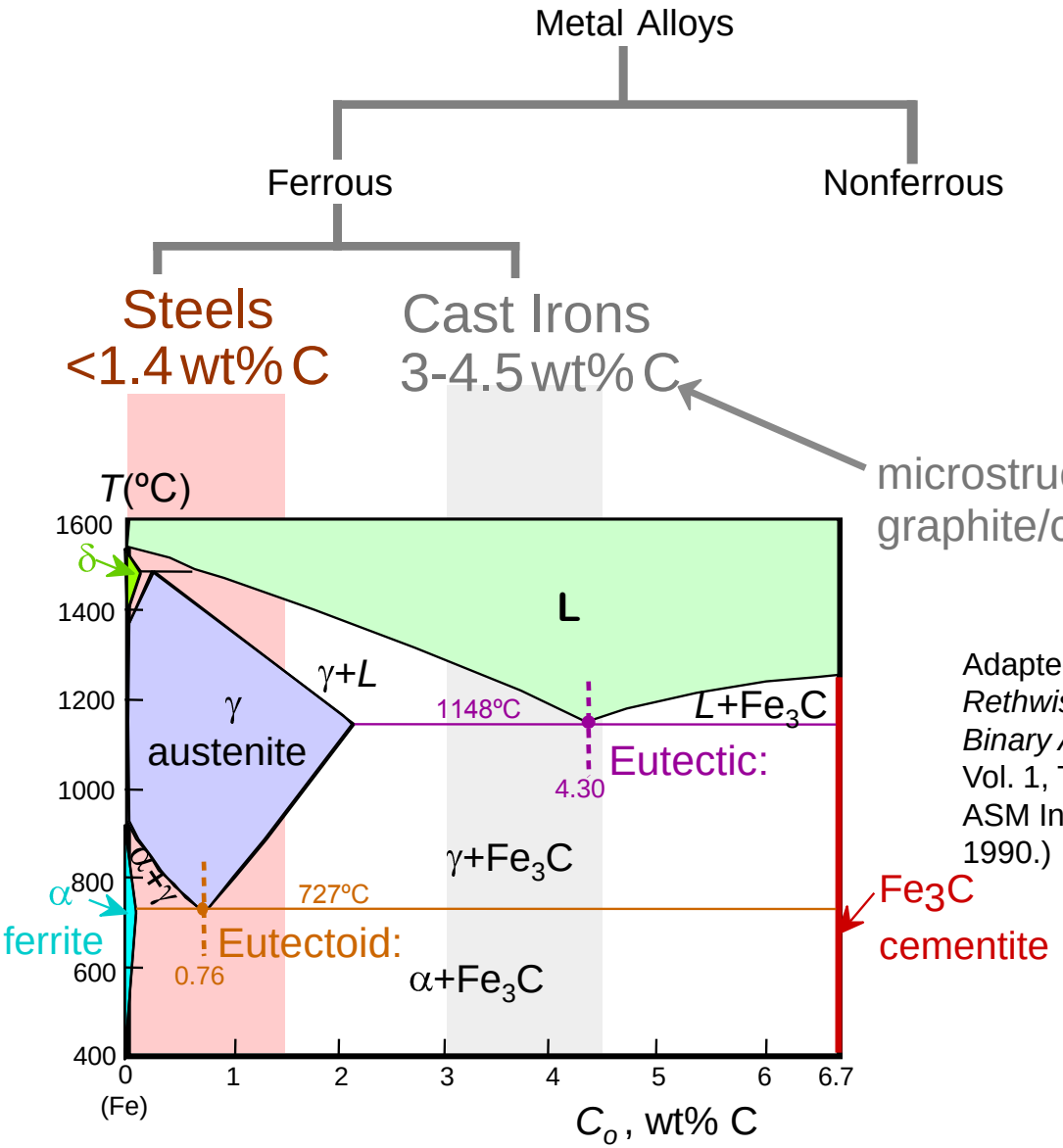
Chapter 11: Applications and Processing of Metal Alloys

ISSUES TO ADDRESS...

- ✓ How are metal alloys classified and what are their common applications?
- What are some of the common fabrication techniques for metals?
- What heat treatment procedures are used to improve the mechanical properties of both ferrous and nonferrous alloys?

