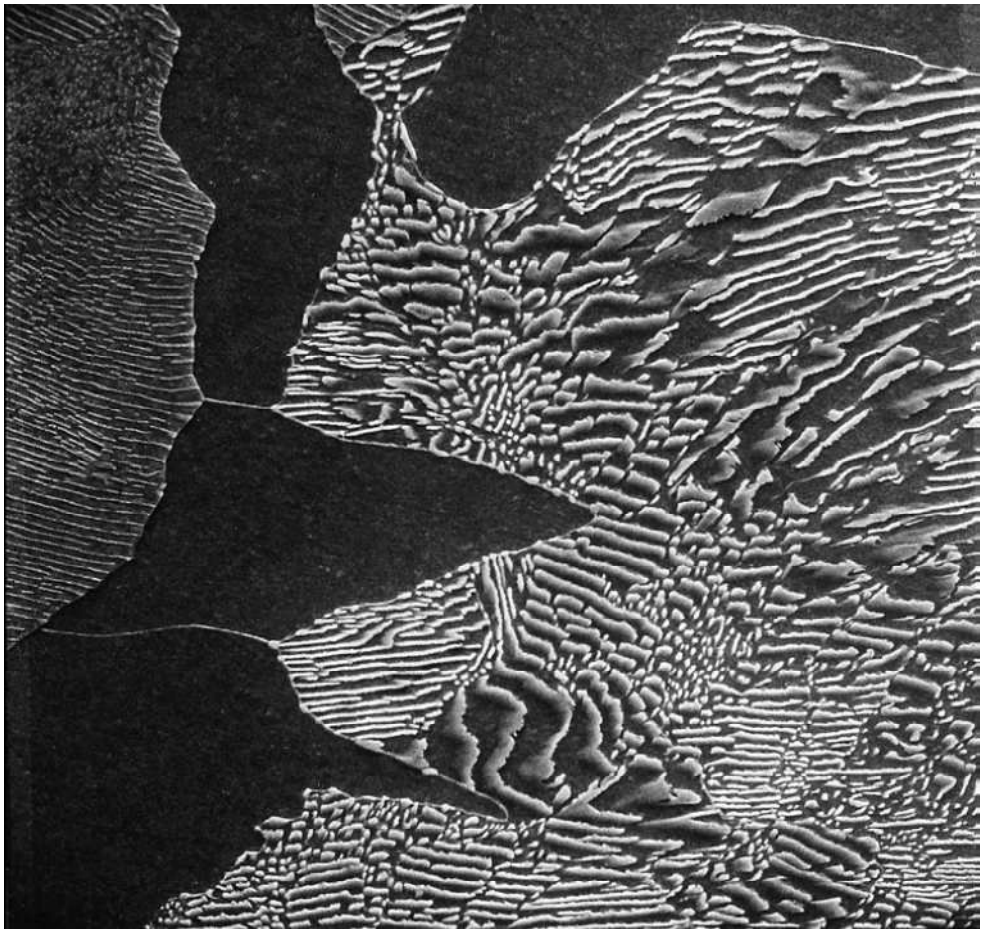
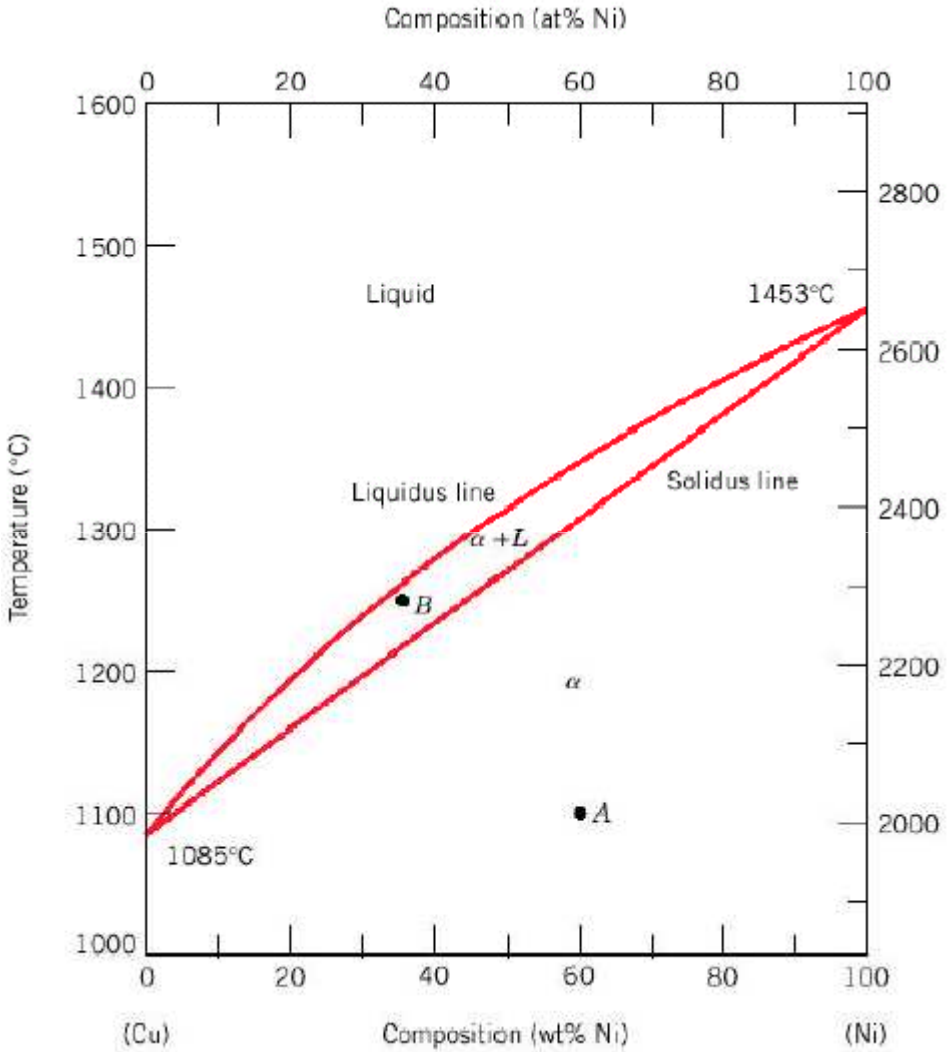
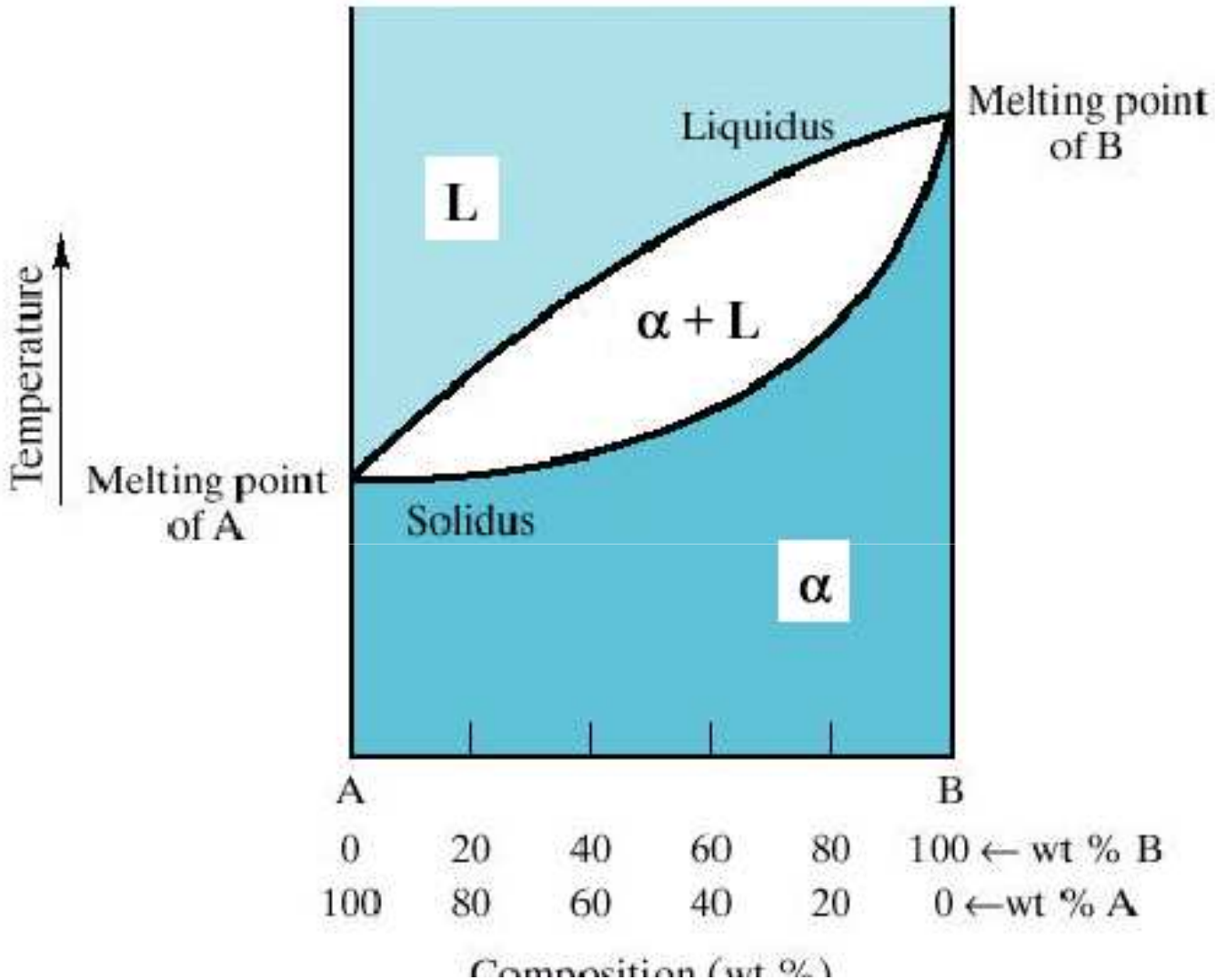
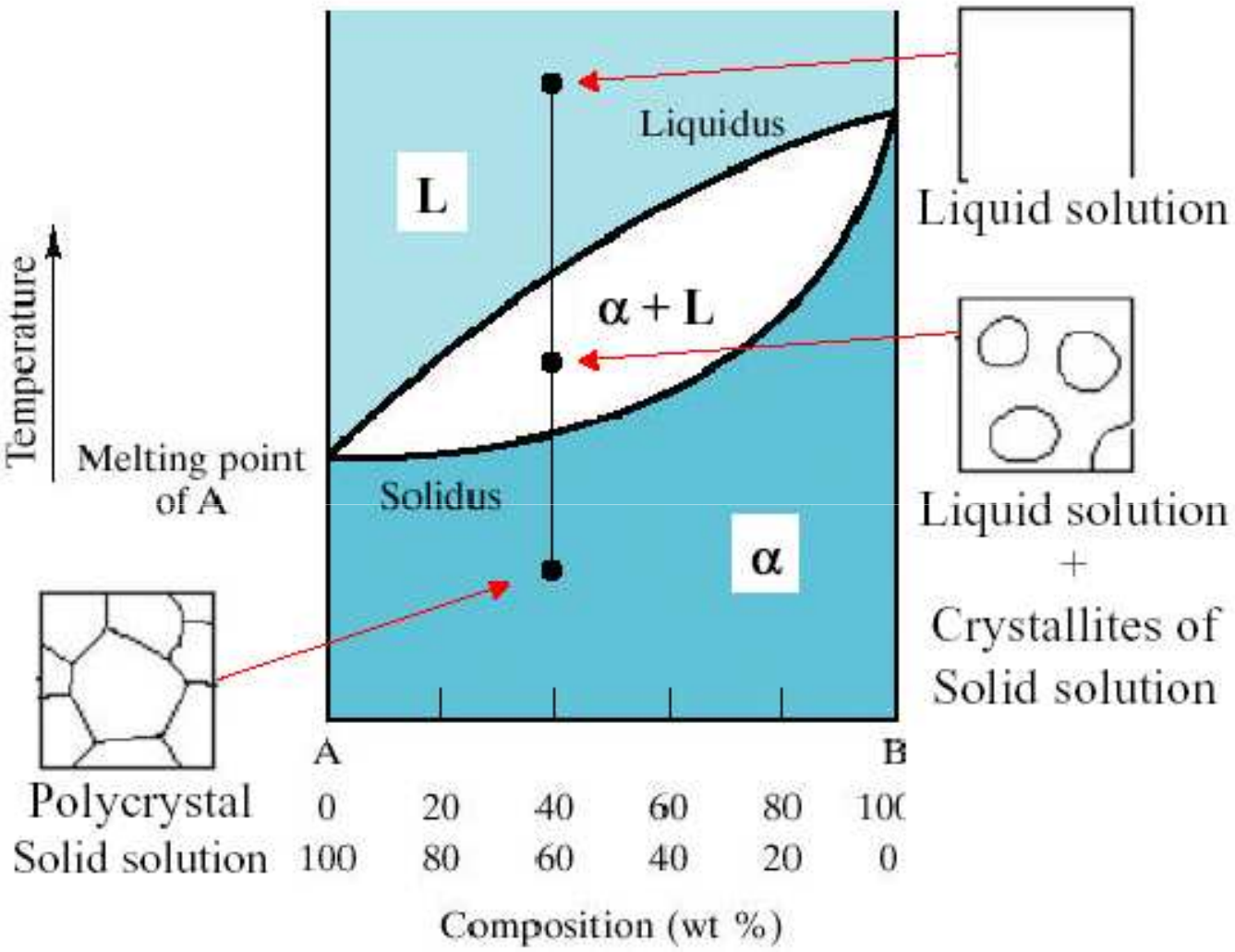
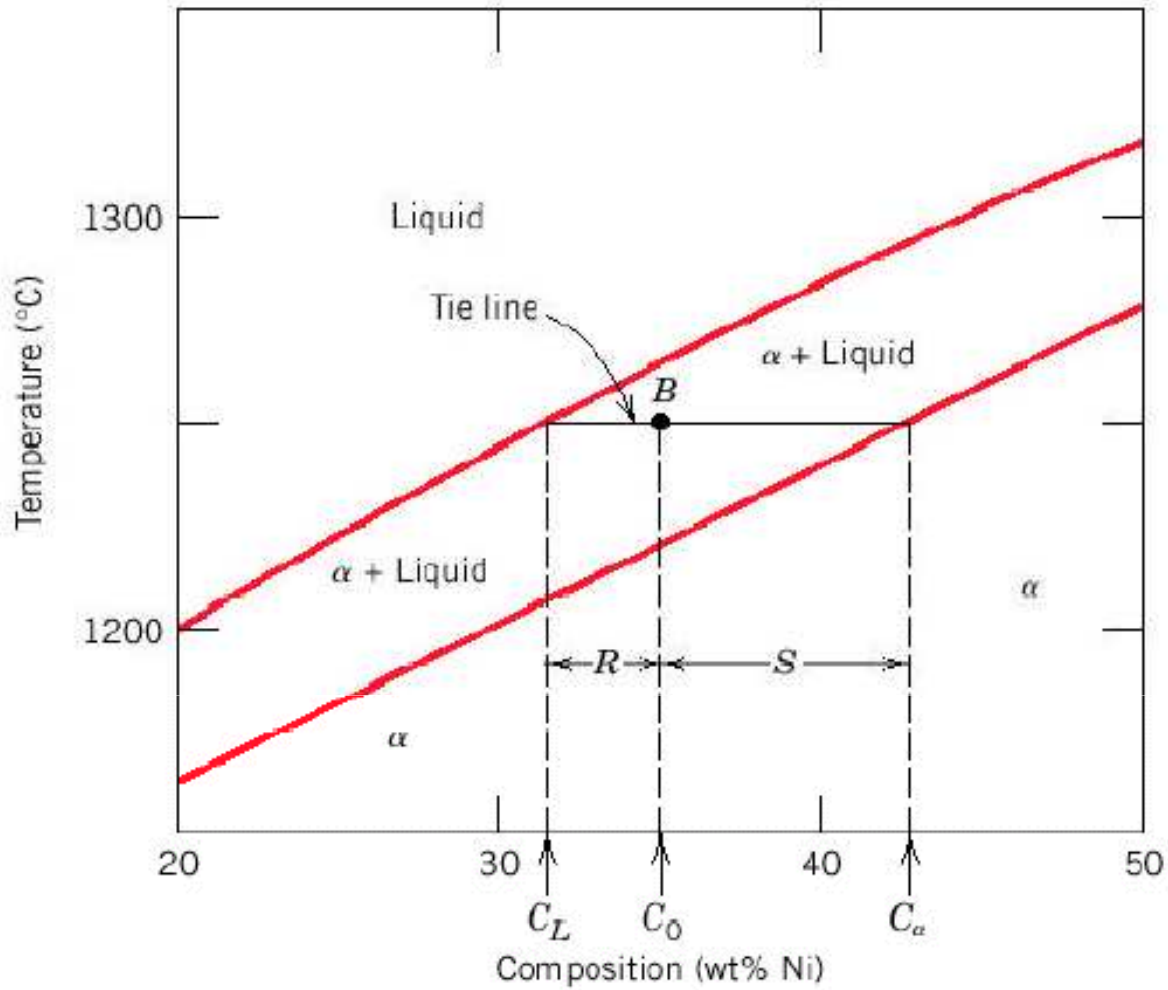
Diagrama de Fases




