TA201A
Manufacturing Processes

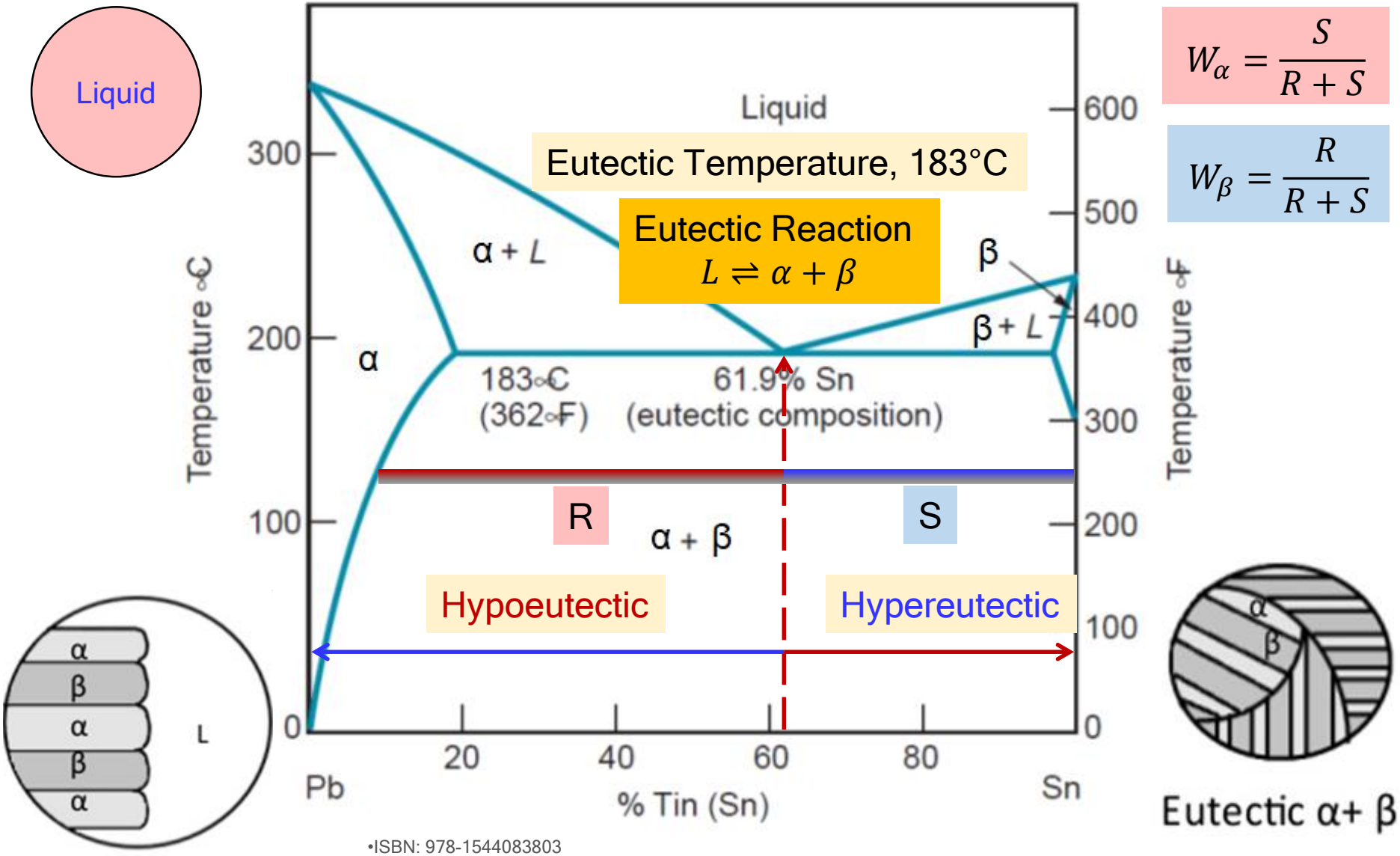
Week-4

30 Aug, 2022

2022-2023 Semester-I

Lecture 4

Eutectic Phase Diagram: Pb-Sn system

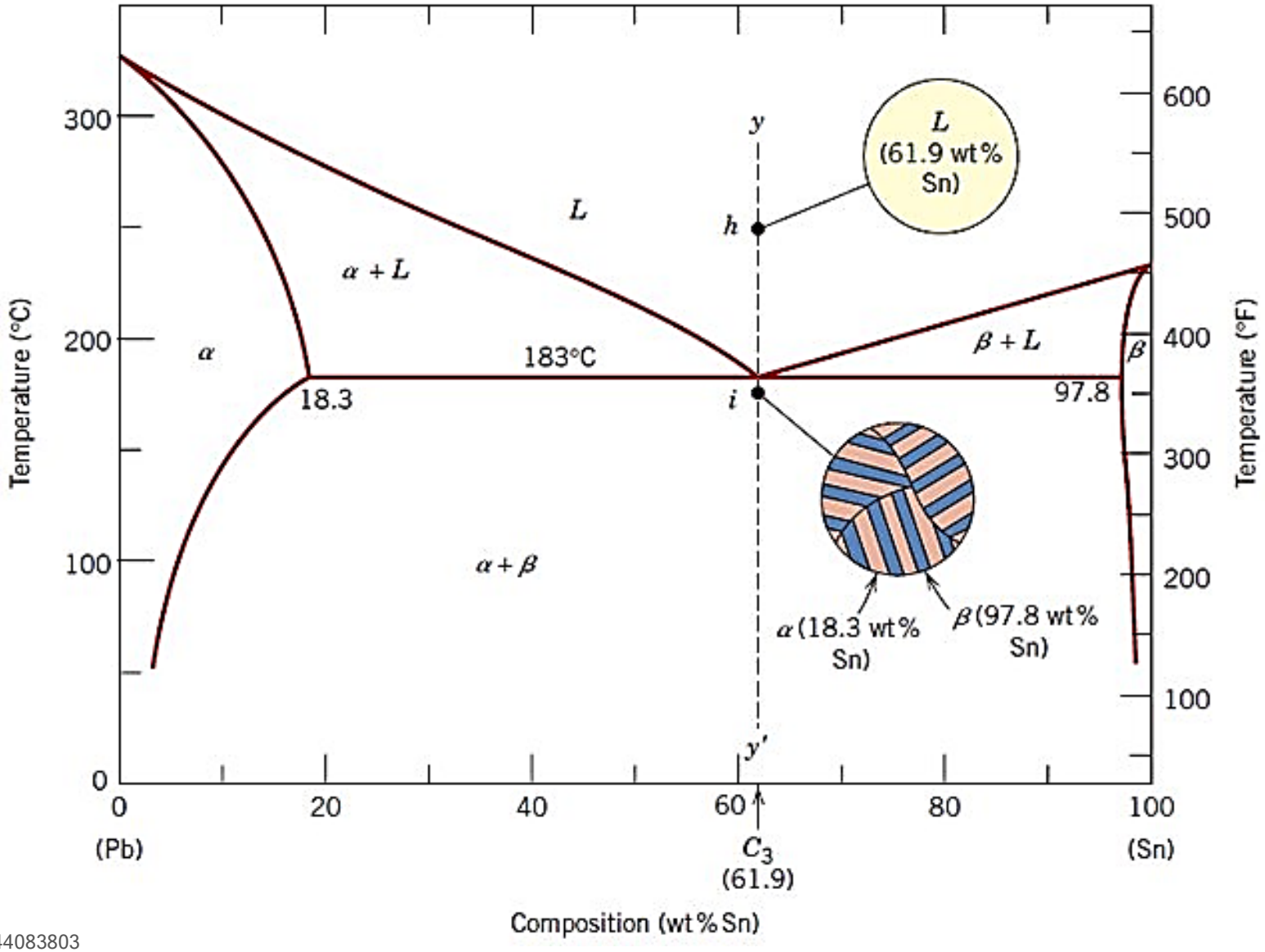


$$W_\alpha = \frac{S}{R+S}$$

$$W_\beta = \frac{R}{R+S}$$

•ISBN: 978-1544083803

Solidification at Eutectic Composition



