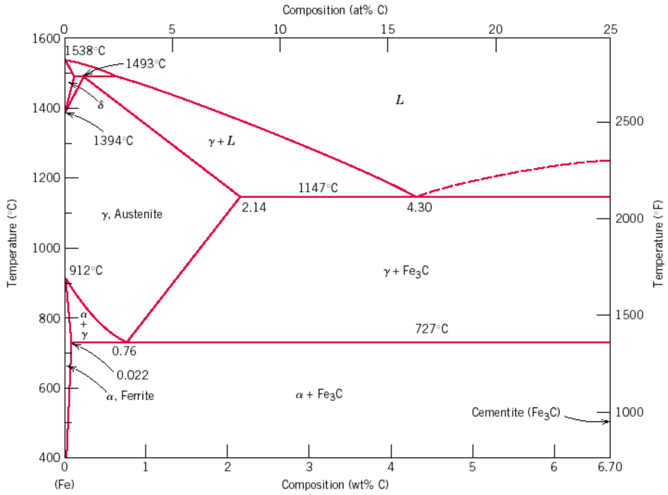
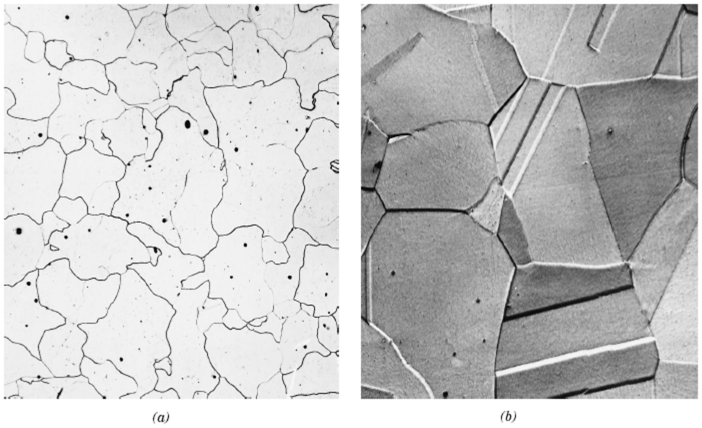
The iron-iron carbide (Fe-Fe_3C) phase diagram

- Ferrite-α -BCC, low C solubility(0.022%wt), magnetic
- Austenite-γ-FCC, high C solubility(2.14%wt), nonmagnetic
- Ferrite-δ-BCC
- Cementite (Fe_3C)
- Eutectic, peritectic, eutectoid
- Iron, ferrite (C<0.008wt%)
- Stainless steel, α+Fe_3C (0.008-2.14wt%)