Composition (at% Ni)
0
20
40
60
80
100
1600
1500
1400
1300
1200
1100
1000
2800
2600
2400
2200
2000
Temperature (°C)
Liquid
1453°C
Liquidus line
Solidus line
α + L
B
α
A
1085°C
(Cu)
Composition (wt% Ni)
(Ni)

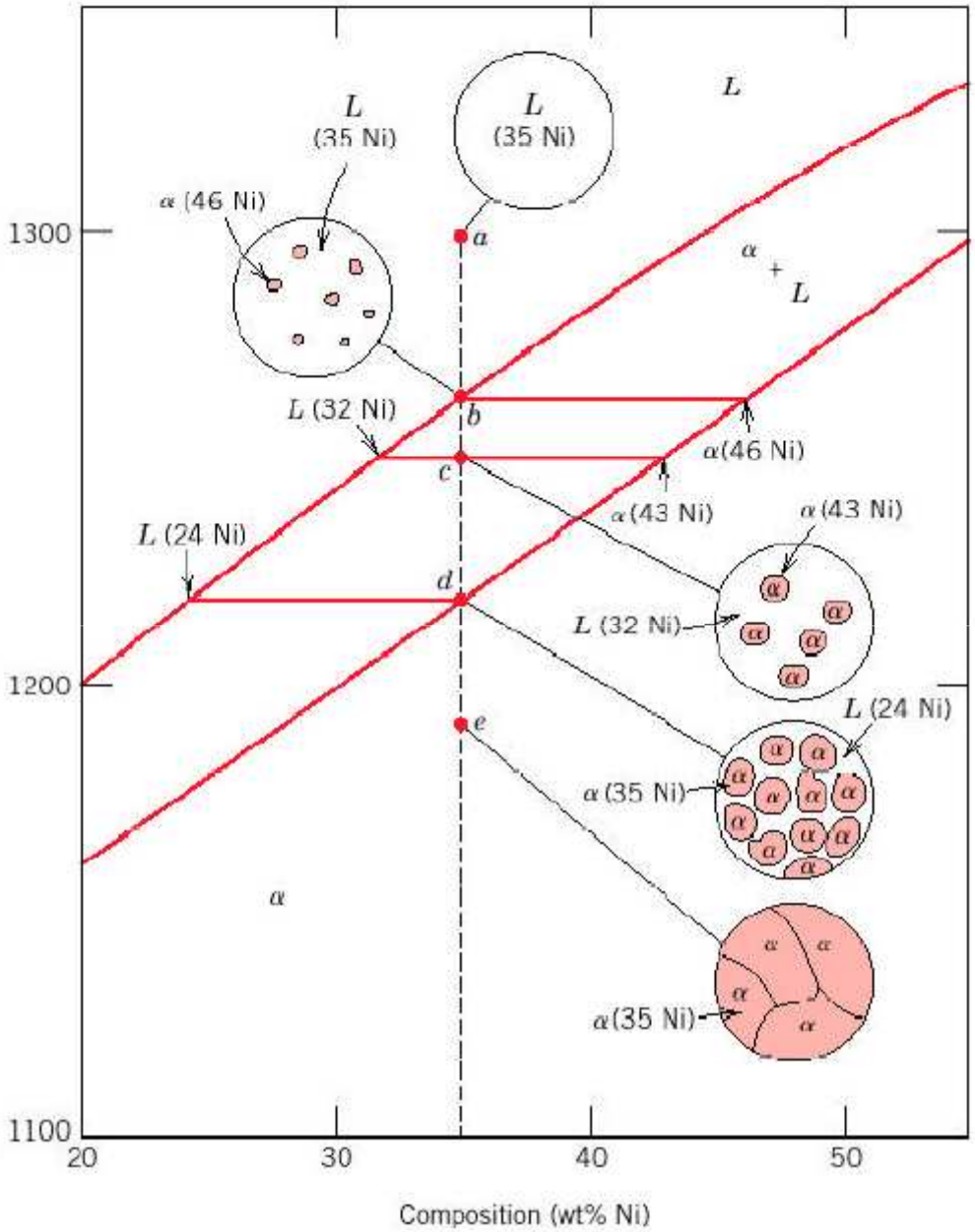

Liquidus
Melting point of B
L
α + L
Temperature
Melting point of A
Solidus
α
A
B
0 20 40 60 80 100 ← wt % B
100 80 60 40 20 0 ←wt % A
Composition (wt %)

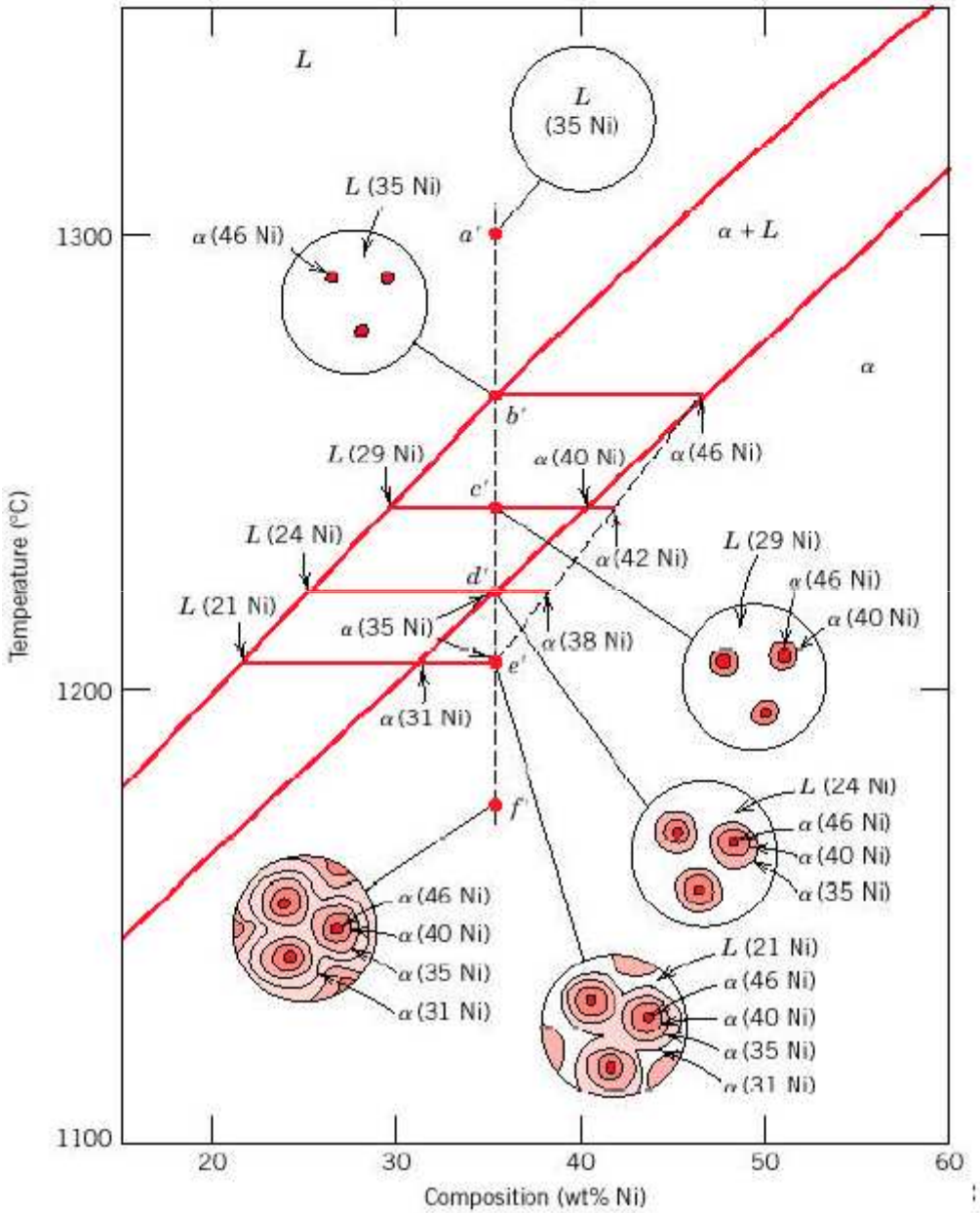

Liquidus
L
α + L
Solidus
α
Temperature
Melting point
of A
Liquid solution
Liquid solution
+
Crystallites of
Solid solution
Polycrystal
Solid solution
A
B
0
20
40
60
80
100
100
80
60
40
20
0
Composition (wt %)