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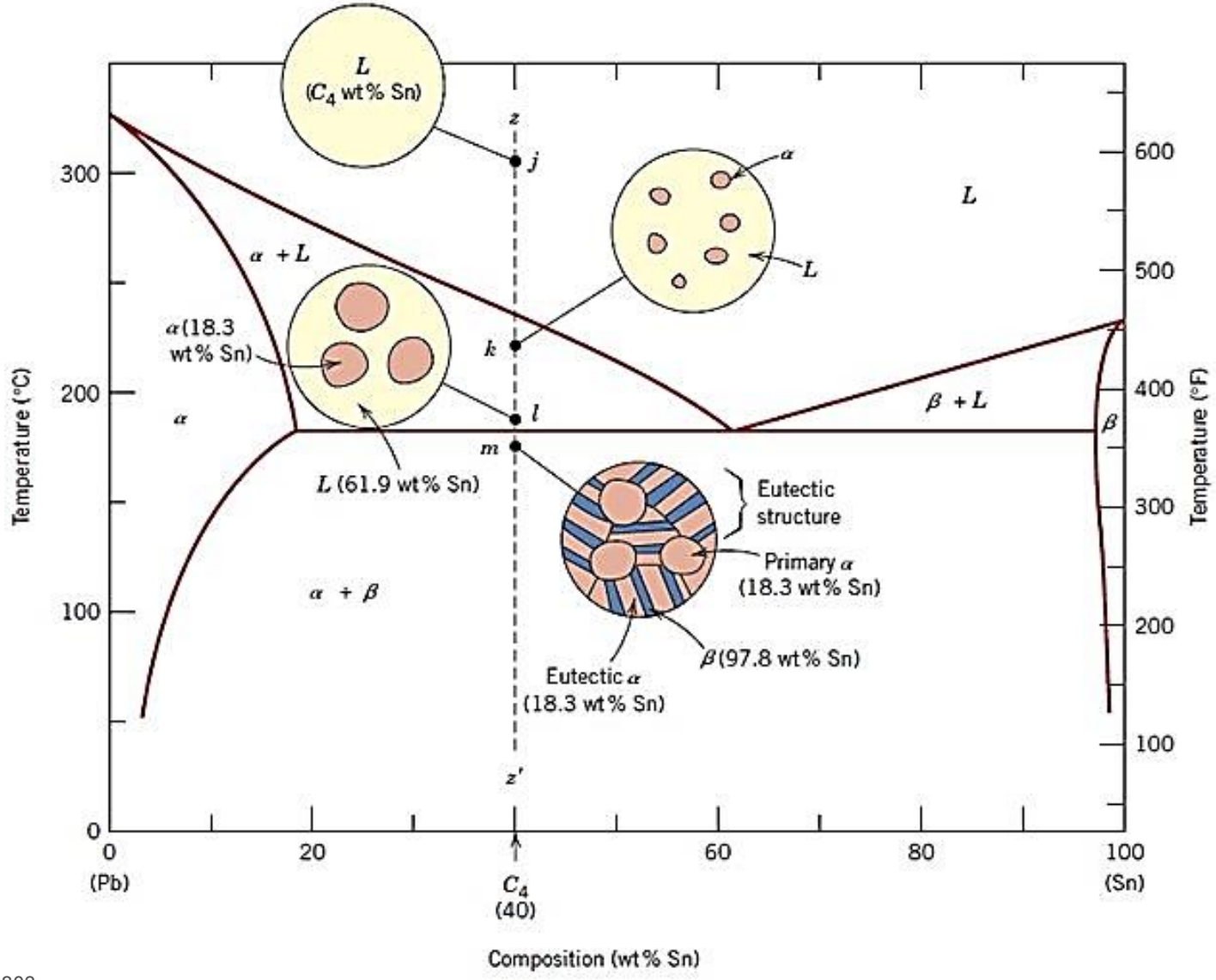

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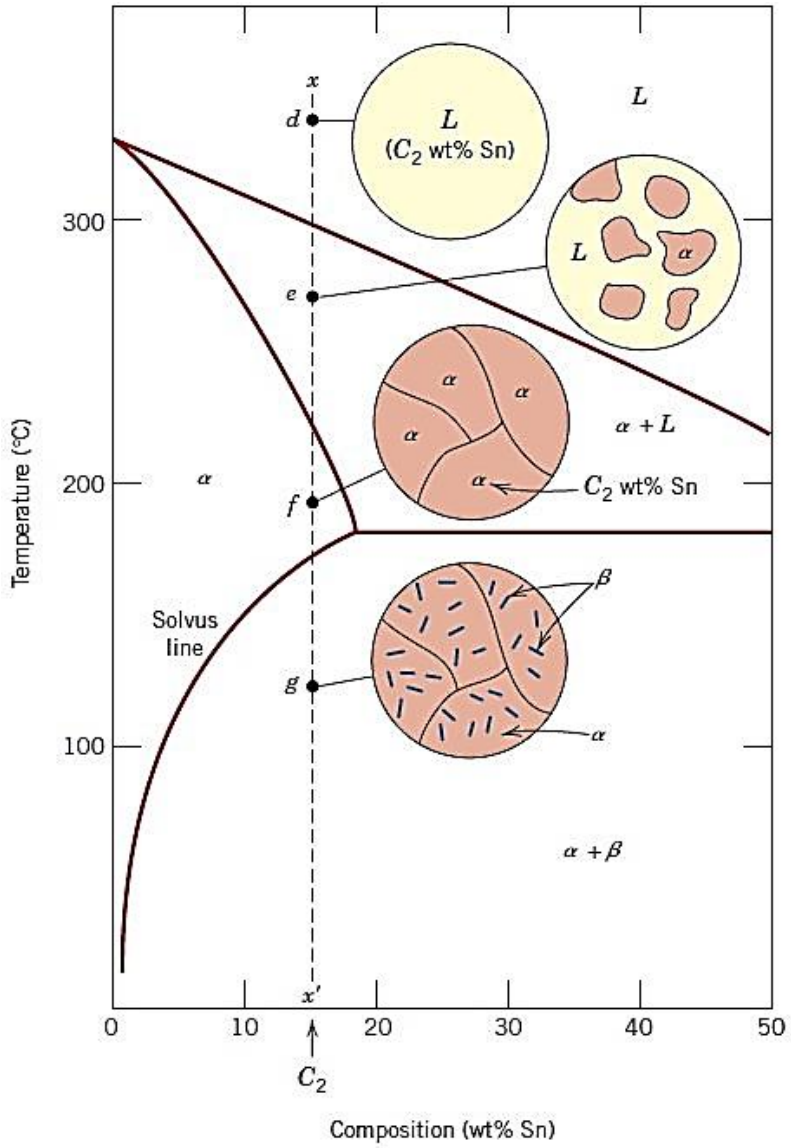
Solidification at Proeutectic Composition with single phase region



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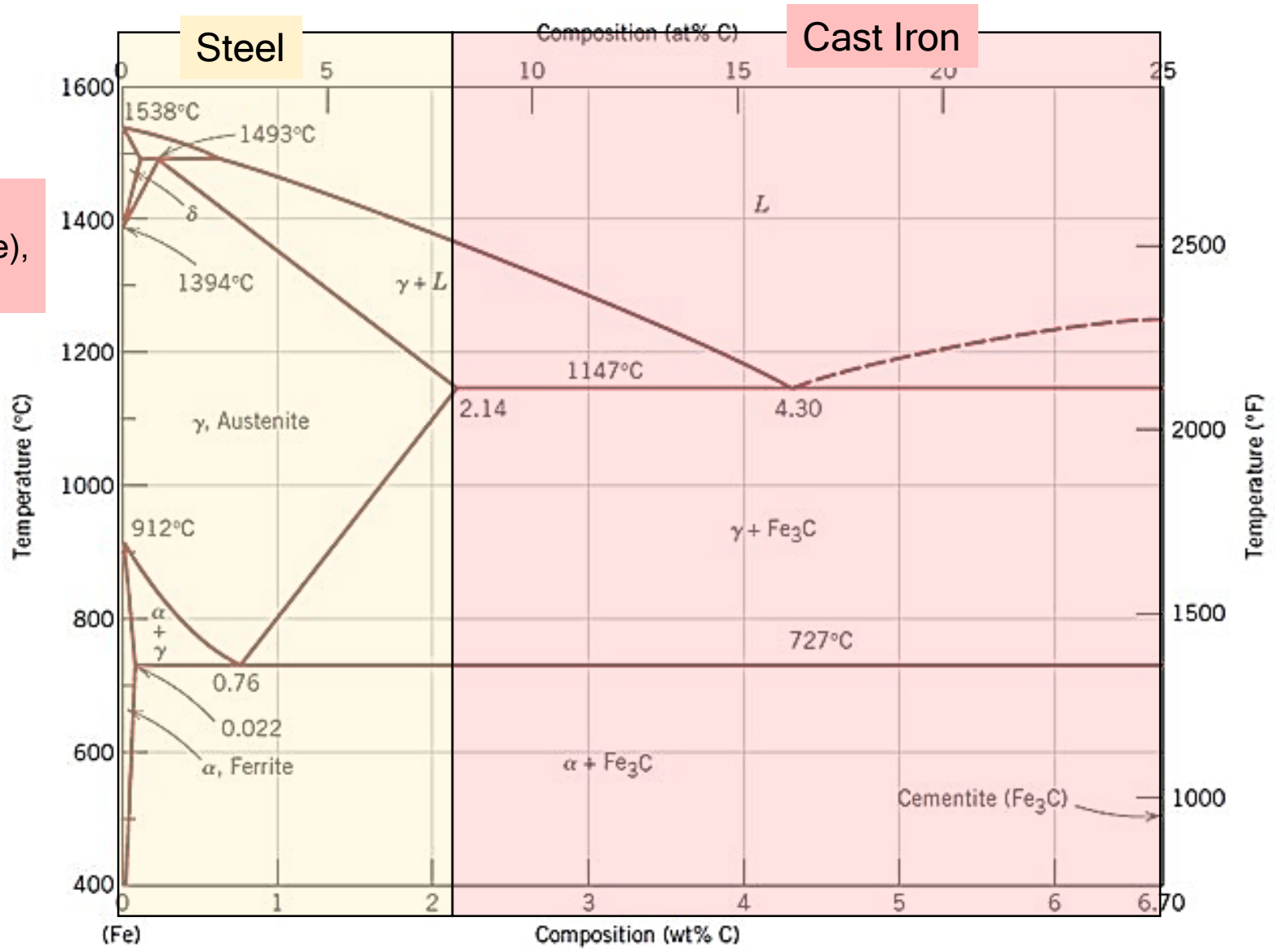
Fe-Fe_3C phase Diagram| Iron-Iron Carbide phase diagram