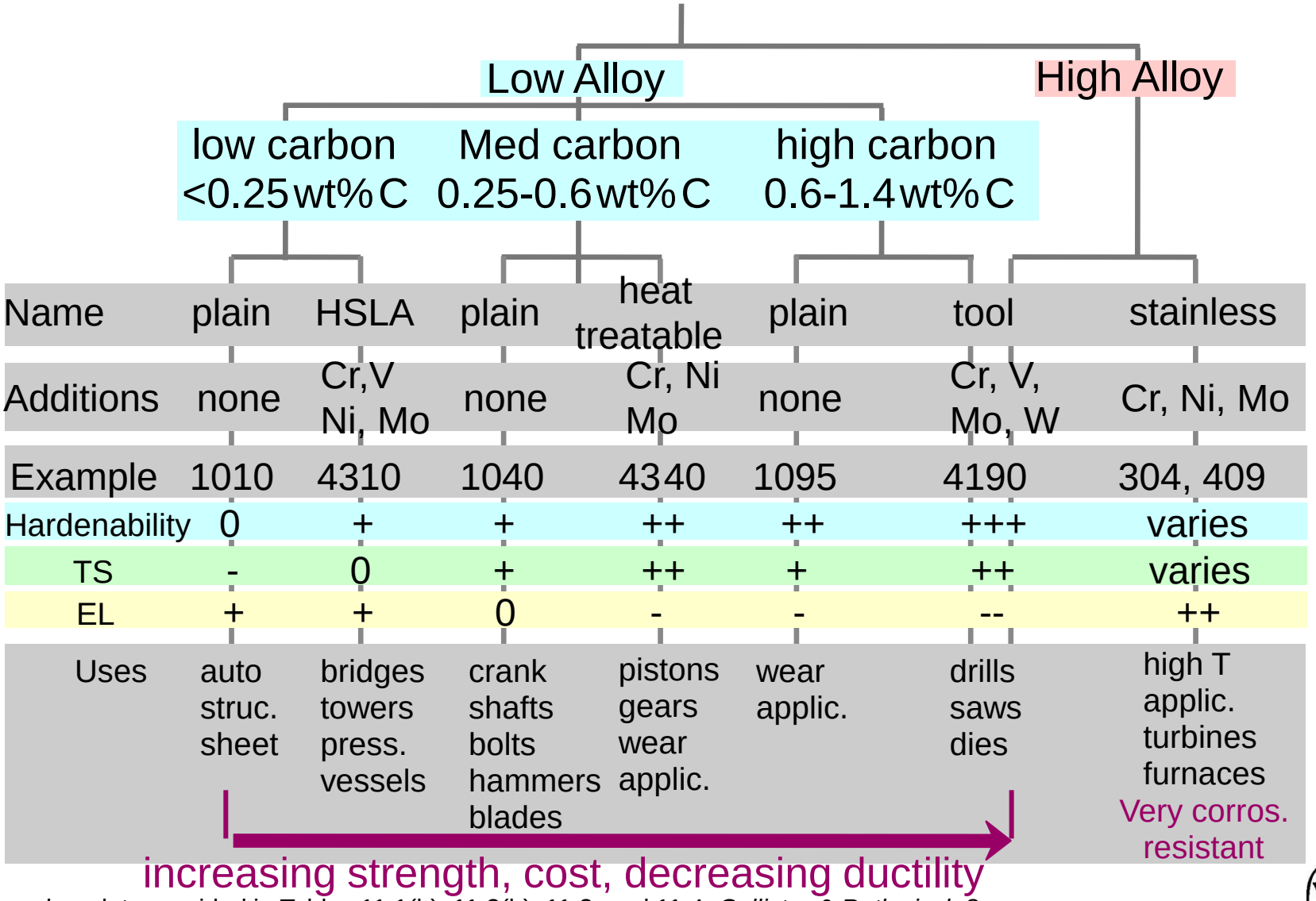
Classification of Metal Alloys



Adapted from Fig. 11.1, *Callister & Rethwisch 8e.*

Adapted from Fig. 9.24, *Callister & Rethwisch 8e.* (Fig. 9.24 adapted from *Binary Alloy Phase Diagrams*, 2nd ed., Vol. 1, T.B. Massalski (Ed.-in-Chief), ASM International, Materials Park, OH, 1990.)