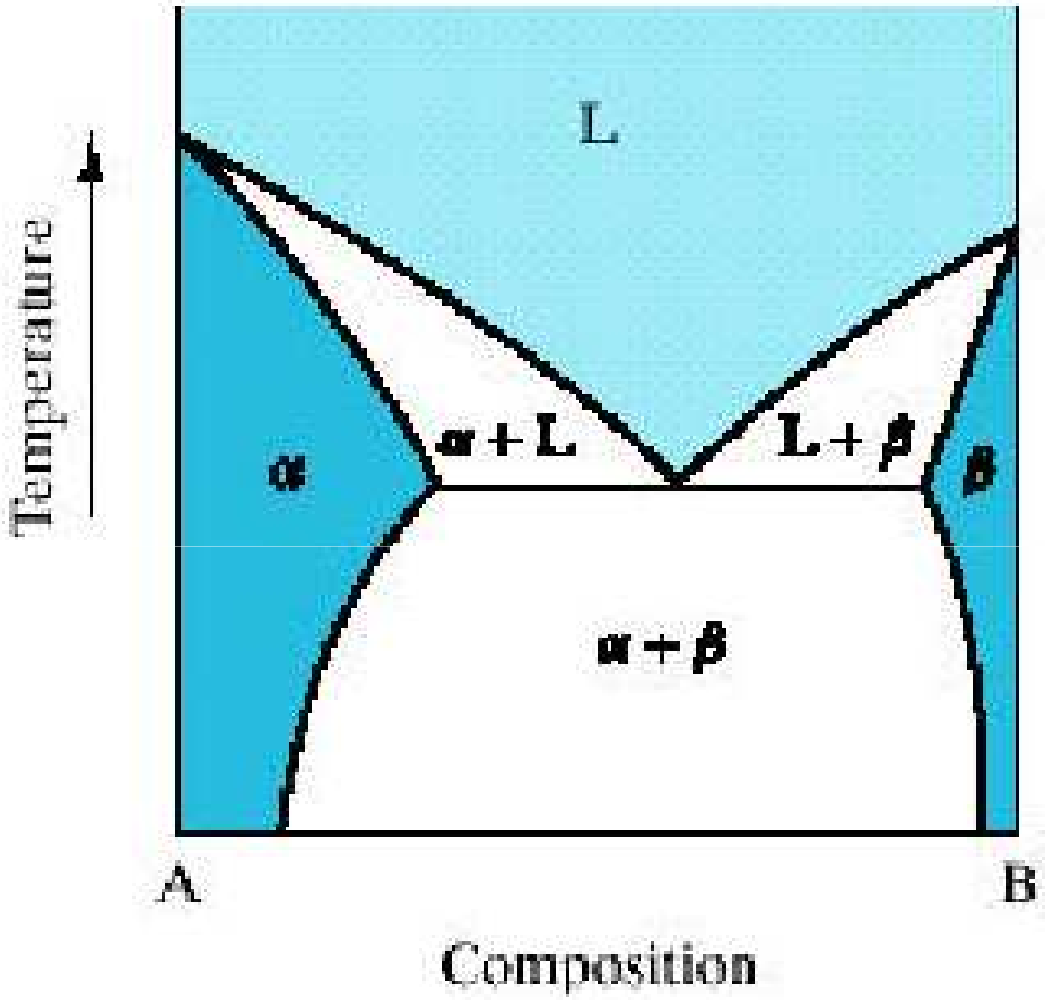


Mass fractions: $W_L = S / (R+S) = (C_\alpha - C_o) / (C_\alpha - C_L)$

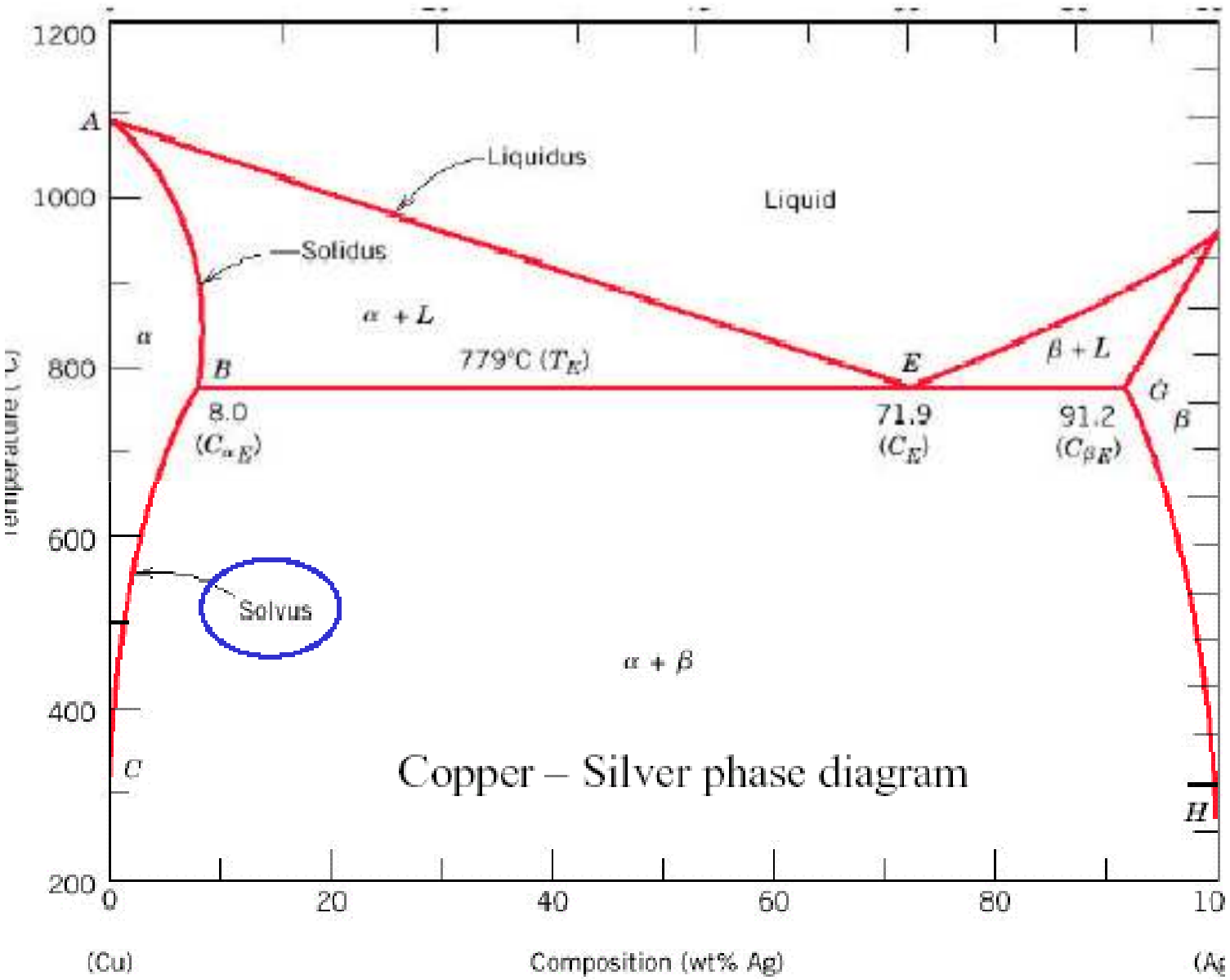
$W_\alpha = R / (R+S) = (C_o - C_L) / (C_\alpha - C_L)$


L
L
(35 Ni)
L
(35 Ni)
α (46 Ni)
a
α
+
L
1300
L (32 Ni)
b
α(46 Ni)
c
α(43 Ni)
α(43 Ni)
L (24 Ni)
d
L (32 Ni)
1200
e
L (24 Ni)
α (35 Ni)
α
α(35 Ni)
1100
20
30
40
50
Composition (wt% Ni)


L
L
(35 Ni)
L (35 Ni)
α (46 Ni)
a'
α + L
α
b'
L (29 Ni)
α (40 Ni)
α (46 Ni)
c'
L (24 Ni)
α (42 Ni)
L (29 Ni)
α (46 Ni)
α (40 Ni)
d'
L (21 Ni)
α (35 Ni)
α (38 Ni)
e'
α (31 Ni)
f'
L (24 Ni)
α (46 Ni)
α (40 Ni)
α (35 Ni)
α (46 Ni)
α (40 Ni)
α (35 Ni)
α (31 Ni)
L (21 Ni)
α (46 Ni)
α (40 Ni)
α (35 Ni)
α (31 Ni)
Temperature (°C)
1300
1200
1100
20
30
40
50
60
Composition (wt% Ni)


L
α
α + L
L + β
β
α + β
A
B
Temperature
Composition

Binary Eutectic Systems (II)



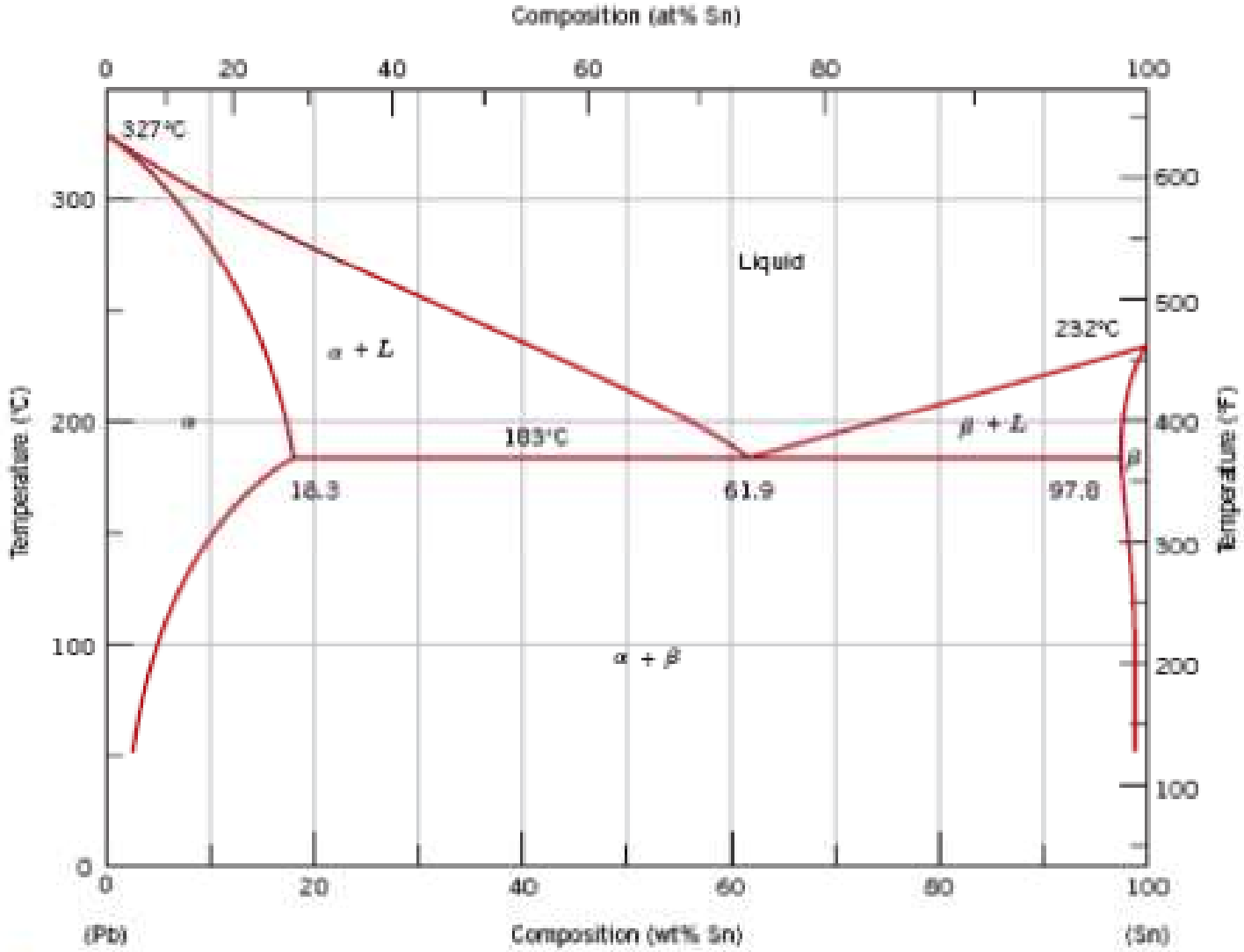
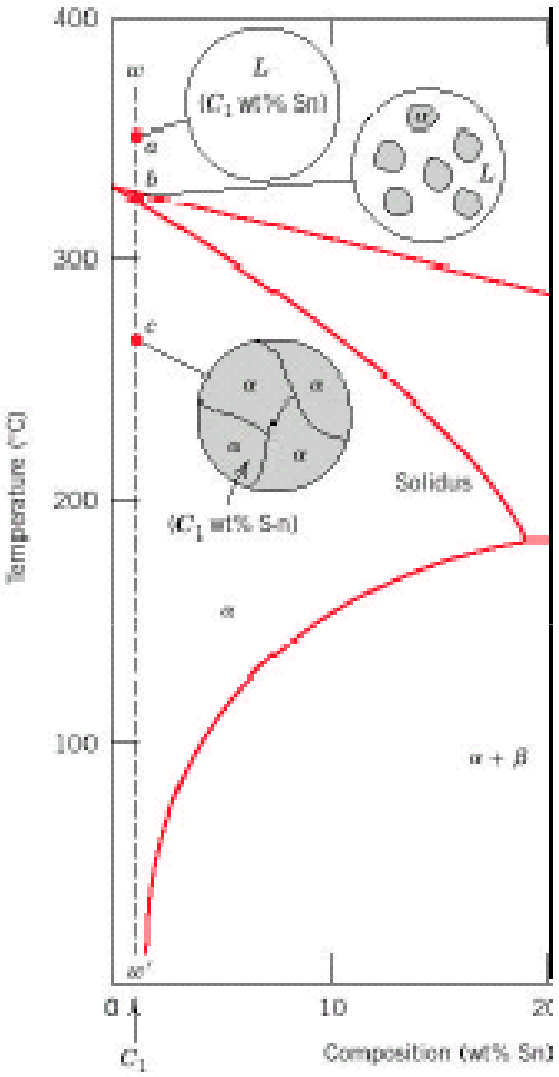
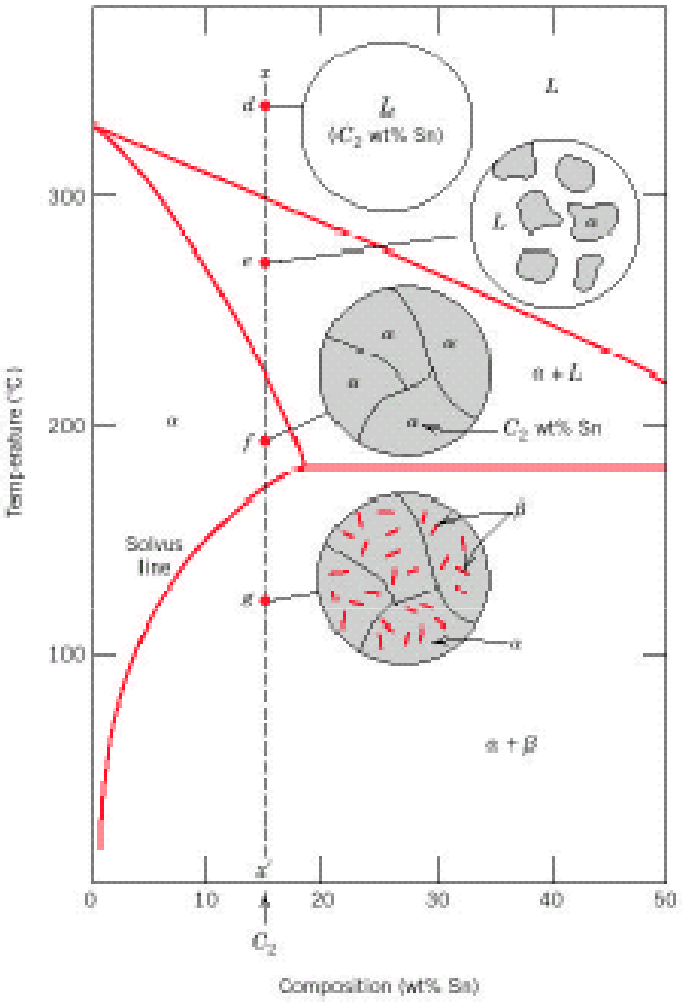


Figure 9.8 The lead–tin phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 3, T. B. Massalski (Editor-in-Chief), 1990. Reprinted by permission of ASM International, Materials Park, OH.]