Allotropes

alpha iron (α-Fe): gamma iron (γ-Fe), delta iron (δ-Fe)

α-Fe: bcc
γ-Fe: fcc
δ-Fe: bcc



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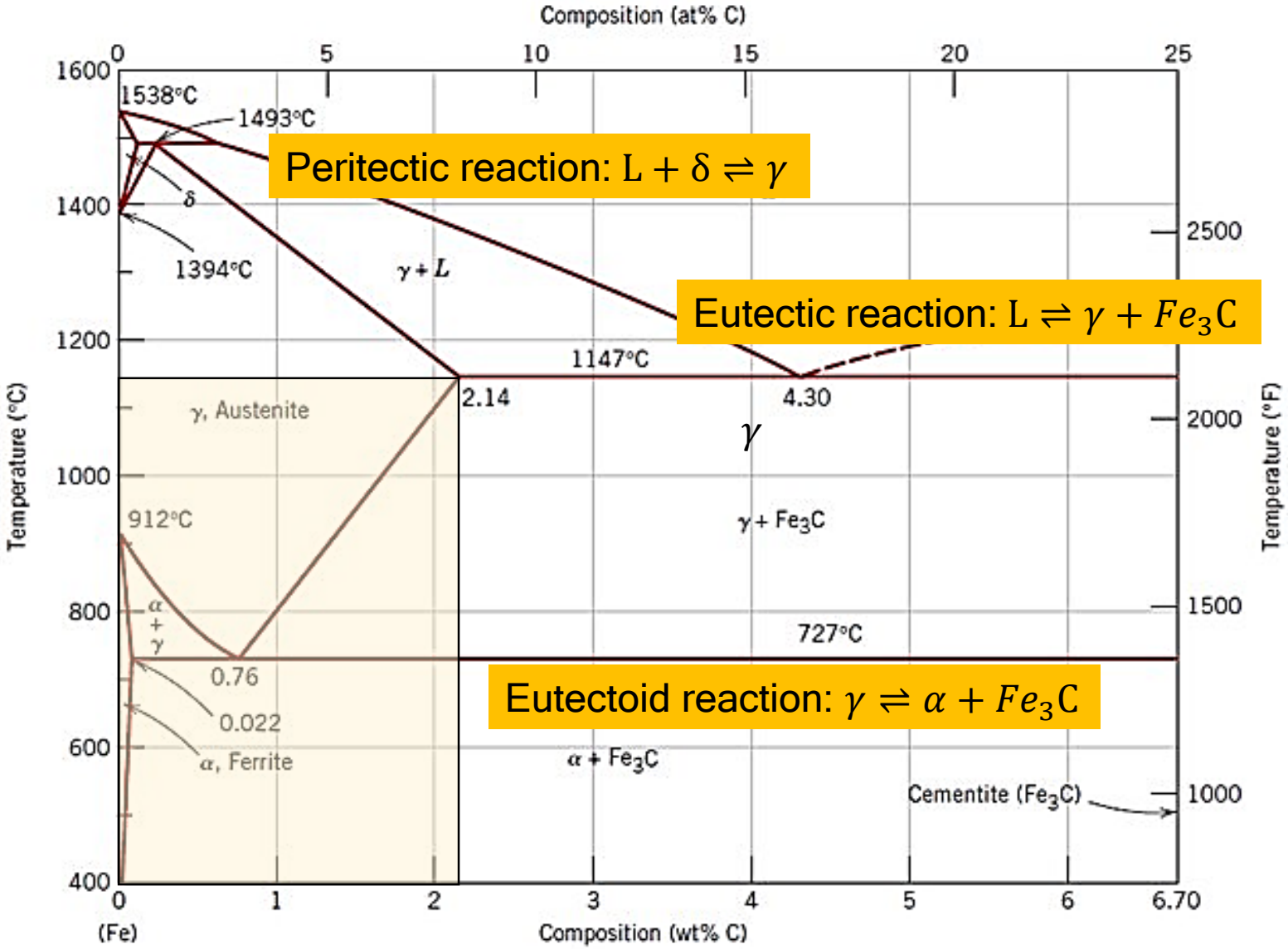
Fe-Fe_3C phase Diagram



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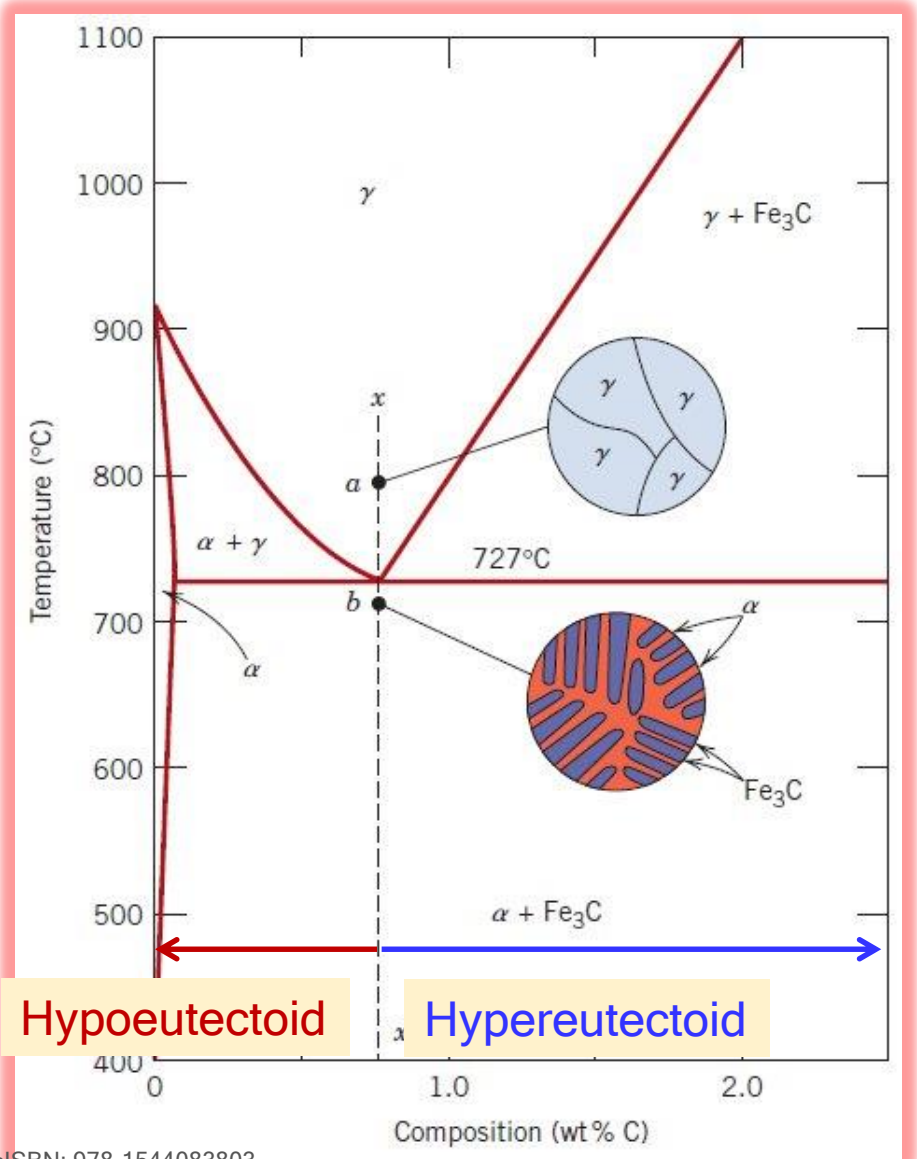
Eutectoid Steel