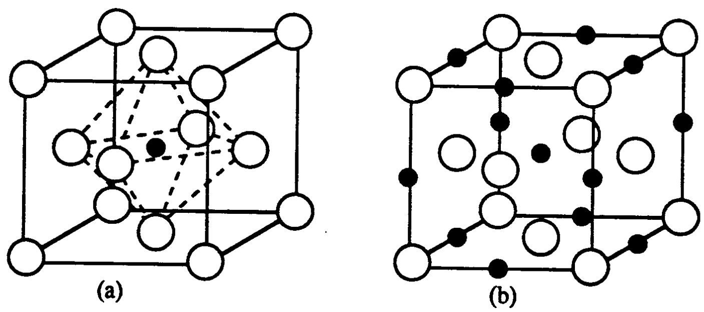


Microstructures of iron

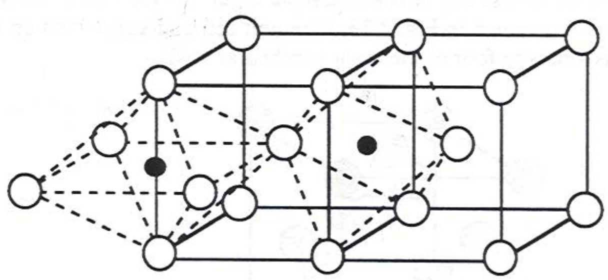


α- ferrite austenite

Interstitial sites of FCC

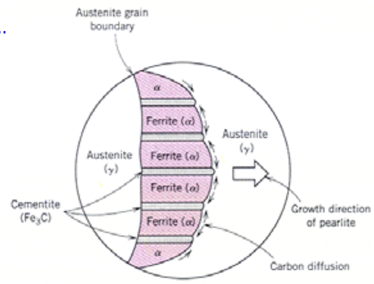


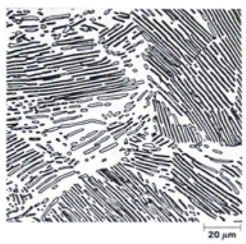
Interstitial sites of BCC

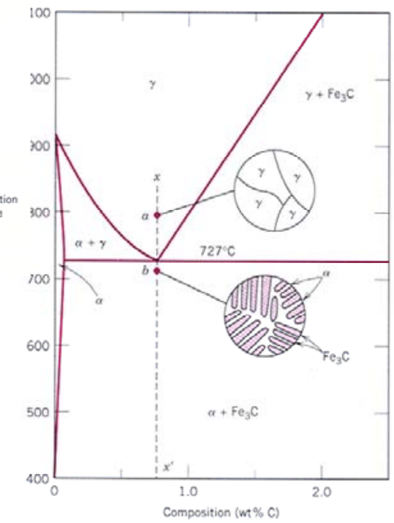


Microstructure in iron-carbon alloys

- Eutectic--pearlite

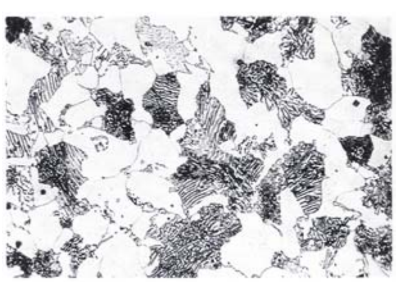


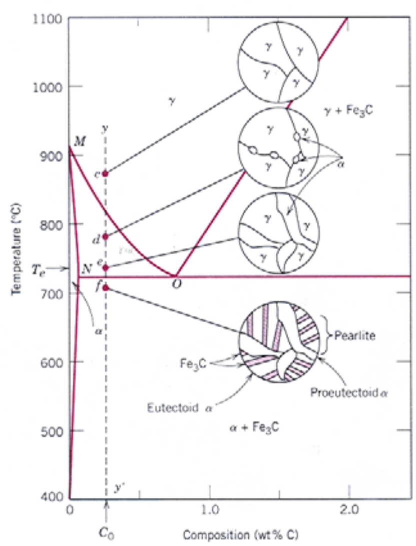




Hypoeutectoid alloys

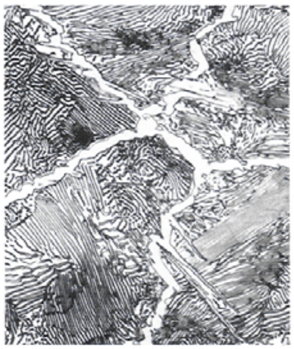
- Hypoeutectoid steel: has a carbon concentration less than the eutectoid

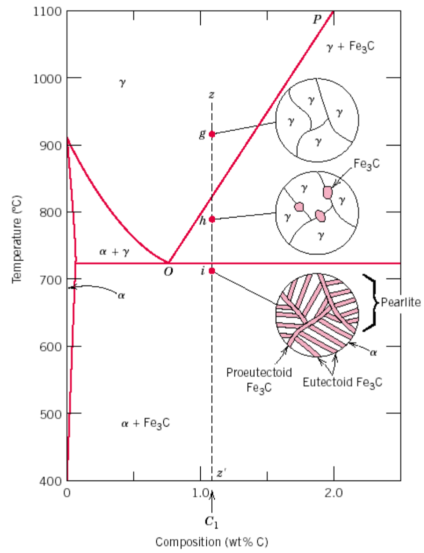




Hypereutectoid alloys

- Hypereutectoid steel: has a carbon content greater than the eutectoid





Example: Phase Equilibria

For a 99.6 wt% Fe-0.40 wt% C at a temperature just below the eutectoid, determine the following

a) composition of Fe_3C and ferrite (α)

b) the amount of carbide (cementite) in grams that forms per 100 g of steel

c) the amount of pearlite and proeutectoid ferrite (α)

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Phase Equilibria

Solution: a) composition of Fe_3C and ferrite (α)

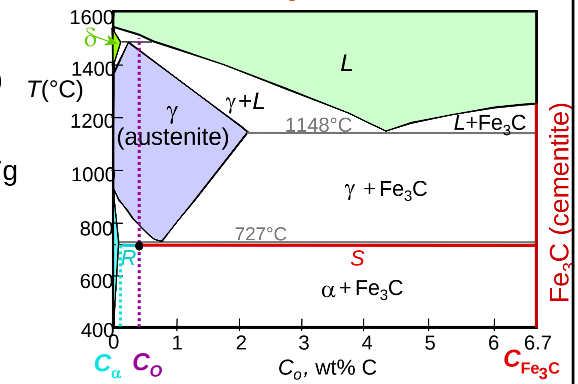
b) the amount of carbide (cementite) in grams that forms per 100 g of steel