Steels



Based on data provided in Tables 11.1(b), 11.2(b), 11.3, and 11.4, *Callister & Rethwisch 8e.*

Ferrous Alloys

Iron-based alloys

- Steels
- Cast Irons

Nomenclature for steels (AISI/SAE)

10xx Plain Carbon Steels

11xx Plain Carbon Steels (resulfurized for machinability)

15xx Mn (1.00 - 1.65%)

40xx Mo (0.20 ~ 0.30%)

43xx Ni (1.65 - 2.00%), Cr (0.40 - 0.90%), Mo (0.20 - 0.30%)

44xx Mo (0.5%)

where xx is wt% C x 100

example: 1060 steel – plain carbon steel with 0.60 wt% C

Stainless Steel >11% Cr

Cast Irons

- Ferrous alloys with > 2.1 wt% C
  - more commonly 3 - 4.5 wt% C
- Low melting – relatively easy to cast
- Generally brittle

- Cementite decomposes to ferrite + graphite

$$Fe_3C \rightarrow 3\,Fe\,(\alpha) + C\,(graphite)$$

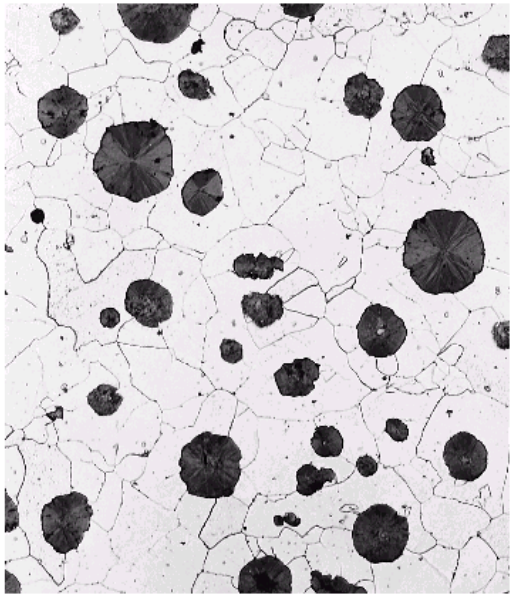
  - generally a slow process

Types of Cast Iron

Adapted from Fig. 11.3(a) & (b), *Callister & Rethwisch 8e.*

Gray iron

- graphite flakes
- weak & brittle in tension
- stronger in compression
- excellent vibrational dampening
- wear resistant



Ductile iron

- add Mg and/or Ce
- graphite as nodules not flakes
- matrix often pearlite – stronger but less ductile

Types of Cast Iron (cont.)

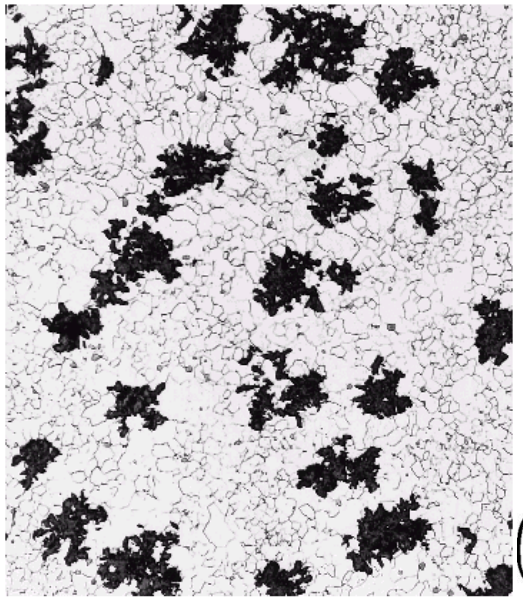
White iron

- < 1 wt% Si
- pearlite + cementite
- very hard and brittle

Adapted from Fig. 11.3(c) & (d), *Callister & Rethwisch 8e.*

Malleable iron

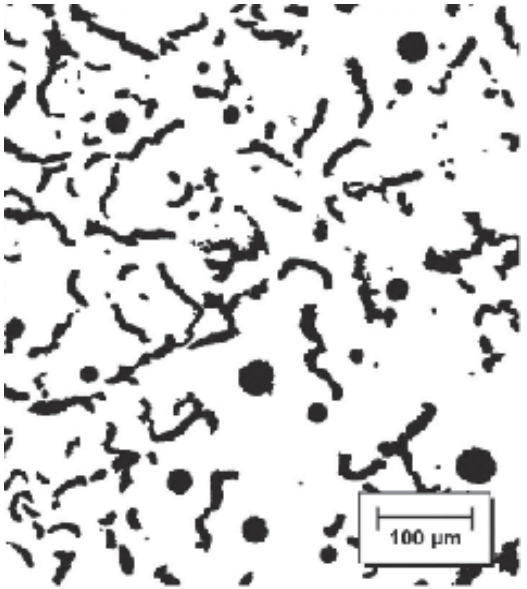
- heat treat white iron at 800-900ºC
- graphite in rosettes
- reasonably strong and ductile



Types of Cast Iron (cont.)