Eutectoid reaction

$\gamma \rightleftharpoons \alpha + Fe_3C$

T=727°C

Composition =0.76 wt.% C

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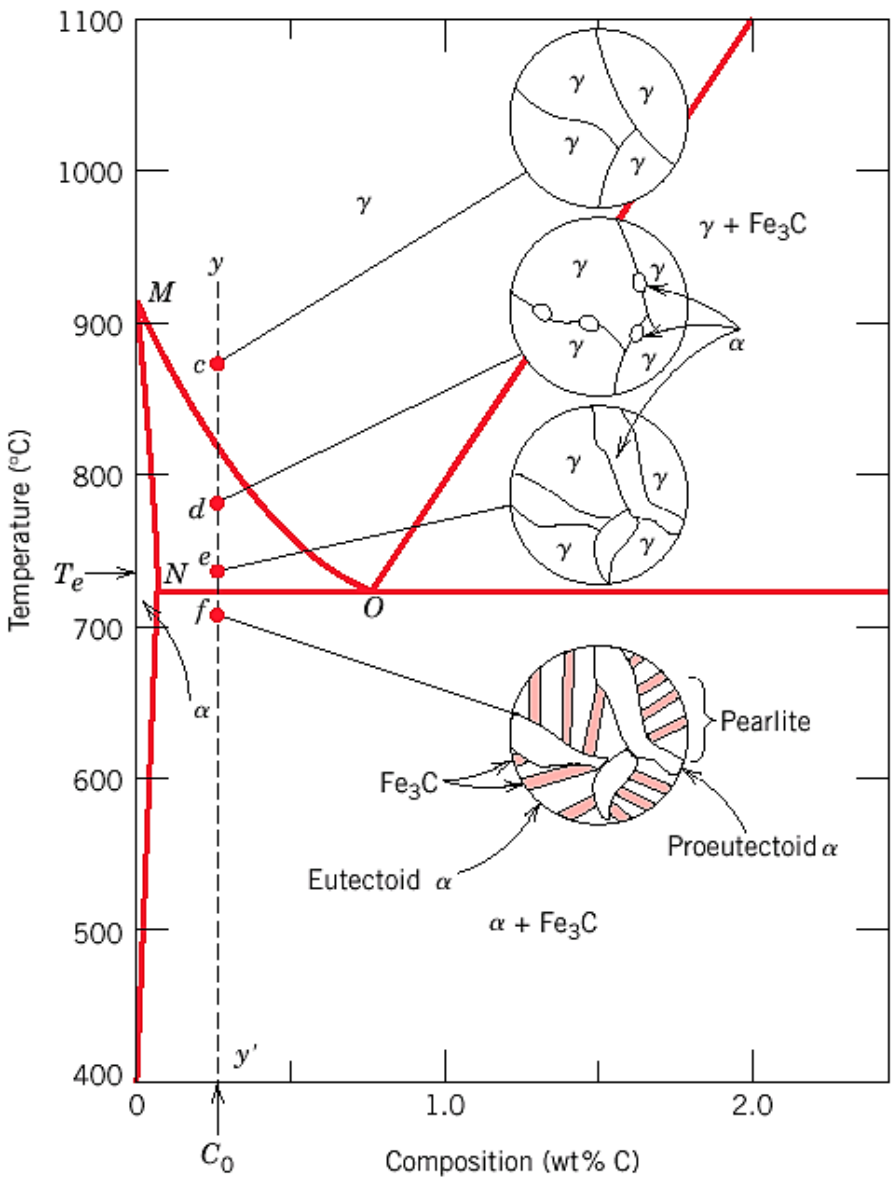
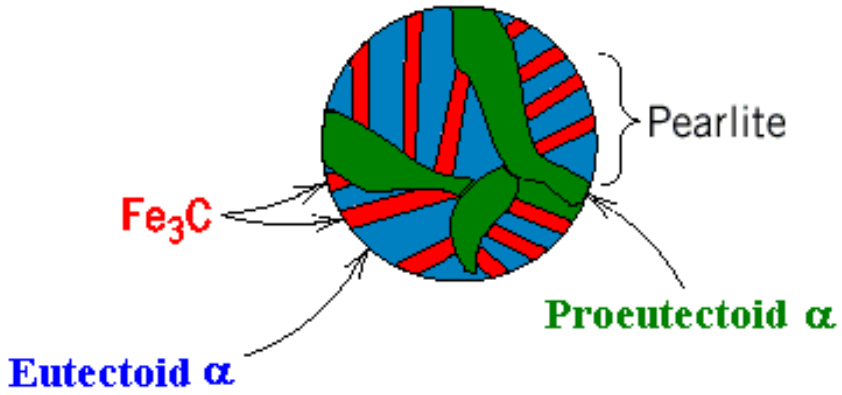
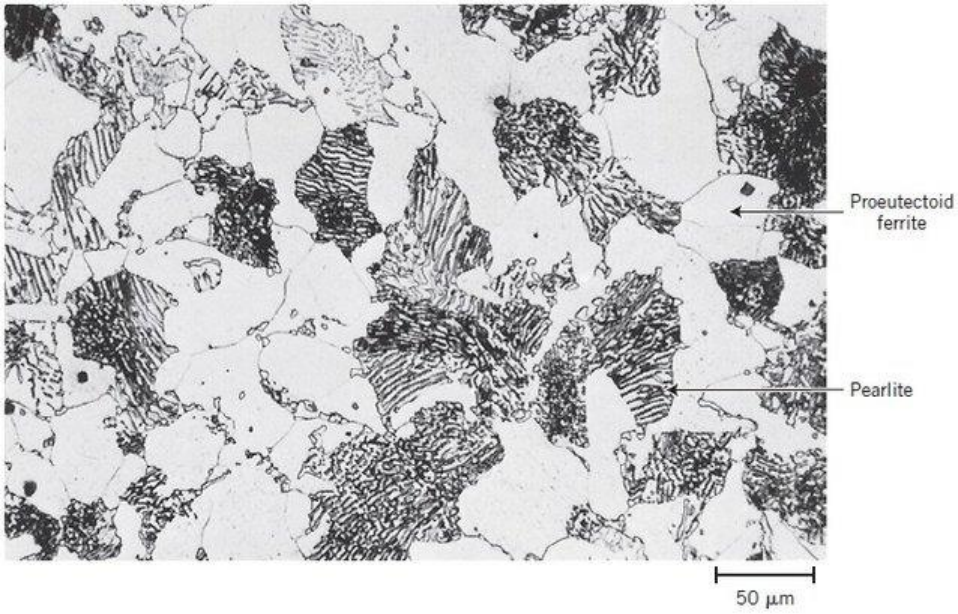
Hypoeutectoid steel







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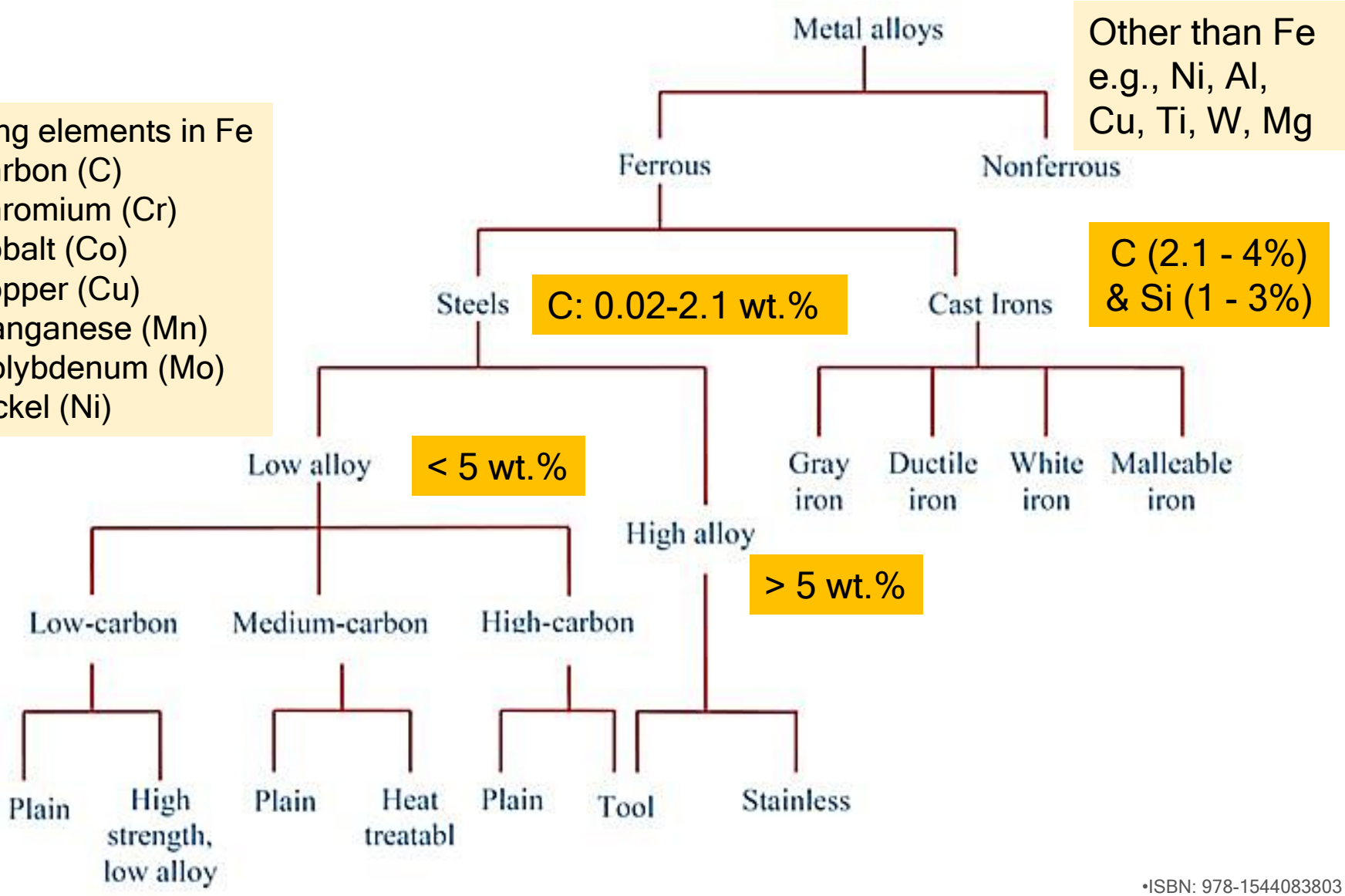
Microstructure

- The microstructure of crystalline materials is defined by the **type, structure, number, shape and topological** arrangement of phases and/or lattice defects .