h
a
s
tl
is
C
e



L

⇓

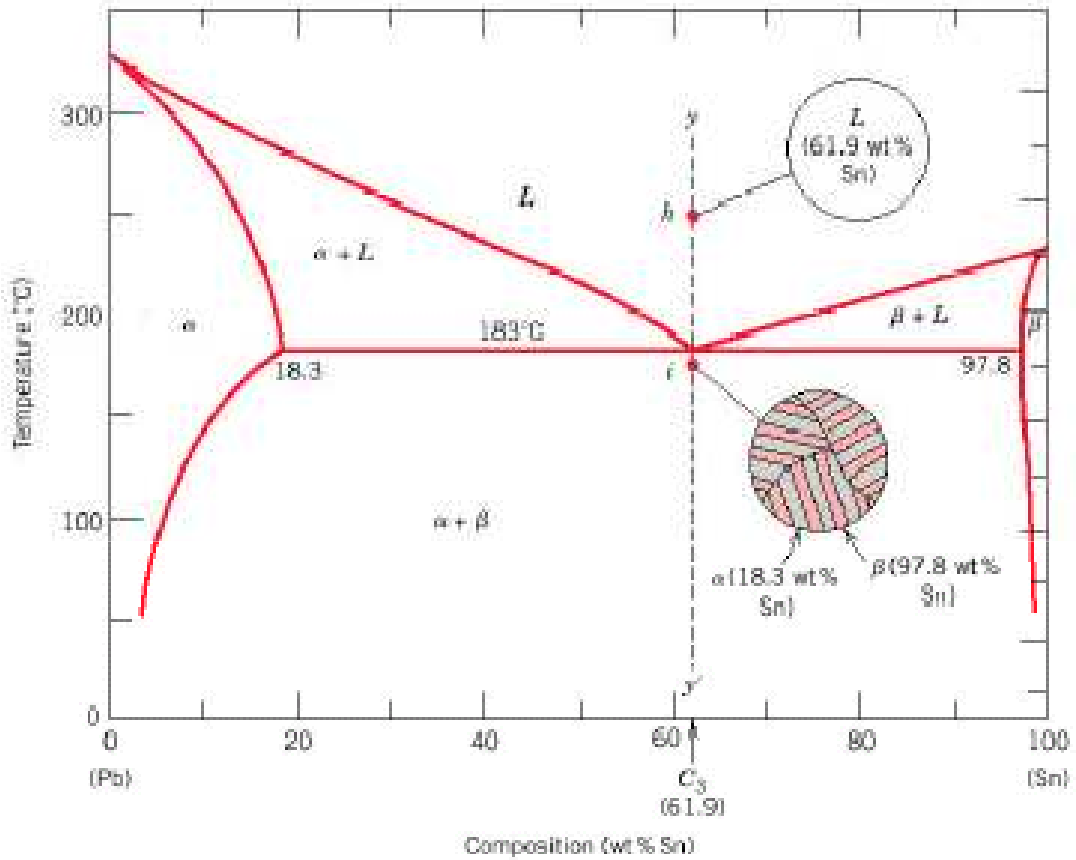
$\alpha + L$

⇓

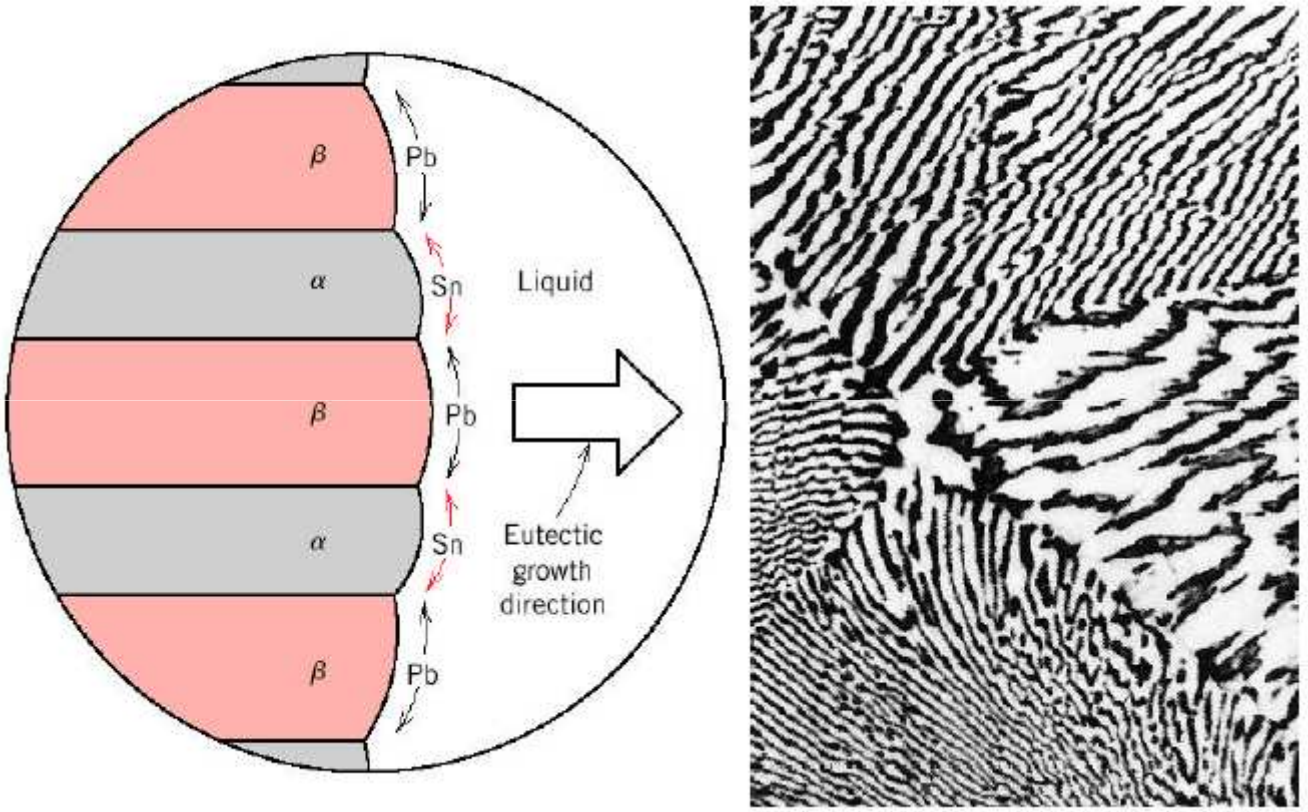
α

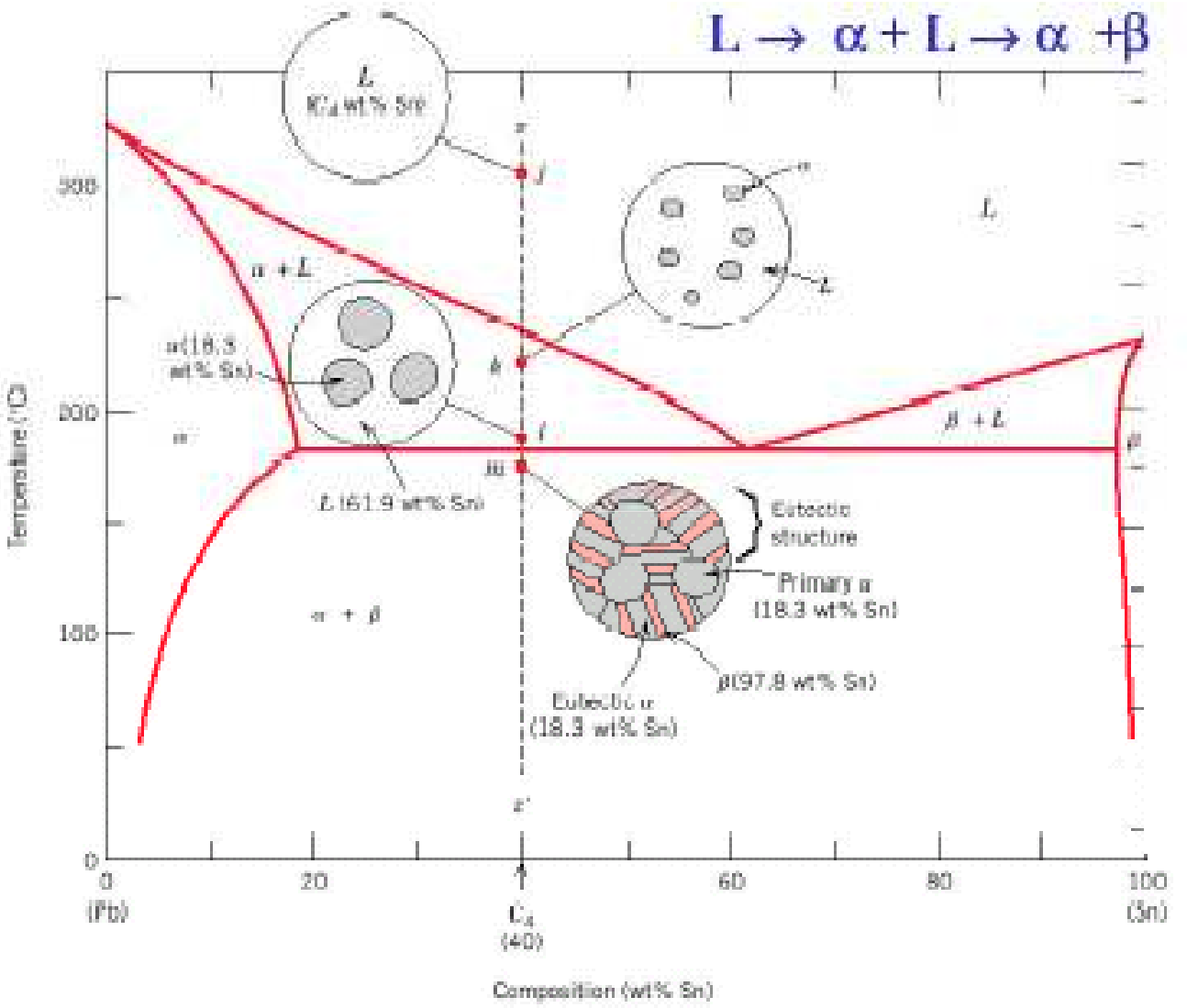
⇓

$\alpha + \beta$

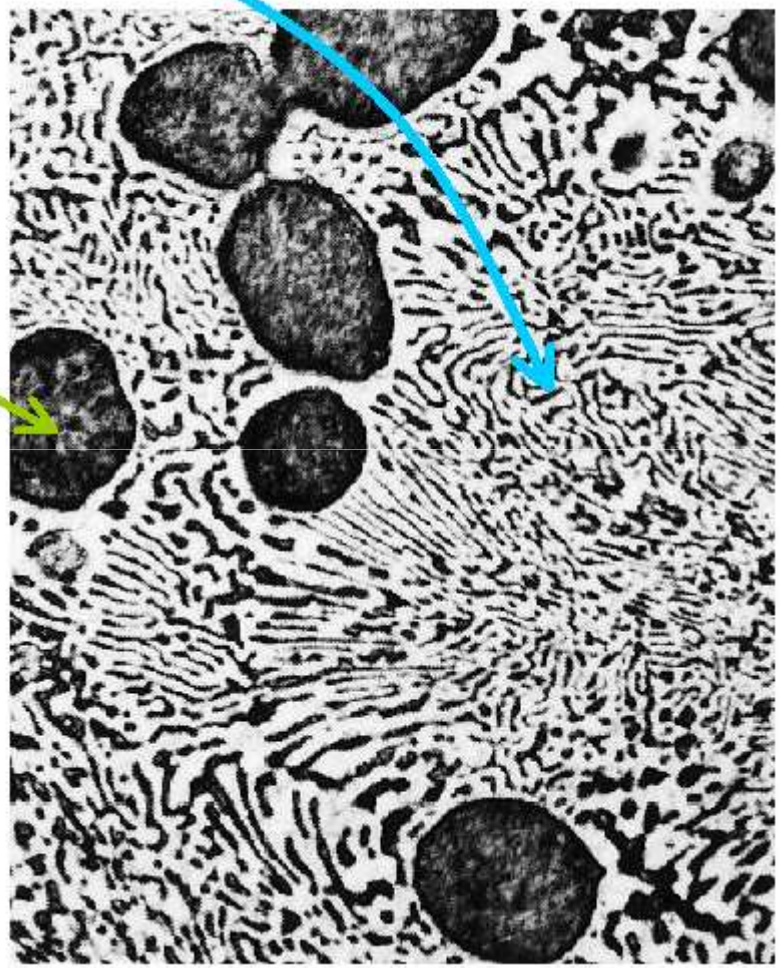


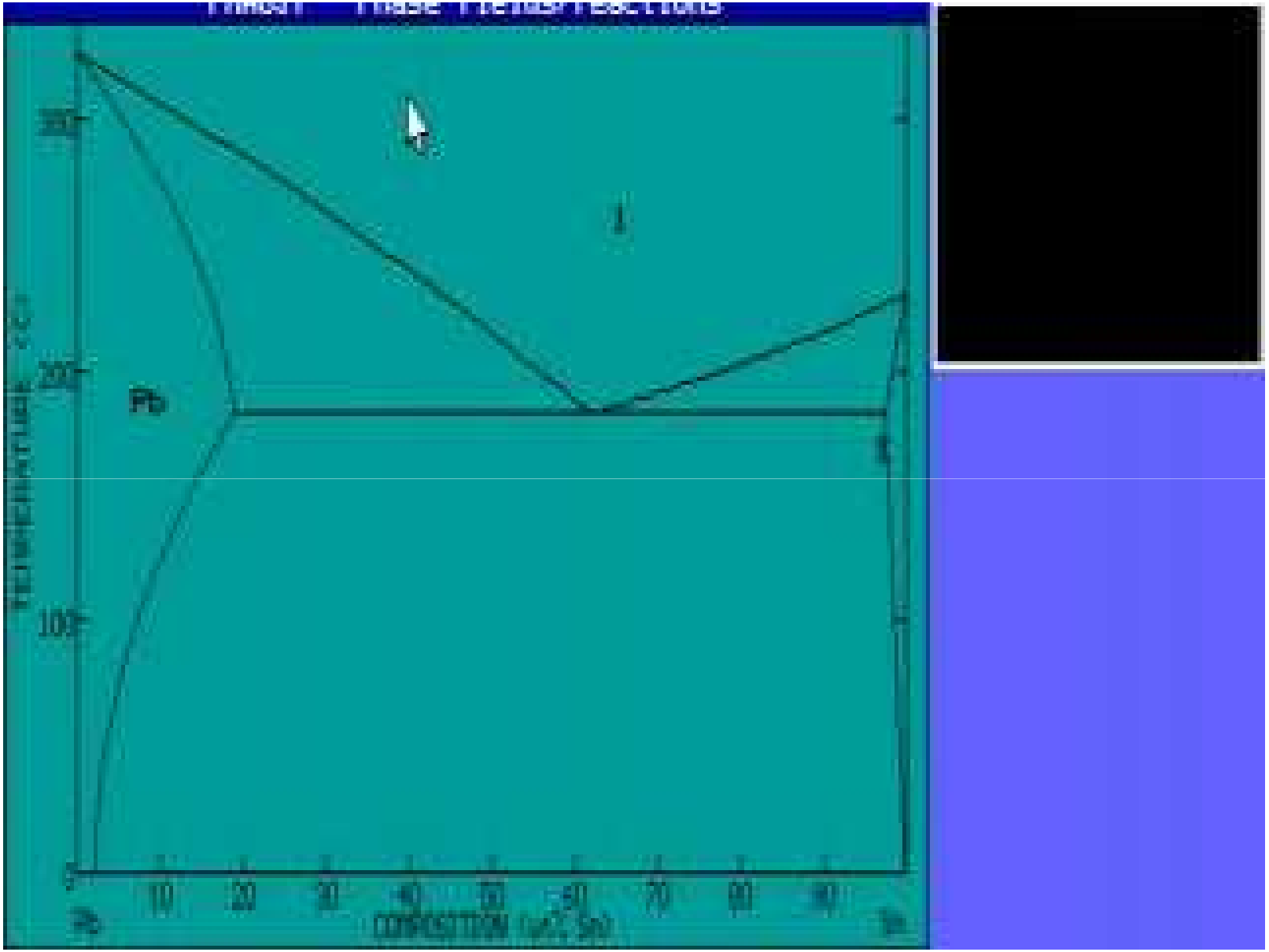
$$L \rightarrow \alpha + \beta$$

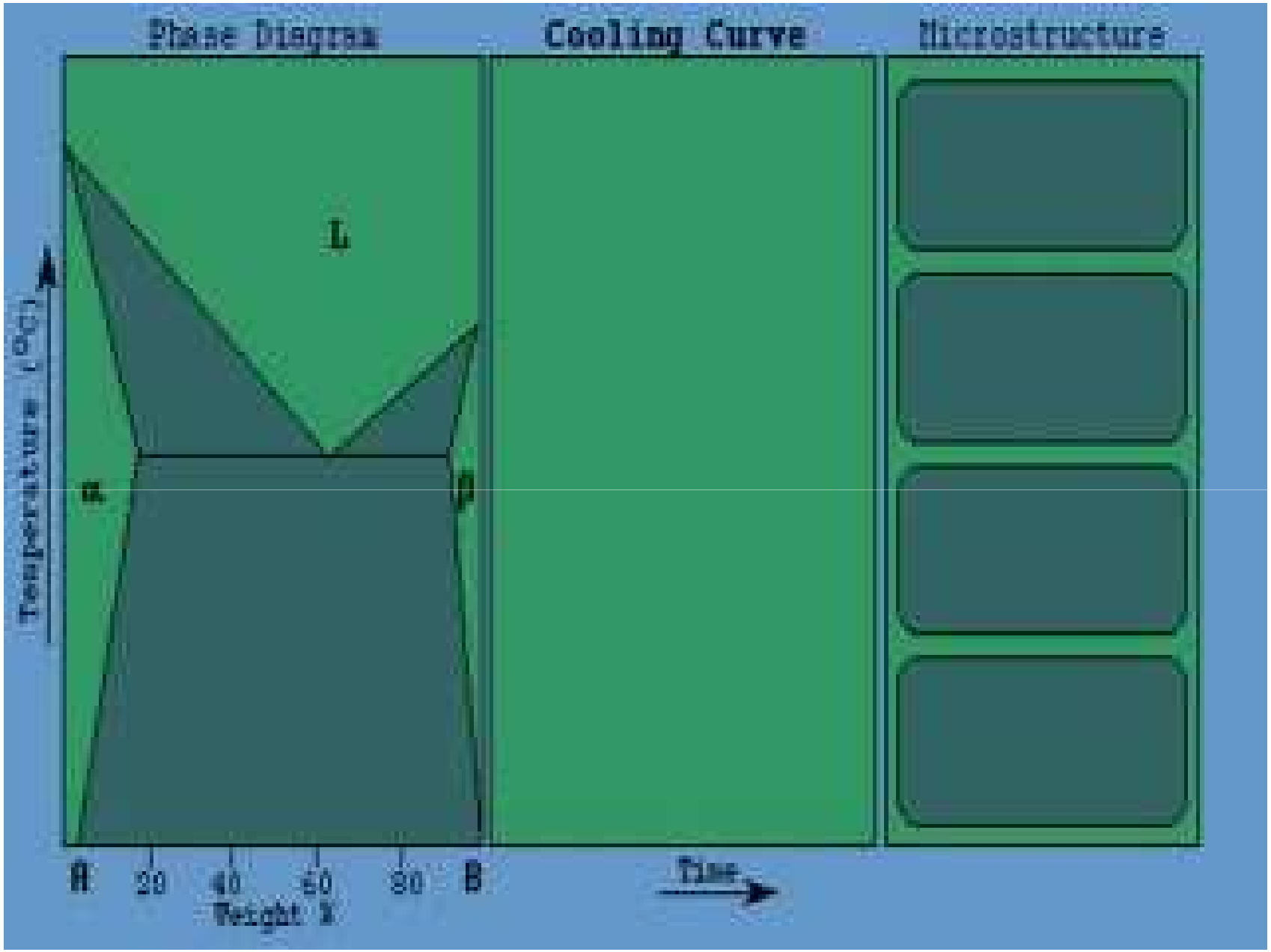

β
α
β
α
β
Pb
Sn
Pb
Sn
Pb
Liquid
Eutectic