Compacted graphite iron

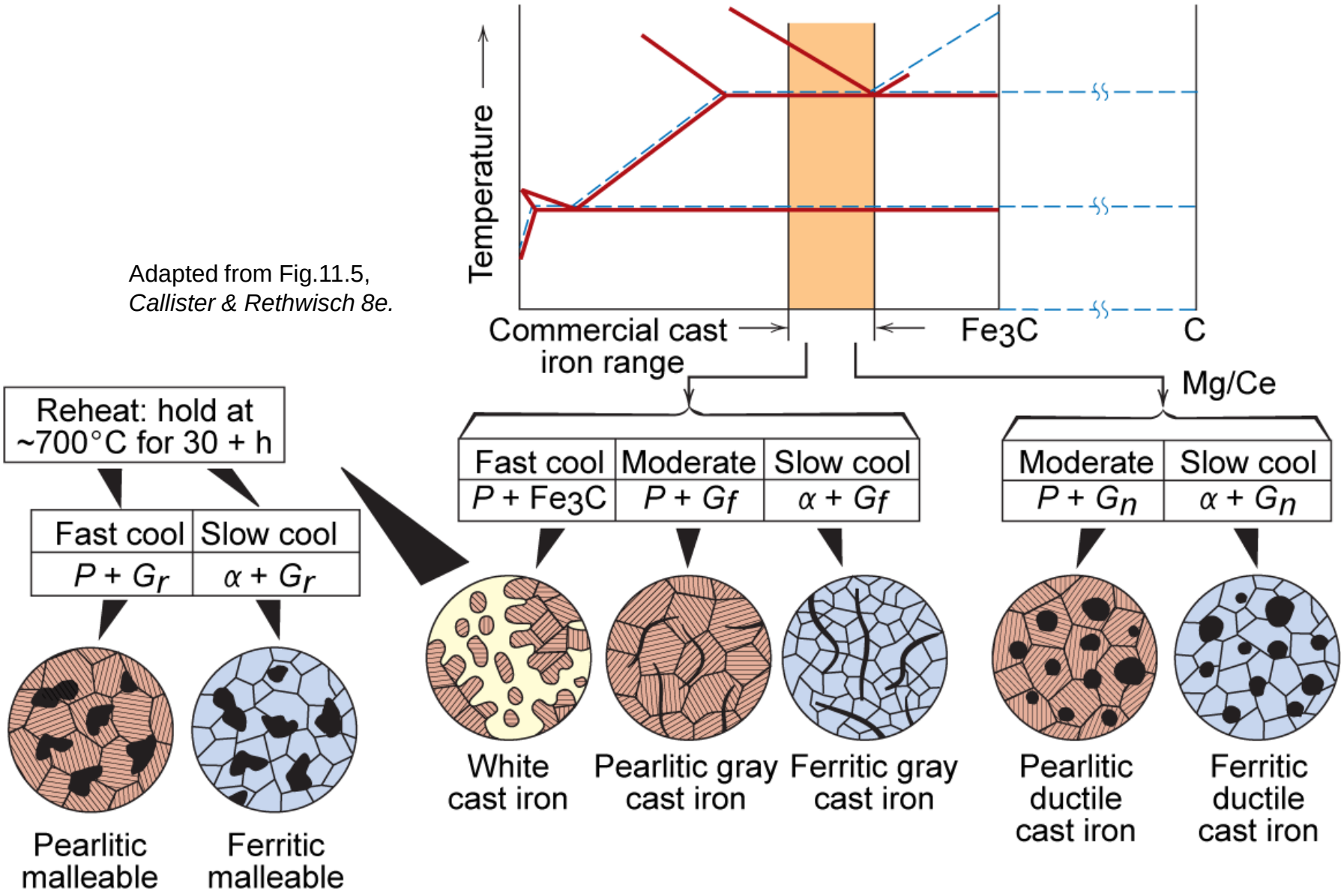
- relatively high thermal conductivity
- good resistance to thermal shock
- lower oxidation at elevated temperatures



Adapted from Fig. 11.3(e),
Callister & Rethwisch 8e.