- **Elements of microstructure:** Point defects, point-defect clusters, dislocations, stacking faults, grain boundaries, interphase interfaces are important elements of the microstructure of most materials.

Classification of alloys

Alloying elements in Fe
- Carbon (C)
- Chromium (Cr)
- Cobalt (Co)
- Copper (Cu)
- Manganese (Mn)
- Molybdenum (Mo)
- Nickel (Ni)



Other than Fe
e.g., Ni, Al,
Cu, Ti, W, Mg

C (2.1 - 4%)
& Si (1 - 3%)

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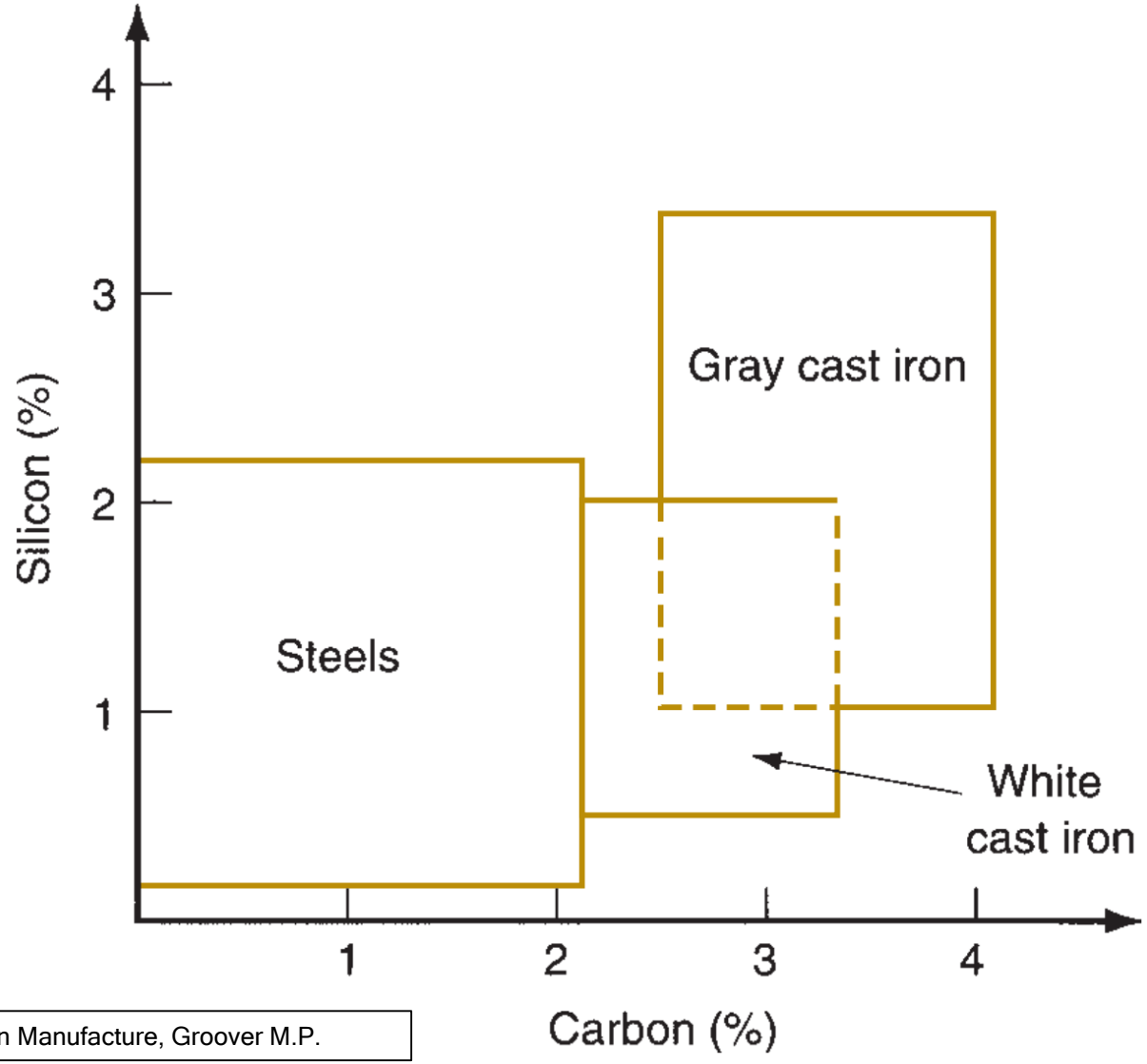
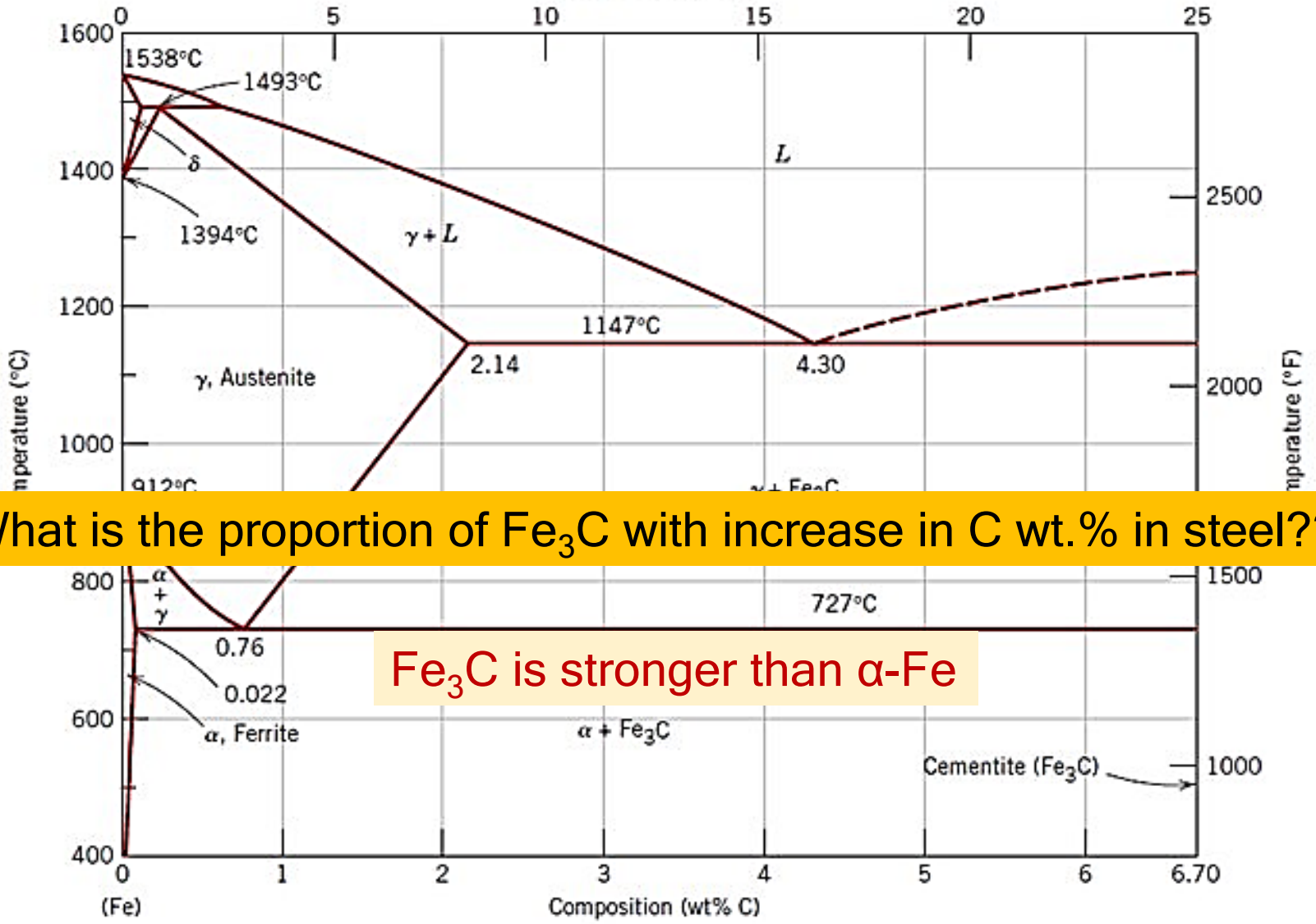
Role of C & Si in Fe



Fundamentals of Modern Manufacture, Groover M.P.