growth
direction

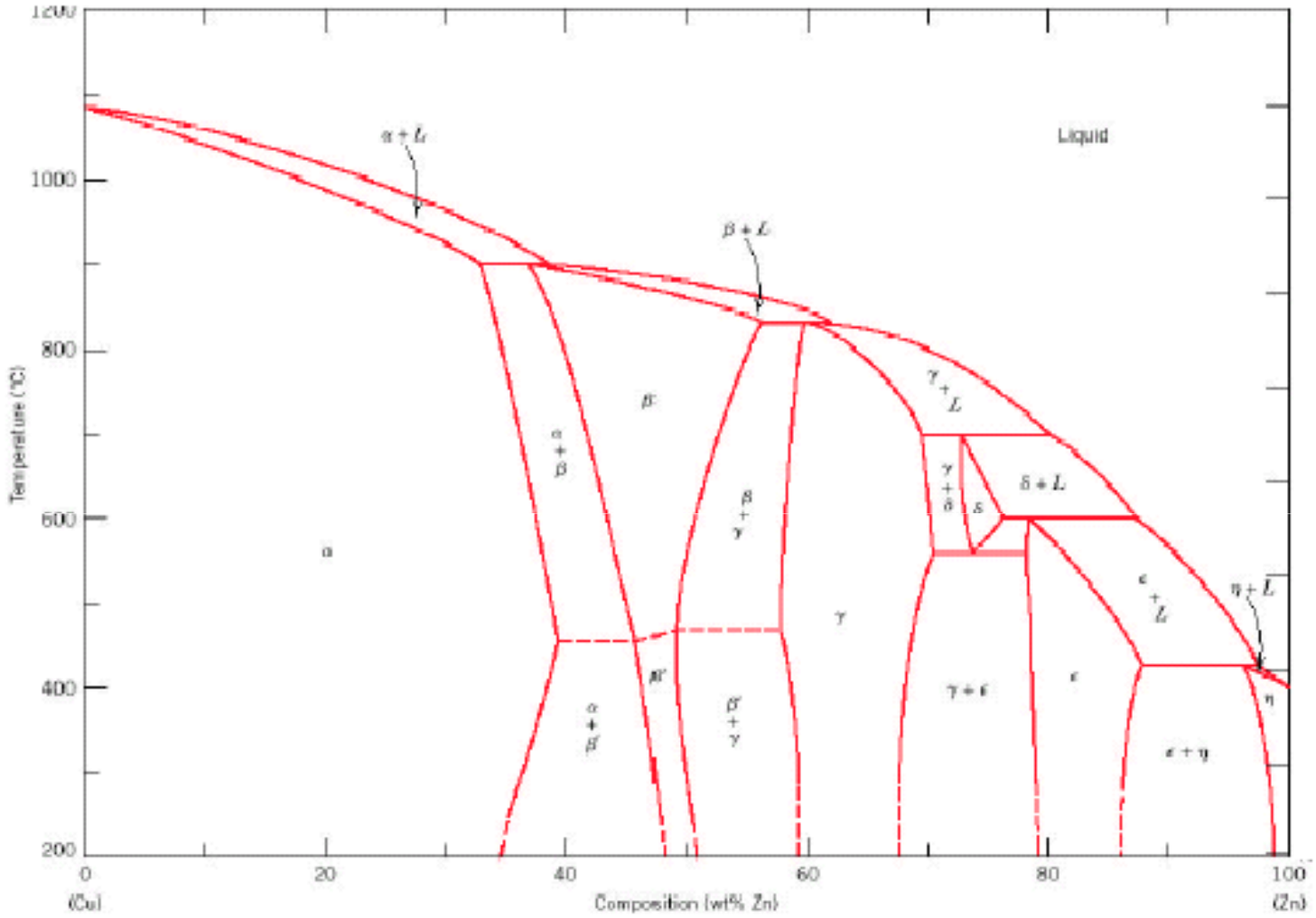

L → α + L → α + β
L
α + L
α(18.3 wt% Sn)
L (61.9 wt% Sn)
β + L
Eutectic structure
Primary α (18.3 wt% Sn)
β(97.8 wt% Sn)
Eutectic α (18.3 wt% Sn)
α + β
Temperature (°C)
300
200
100
0
0
20
60
80
100
(Pb)
(Sn)
C_4
(40)
Composition (wt% Sn)

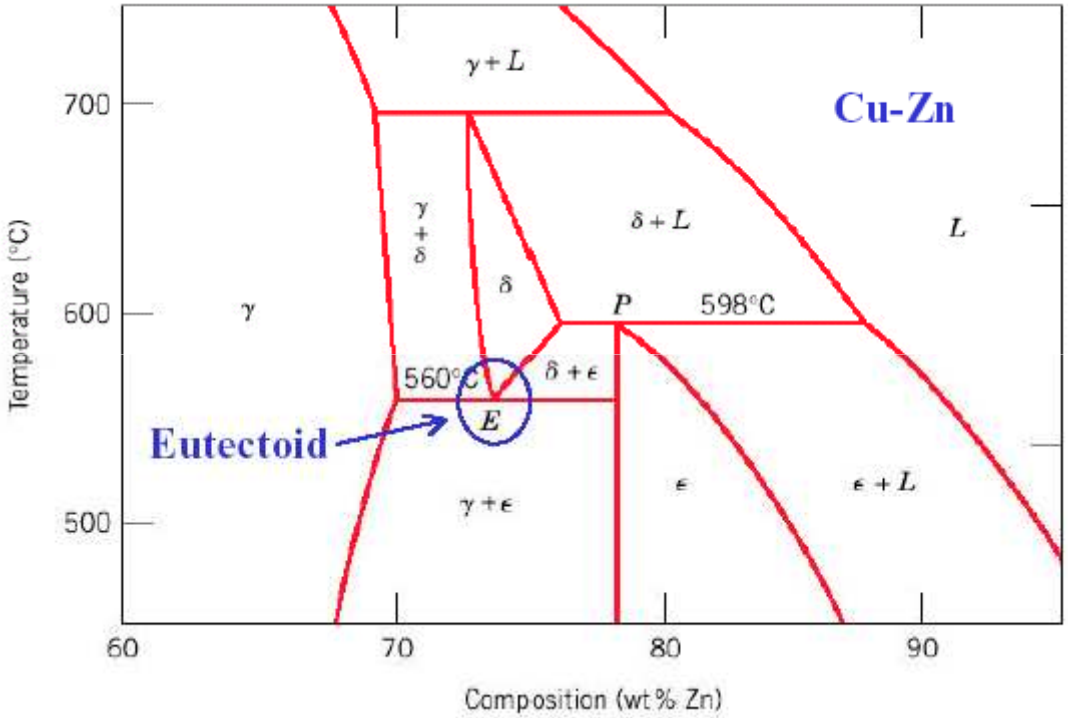
primary α phase and the eutectic structure.

