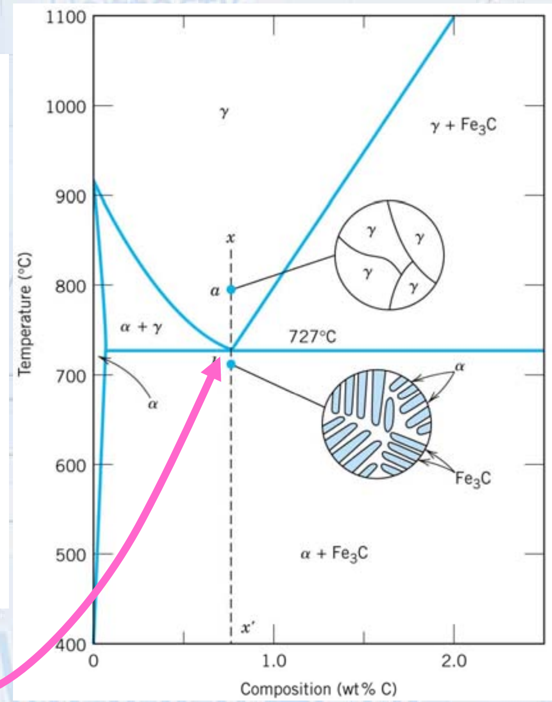

(a) (b)

Pure iron BCC (ferrite) or α iron



How does the microstructure develop in a eutectoid Fe-C alloy?

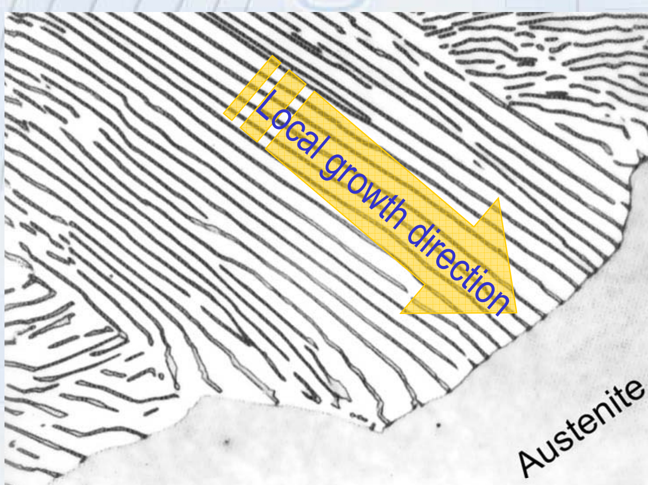


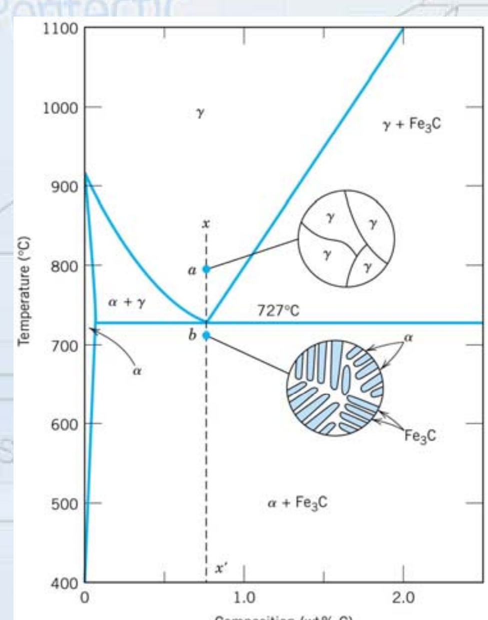


Alternate α and cementite lamellae develop at <u>one temperature</u>

More on the eutectoid (pearlite) microstructure development.

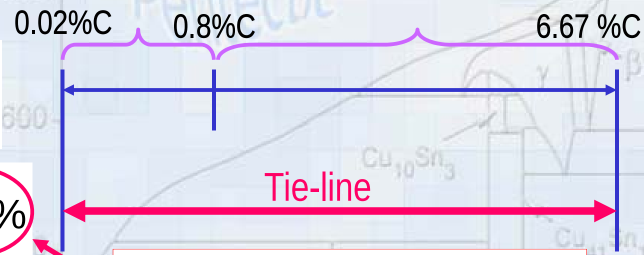
Austenite ⇆ Ferrite + Cementite @ 723°C





Growth of pearlite into an austenite grain.
What would happen to the interlamellar distance if we increase the growth velocity?

Example Problem



$$\text{wt.\% ferrite} = \frac{6.67 - 0.8}{6.67 - 0.02} \cdot 100$$

$$= \frac{5.87}{6.65} \cdot 100 = 88.3\%$$

$$\text{wt.\% cementite} = \frac{0.8 - 0.02}{6.67 - 0.02} \cdot 100$$

$$= \frac{0.78}{6.65} \cdot 100 = 11.7\%$$

The 8:1 proportion can be observed in the micrograph comparing the thickness