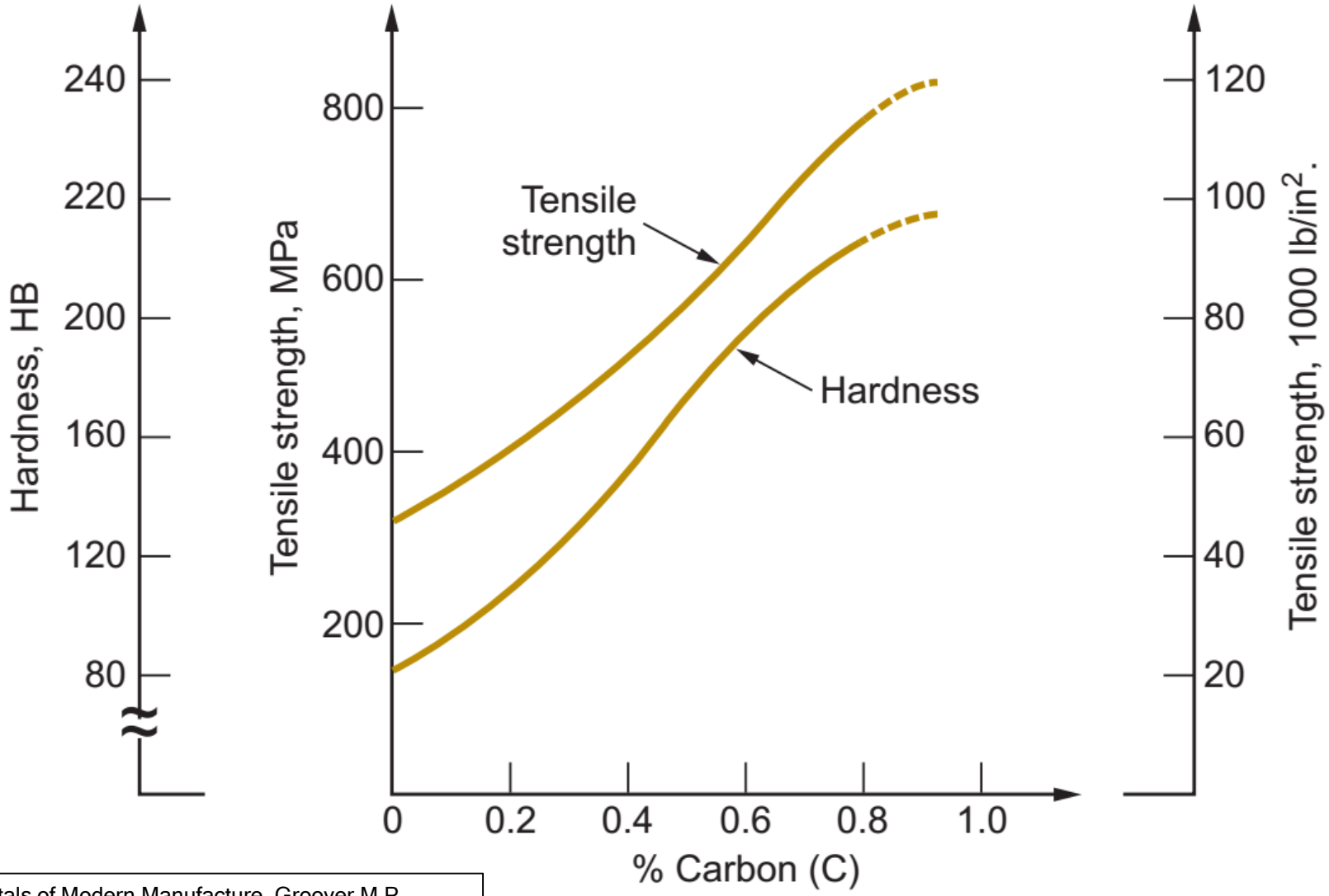
Fe-Fe_3C phase diagram: Revisited



What is the proportion of Fe_3C with increase in C wt.% in steel??

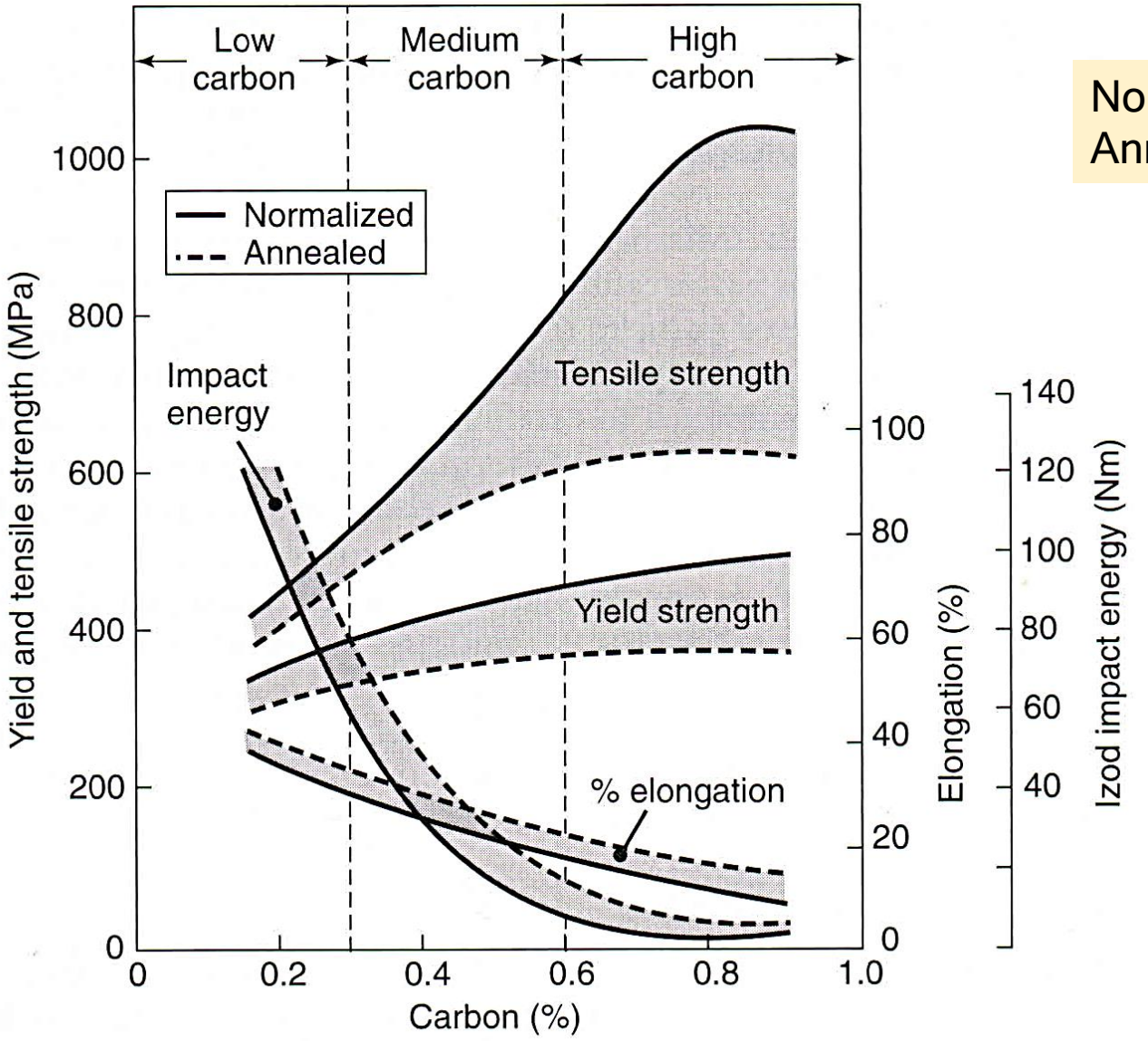
Fe_3C is stronger than α-Fe

Properties: Role of C in steel



Fundamentals of Modern Manufacture, Groover M.P.

Properties: Role of C in steel



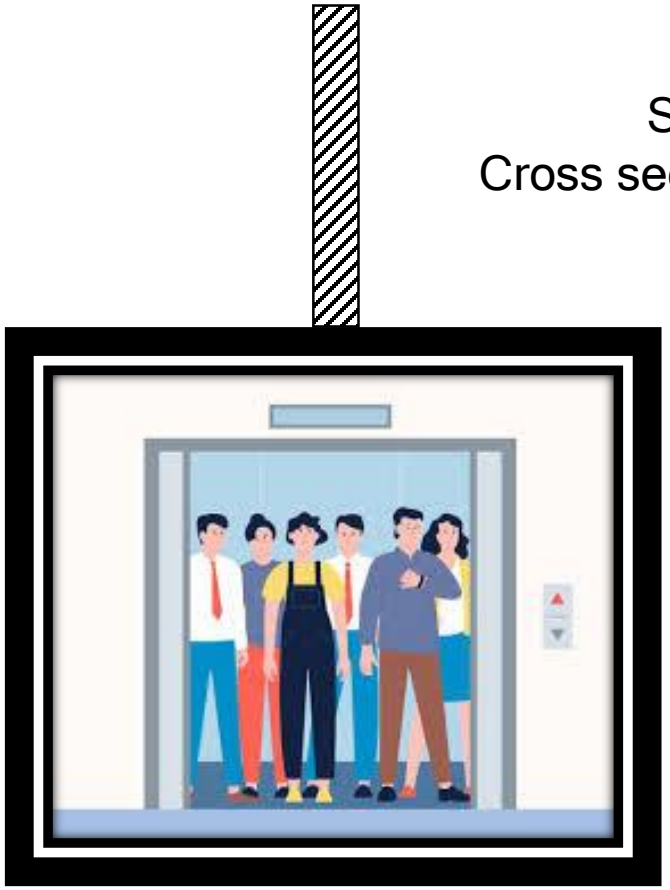
Normalized?
Annealed?