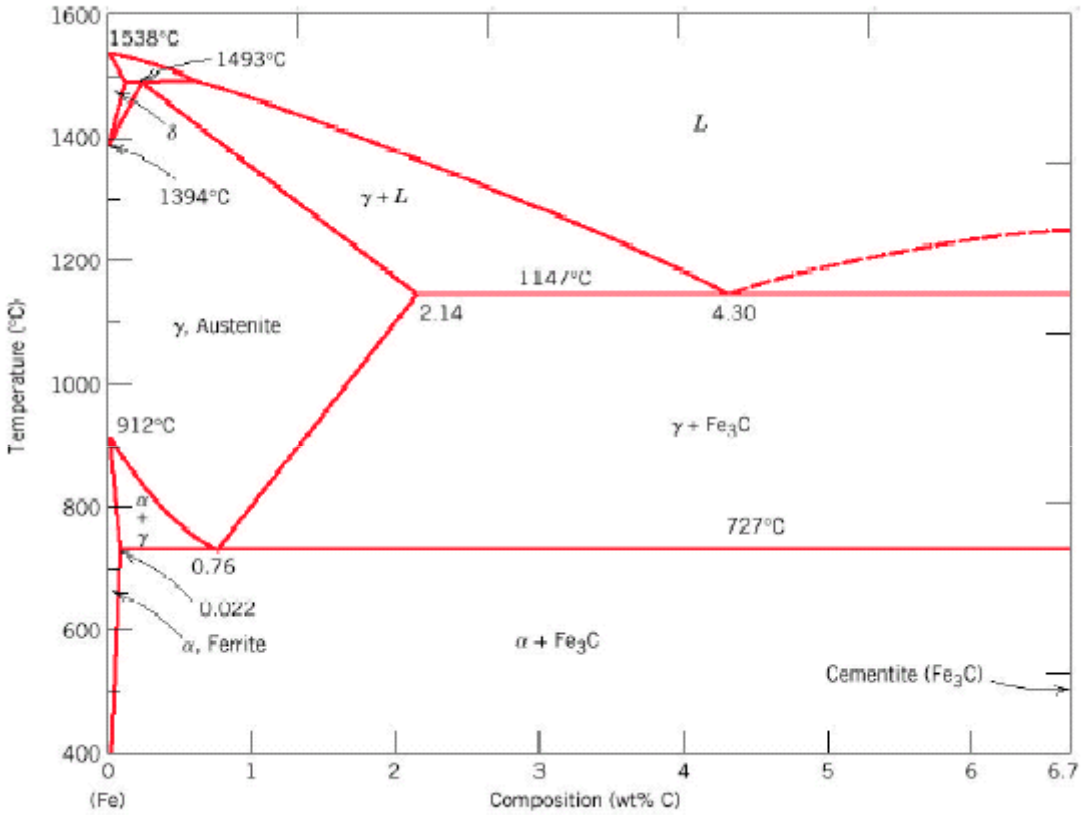


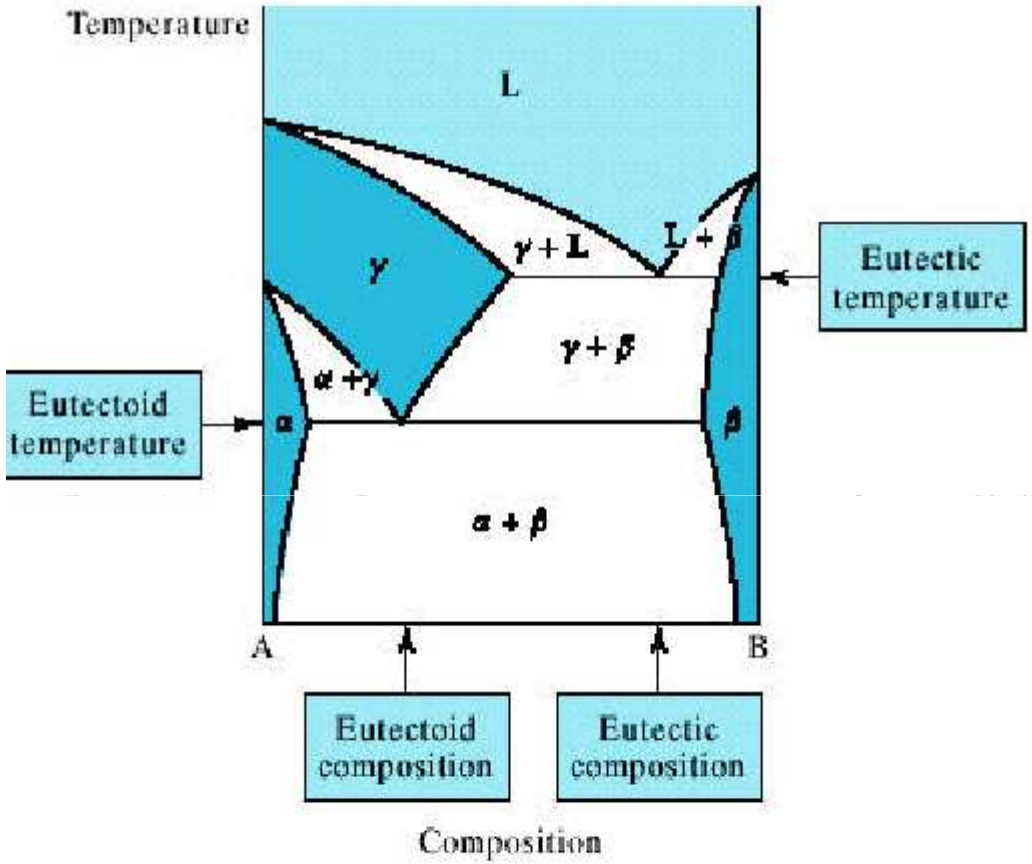

L
Pb
200
100
10
20
30
40
50
60
70
80
90

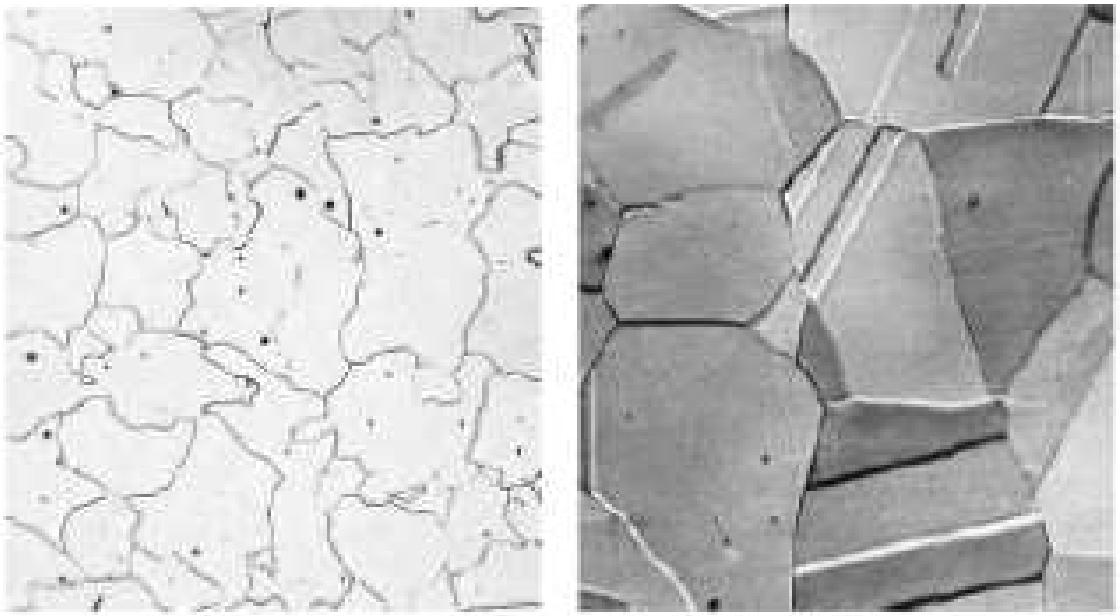

Phase Diagram
Cooling Curve
Microstructure
L
α
β
Temperature (°C)
A
20
40
50
80
B
Weight %
Time


Liquid
α + L
β + L
γ + L
δ + L
ε + L
η + L
α
α + β
β
β + γ
γ
γ + δ
δ
γ + ε
ε
ε + η
η
α + β'
β'
β' + γ
Temperature (°C)
1000
800
600
400
200
0
20
40
60
80
100
(Cu)
Composition (wt% Zn)
(Zn)


Cu-Zn
γ + L
δ + L
L
γ + δ
γ
δ
P
598°C
560°C
δ + ε
E
Eutectoid
γ + ε
ε
ε + L
700
600
500
60
70
80
90
Temperature (°C)
Composition (wt % Zn)


1600
1400
1200
1000
800
600
400
Temperature (°C)
1538°C
1493°C
δ
1394°C
L
γ + L
1147°C
2.14
4.30
γ, Austenite
912°C
γ + Fe3C
α + γ
727°C
0.76
0.022
α, Ferrite
α + Fe3C
Cementite (Fe3C)
0
(Fe)
1
2
3
4
5
6
6.7
Composition (wt% C)


Temperature
L
γ
γ + L
L + β
Eutectic temperature
γ + β
α + γ
Eutectoid temperature
α
β
α + β
A
B
Eutectoid composition
Eutectic composition
Composition

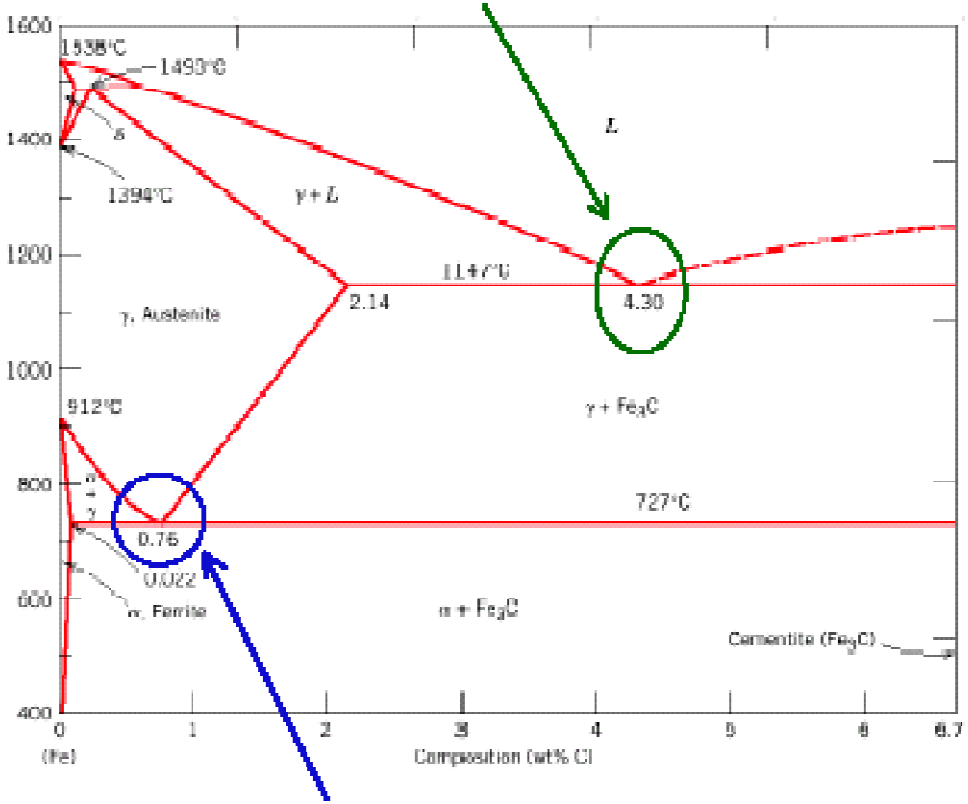


(a) (b)

Figure 9.25
Photomicrographs of (*a*) α ferrite (90×) and (*b*) austenite (325×). (Copyright 1971 by United States Steel Corporation.)

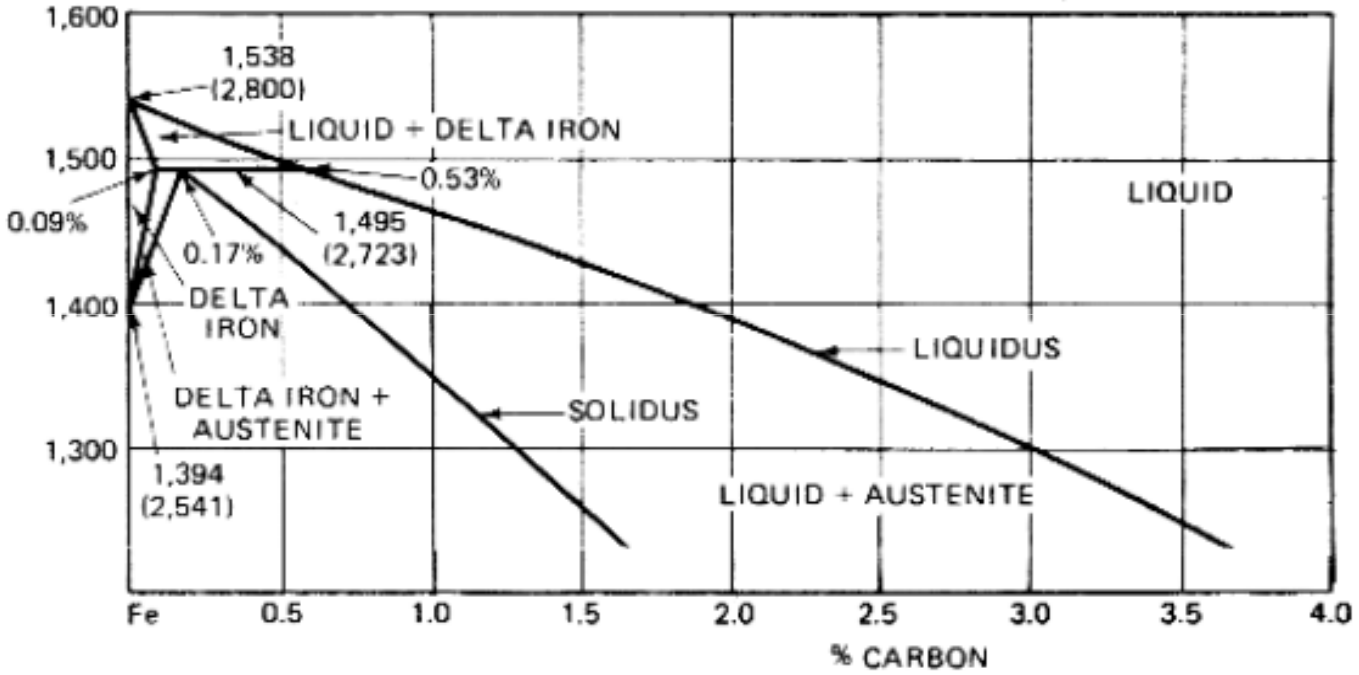
Eutectic: 4.30 wt% C, 1147 °C

$L \leftrightarrow \gamma + Fe_3C$

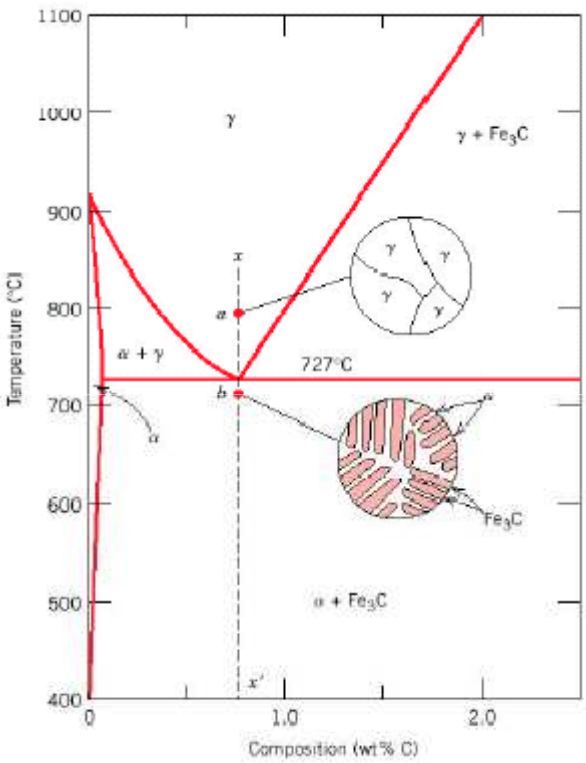


Eutectoid: 0.76 wt%C, 727 °C

$\gamma(0.76\ wt\%\ C) \leftrightarrow \alpha\ (0.022\ wt\%\ C) + Fe_3C$


1,600
1,500
1,400
1,300
1,538
(2,800)
LIQUID + DELTA IRON
0.53%
0.09%
0.17%
1,495
(2,723)
DELTA
IRON
DELTA IRON +
AUSTENITE
1,394
(2,541)
LIQUIDUS
SOLIDUS
LIQUID
LIQUID + AUSTENITE
Fe
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
% CARBON

Microstructure of eutectoid steel (I)



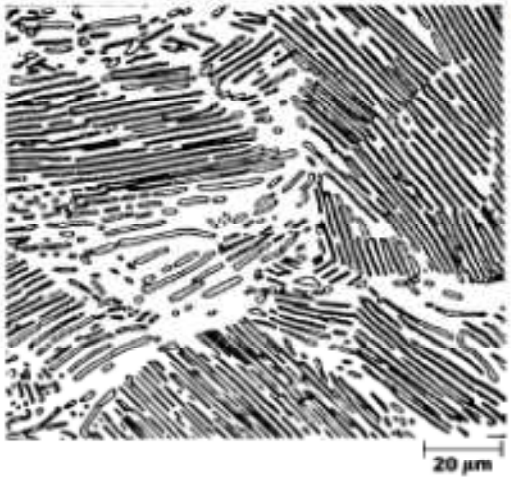


Figure 9.27 Photomicrograph of a eutectoid steel showing the pearlite microstructure consisting of alternating layers of α ferrite (the light phase) and Fe_3C (thin layers most of which appear dark). 500×. (Reproduced with permission from *Metals Handbook*, 9th edition, Vol. 9, *Metallography and Microstructures*, American Society for Metals, Materials Park, OH, 1985.)