Production of Cast Irons

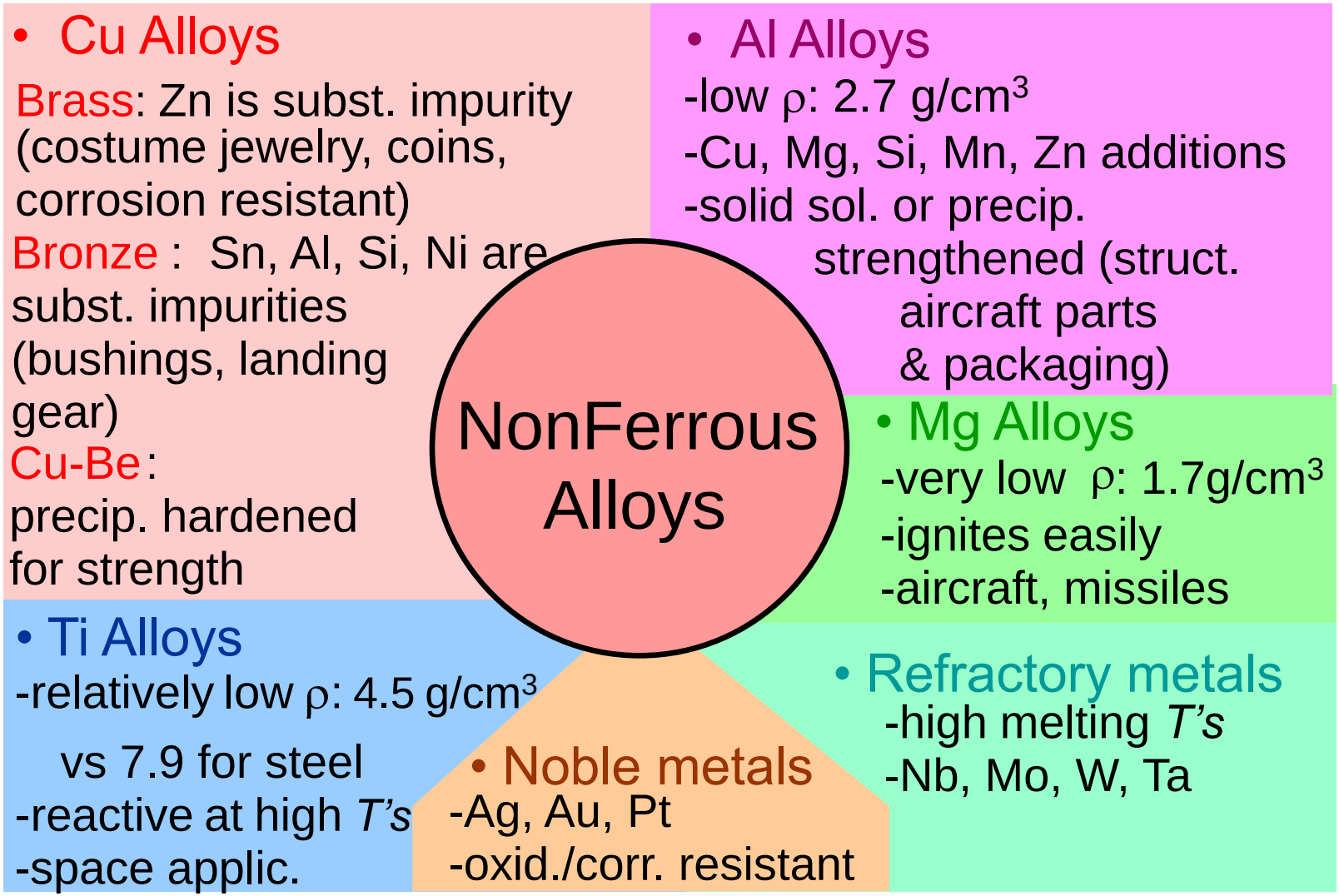
Adapted from Fig.11.5,
Callister & Rethwisch 8e.



Limitations of Ferrous Alloys

1) Relatively high densities
2) Relatively low electrical conductivities
3) Generally poor corrosion resistance

Nonferrous Alloys



Based on discussion and data provided in Section 11.3, *Callister & Rethwisch 3e.*