Strength: Low C Vs High C

Low C

High C

Steel wire
Cross section area: 1 cm^2



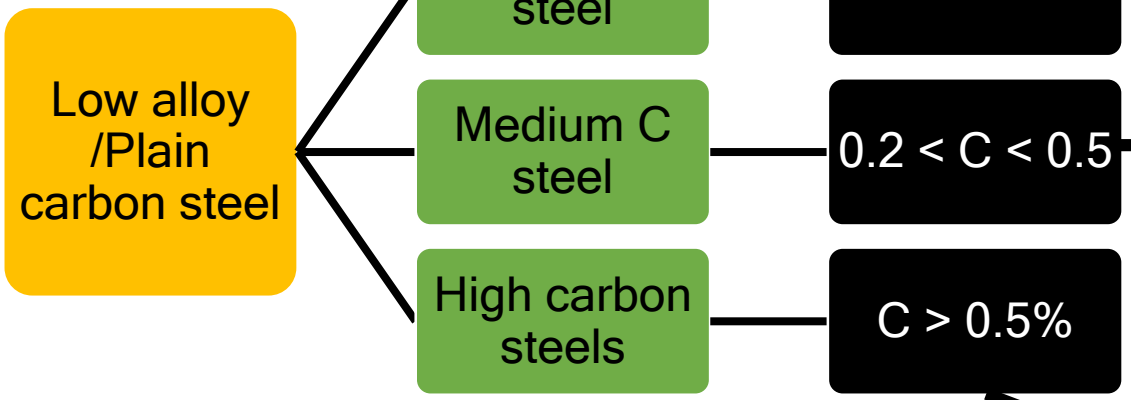
3 - 4 max

10 - 12

Courtesy: Google images

Low Alloy or Plain Carbon Steel

- Plain carbon steel
  - Principal alloying element C



- Most widely used
- Not very strong
- Automobile sheet metal part, railroad rails

Machinery components and engine parts (crank shaft and connecting rod)

- For higher stiffness and hardness
- Springs, cutting tools (and blades) and wear resistant parts

Alloy steels

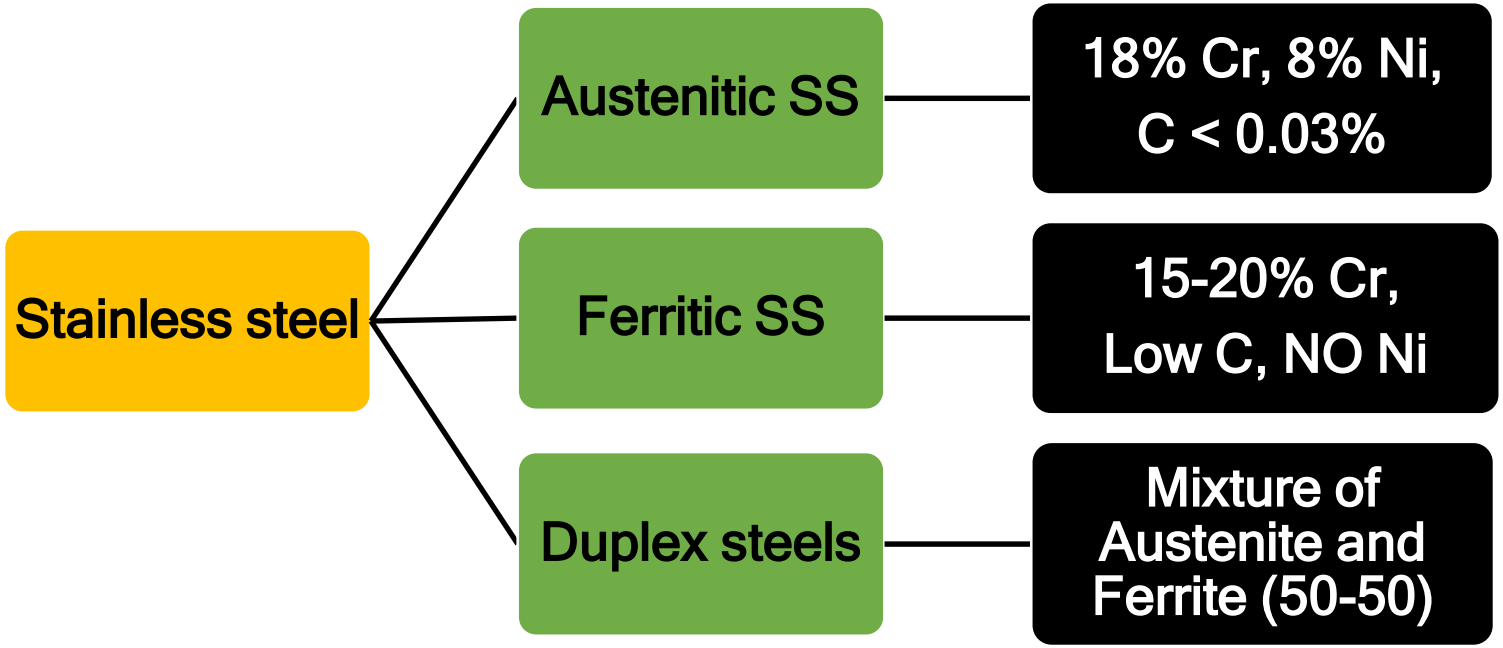
Low alloy steel

- Iron carbon alloys that contain additional alloying elements in amounts totaling less than 5% (wt.%)
- Better mechanical properties than plain C steel
  - Strength
  - Hardness
  - Wear resistance
  - Toughness
- Heat treatment is often required
- Alloying elements usually added in combination

Stainless steel

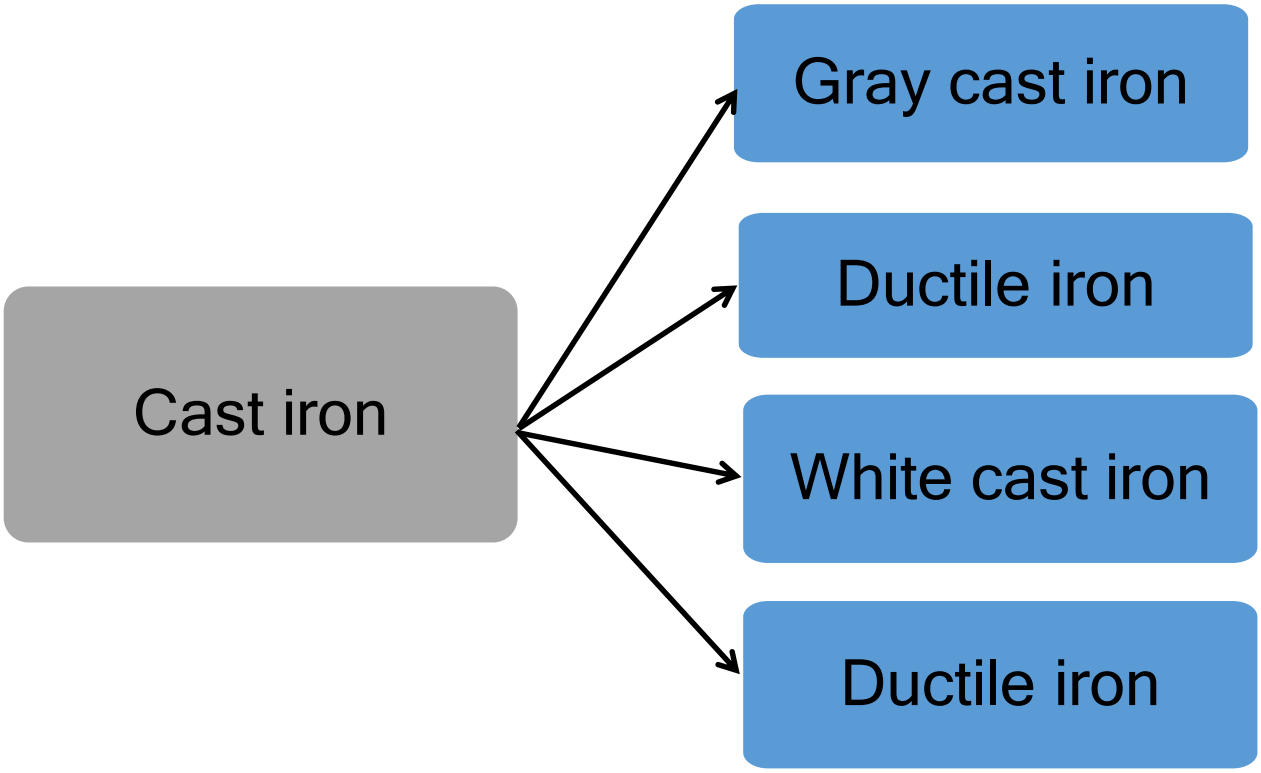
Stainless steels: Highly alloyed for high corrosion resistance