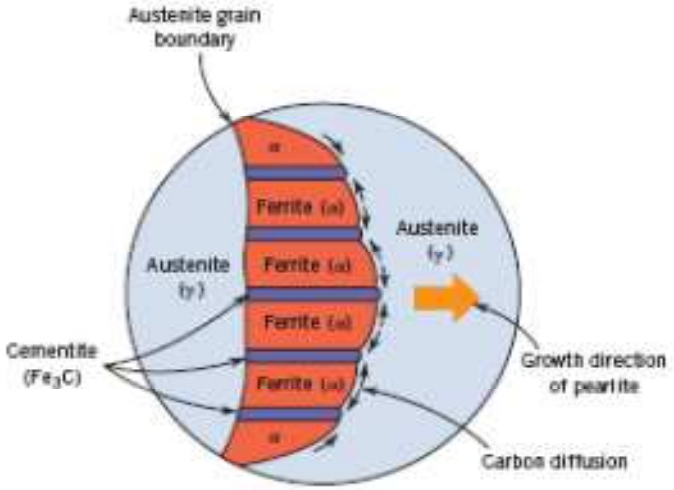
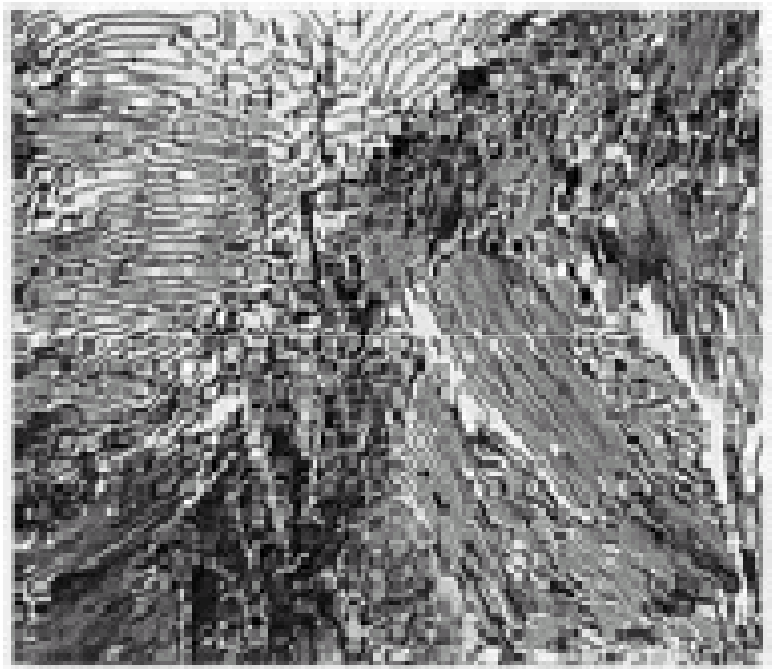
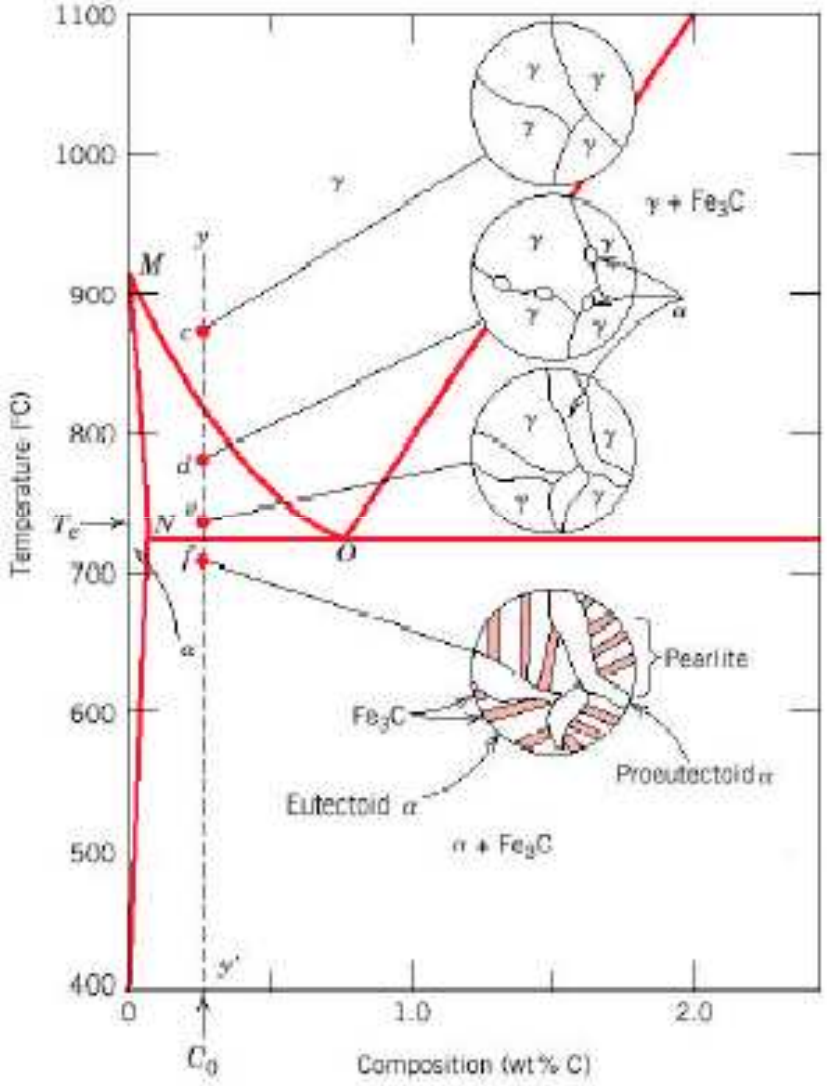


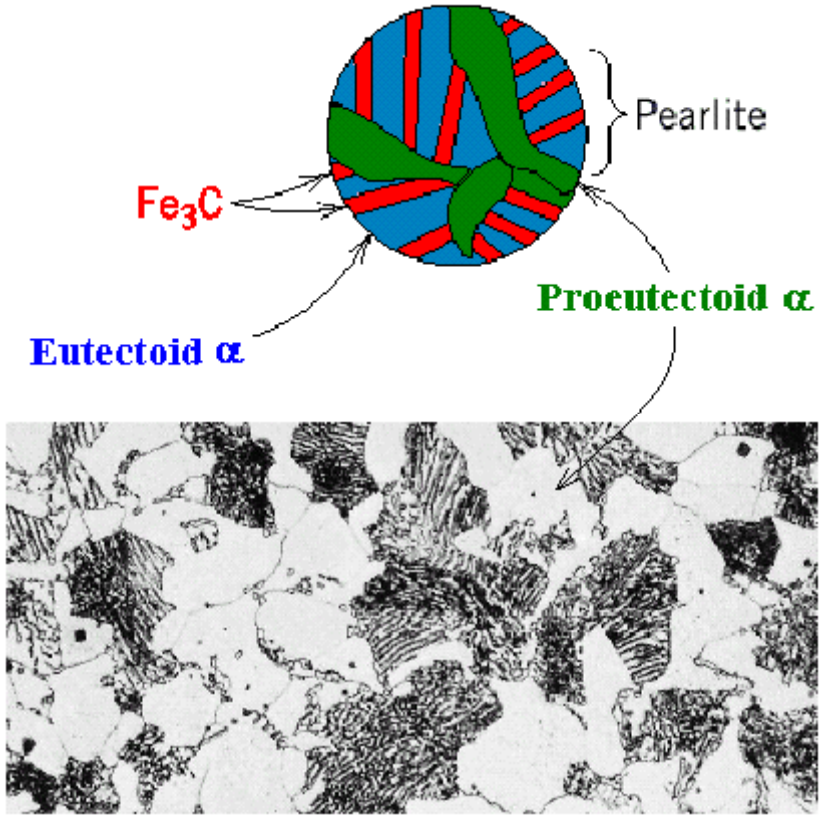
Figure 9.28 Schematic representation of the formation of pearlite from austenite; direction of carbon diffusion indicated by arrows.



Aço eutetóide 0,76% C - Perlita

$\gamma \rightarrow \alpha + \gamma \rightarrow \alpha + Fe_3C$




Pearlite
Fe_3C
Proeutectoid α
Eutectoid α

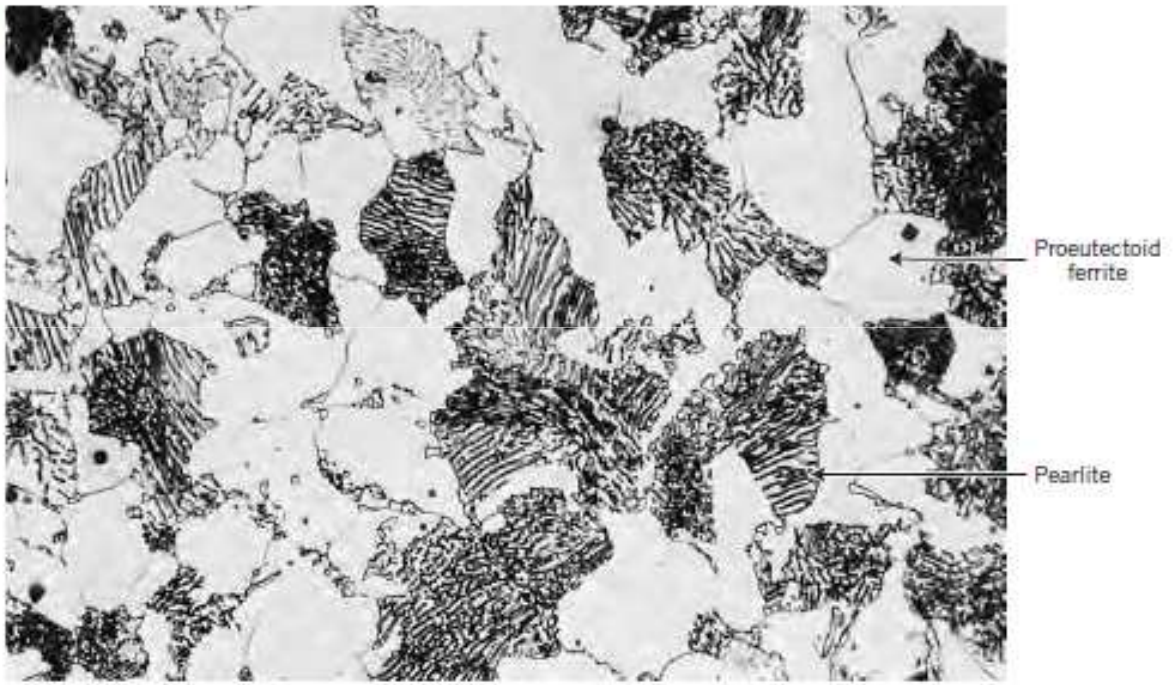
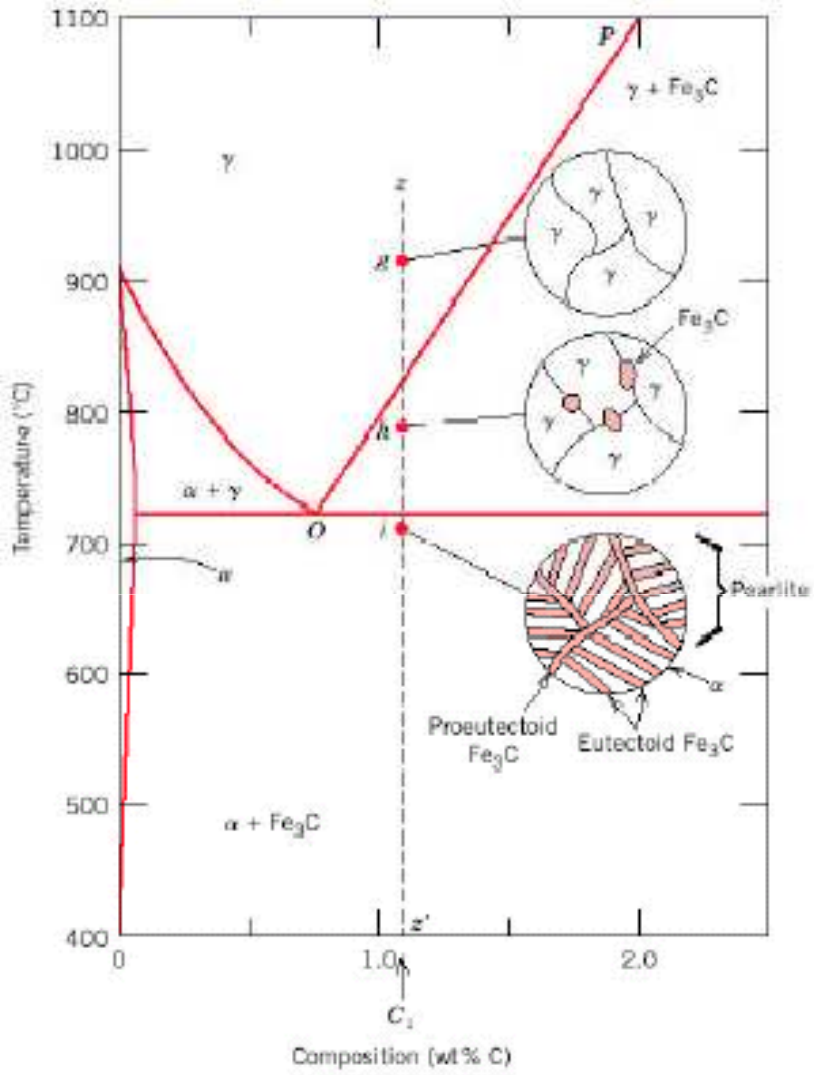


Figure 9.30 Photomicrograph of a 0.38 wt% C steel having a microstructure consisting of pearlite and proeutectoid ferrite. 635×. (Photomicrograph courtesy of Republic Steel Corporation.)