C_O = 0.40 wt% C
C_α = 0.022 wt% C
C_{Fe_3C} = 6.70 wt% C

$$\frac{Fe_3C}{Fe_3C+\alpha} = \frac{C_O - C_\alpha}{C_{Fe_3C} - C_\alpha} \text{x}100$$

$$= \frac{0.4-0.022}{6.7-0.022} x\,100 = 5.7\text{g}$$

$Fe_3C = 5.7$ g
$\alpha = 94.3$ g



Phase Equilibria

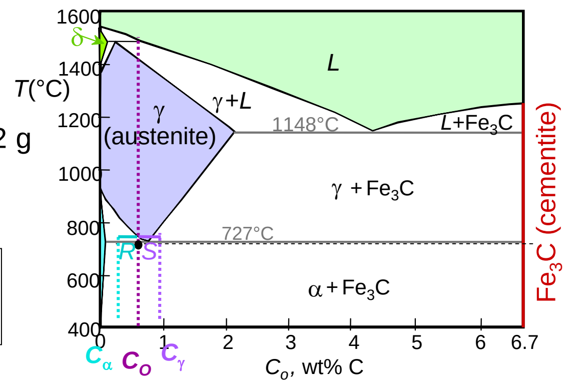
c. the amount of pearlite and proeutectoid ferrite (α)

note: amount of pearlite = amount of γ just above T_E

C_o = 0.40 wt% C
C_α = 0.022 wt% C
$C_{pearlite} = C_\gamma$ = 0.76 wt% C

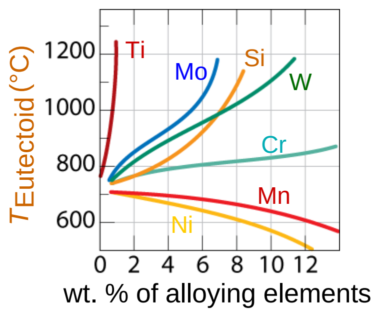
$$\frac{\gamma}{\gamma+\alpha} = \frac{C_O - C_\alpha}{C_\gamma - C_\alpha} \text{ x } 100 = 51.2 \text{ g}$$

pearlite = 51.2 g
proeutectoid α = 48.8 g

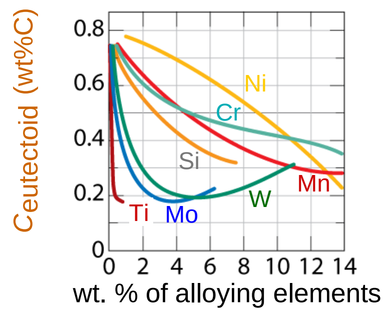


The influence of other alloying elements

- $T_{eutectoid}$ changes:



- $C_{eutectoid}$ changes:



Review Fe-C phase diagram

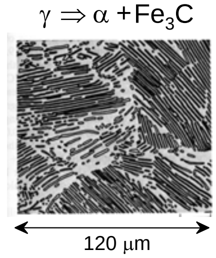
- 2 important points

-Eutectic (*A*):

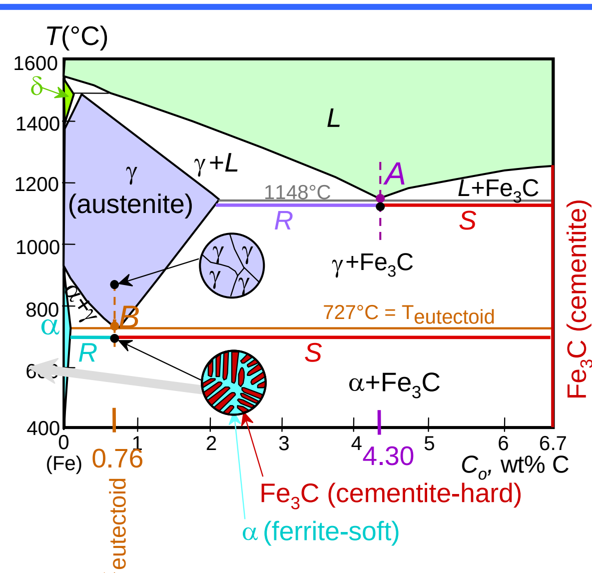
$L \Rightarrow \gamma + Fe_3C$

-Eutectoid (*B*):

$\gamma \Rightarrow \alpha + Fe_3C$



Result: Pearlite = alternating layers of α and Fe_3C phases



Summary

- Phase diagrams are useful tools to determine:
  - --the number and types of phases,
  - --the wt% of each phase,
  - --and the composition of each phase

  for a given *T* and composition of the system.
- Alloying to produce a solid solution usually
  - --increases the tensile strength (*TS*)
  - --decreases the ductility.
- Binary eutectics and binary eutectoids allow for a range of microstructures.