- High strength and ductility
- Cr > 15%



Cast iron

- Cast iron: alloy containing C (2.1 - ~ 4%) and Si (1 - 3%)



Microstructures & Applications of cast iron

https://engineeringlearn.com/types-of-cast-iron-and-their-uses-with-composition-properties/

Cast Irons

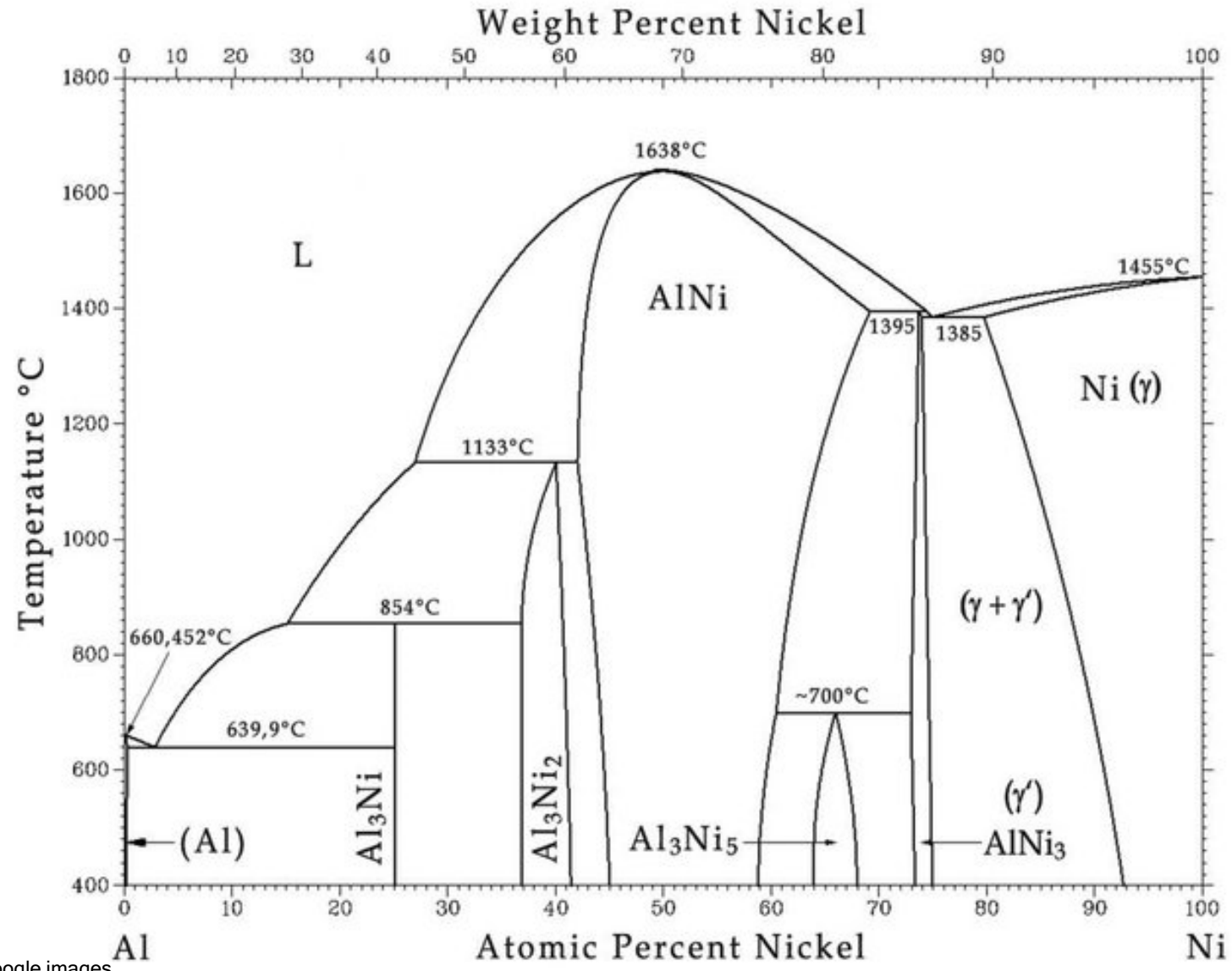
- Gray Cast Iron (2.5-4% C, 1-3% Si)
  - Graphite flakes form throughout
  - Good vibration damping (engine and other machinery)
  - Good internal lubrication (machineable)
  - Low ductility
  - Application: automotive engine blocks
- Ductile iron (2.5-4% C, 1-3% Si)
  - Chemically treated before pouring so spheroids ➔ ductile
  - Application: Machinery component requiring high strength and good wear resistance
- White Cast Iron (Lesser C and Si than gray CI)
  - Cooling of molten metal is much faster so C remains in the form of Fe_3C and does not precipitate out in form of flakes
  - Hard and brittle
  - Excellent wear resistance
  - Good strength
  - Application: Railway brake shoes

Materials: Strategic & Critical applications

Ni based alloys

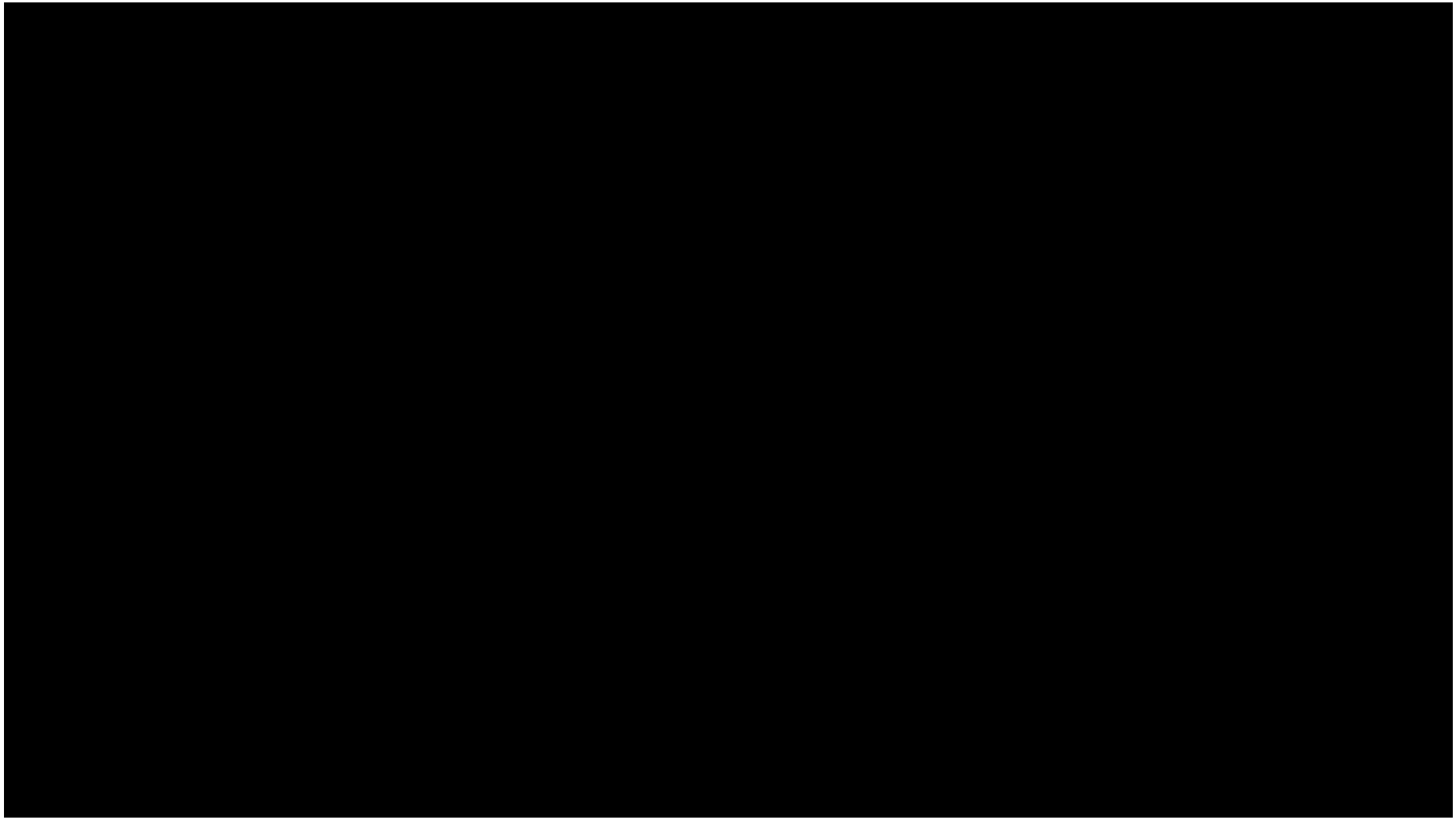
https://www.cam.ac.uk/research/news/super-superalloys-hotter-stronger-for-even-longer

Superalloys: γ-γ’ microstructure



Courtesy: Google images

Superalloys: γ-γ’ microstructure



https://www.youtube.com/watch?v=wYHch5QIWTQ