Aço hipoeutetóide 0,45% C – Ferrita e Perlita

$\gamma \rightarrow \gamma + Fe_3C \rightarrow \alpha + Fe_3C$



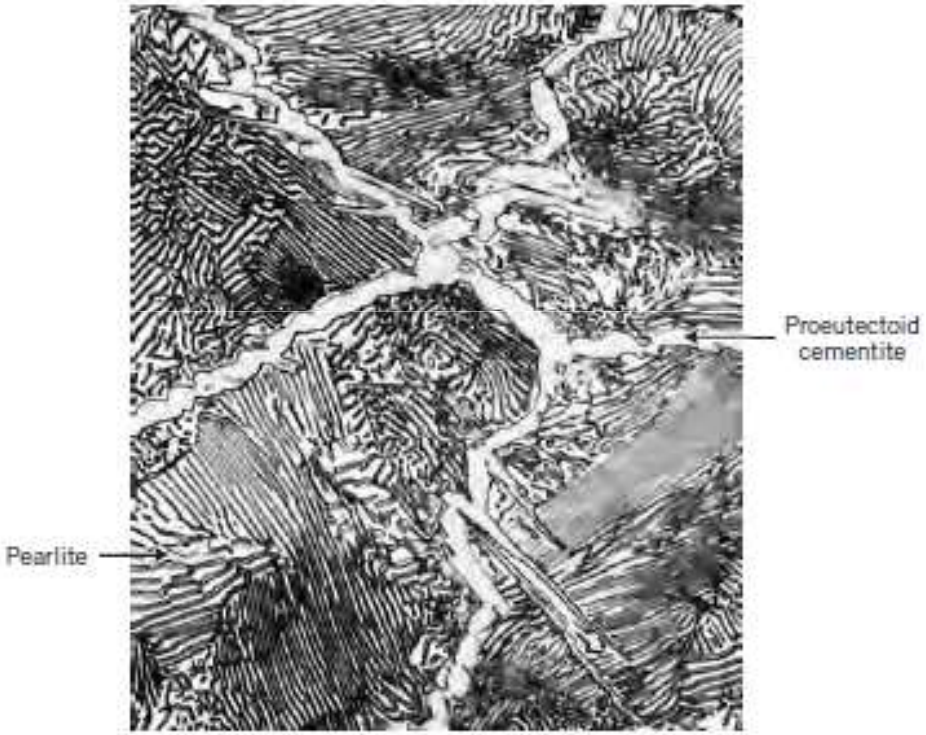
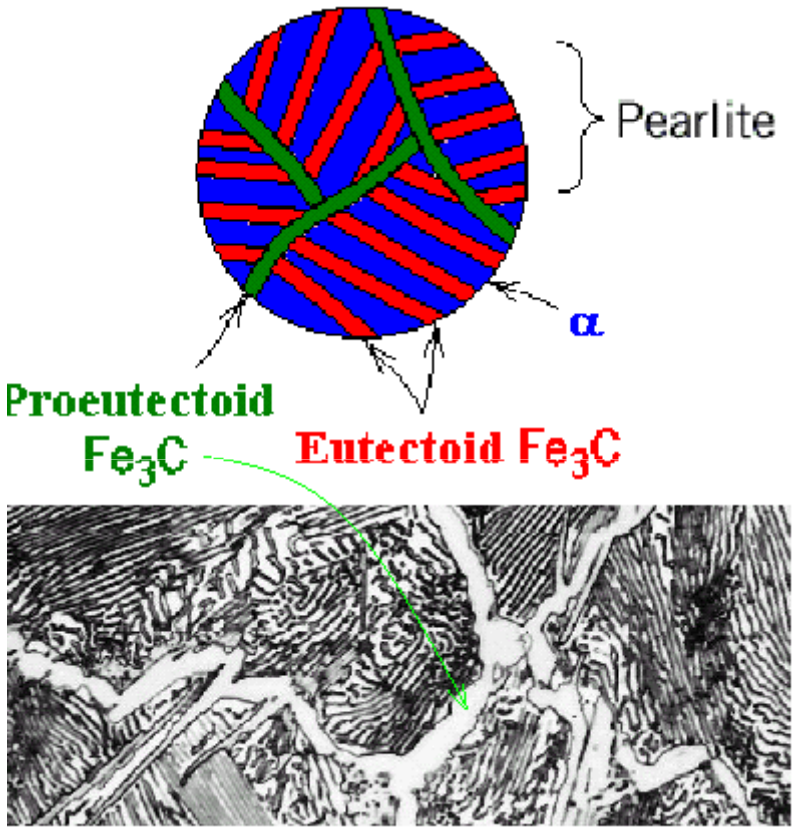
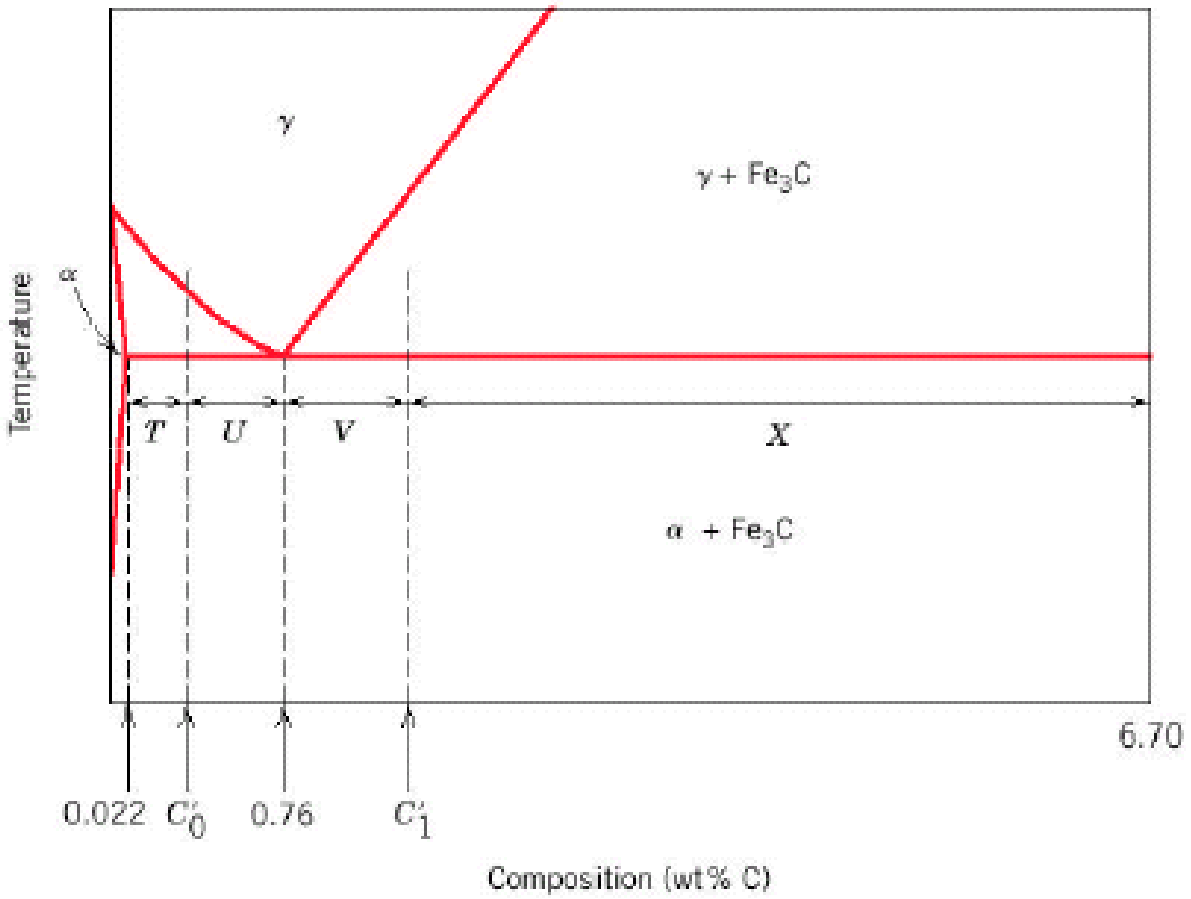


Figure 9.33 Photomicrograph of a 1.4 wt% C steel having a microstructure consisting of a white proeutectoid cementite network surrounding the pearlite colonies. 1000×. (Copyright 1971 by United States Steel Corporation.)


Pearlite
α
Proeutectoid
Fe3C
Eutectoid Fe3C

Aço hipereutetóide 0,9% C – Perlita e Cementita


γ
γ + Fe3C
α + Fe3C
R
T
U
V
X
Temperature
0.022
C'0
0.76
C'1
6.70
Composition (wt% C)

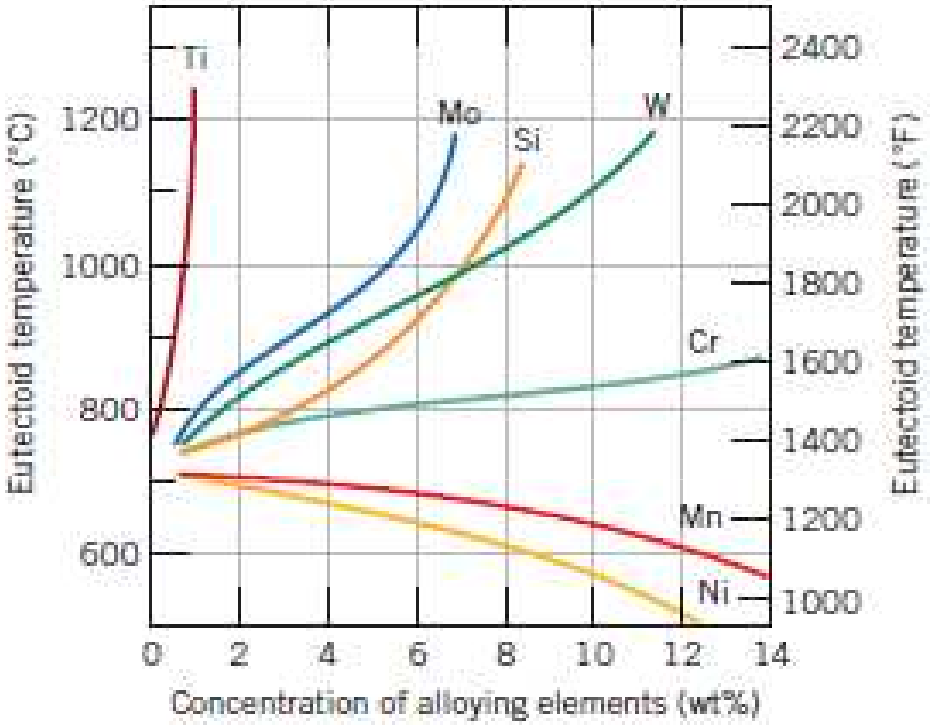


Figure 9.34 The dependence of eutectoid temperature on alloy concentration for several alloying elements in steel. (From Edgar C. Bain, *Functions of the Alloying Elements in Steel*, American Society for Metals, 1939, p. 127.)

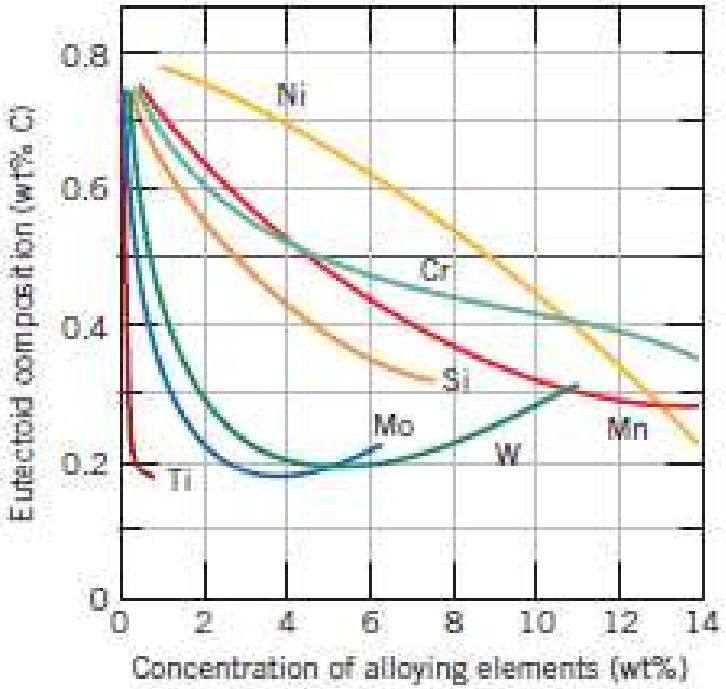


Figure 9.35 The dependence of eutectoid composition (wt% C) on alloy concentration for several alloying elements in steel. (From Edgar C. Bain, *Functions of the Alloying Elements in Steel*, American Society for Metals, 1939, p. 127.)