METALURGI FISIK

Sifat Mekanik dan Struktur Mikro

Sifat – Sifat Material

Sifat Fisik :

(berat jenis, daya hantar panas dan listrik, dll.)

Sifat Mekanik :

(Kekuatan, Kekerasan, Keuletan, Ketegaran, Kekakuan, dll.)

Sifat Kimia :

(tahan karat, tahan oksidasi, dll.)

Sifat Teknologi :

(Formability, Weldability, castability, machinability, dll.)

Sifat logam → Komposisi Kimia

→ Struktur Mikro

Atom logam → konfigurasi elektron

↓

Sel satuan → geometri kristal

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Butir (Grain) → ukuran

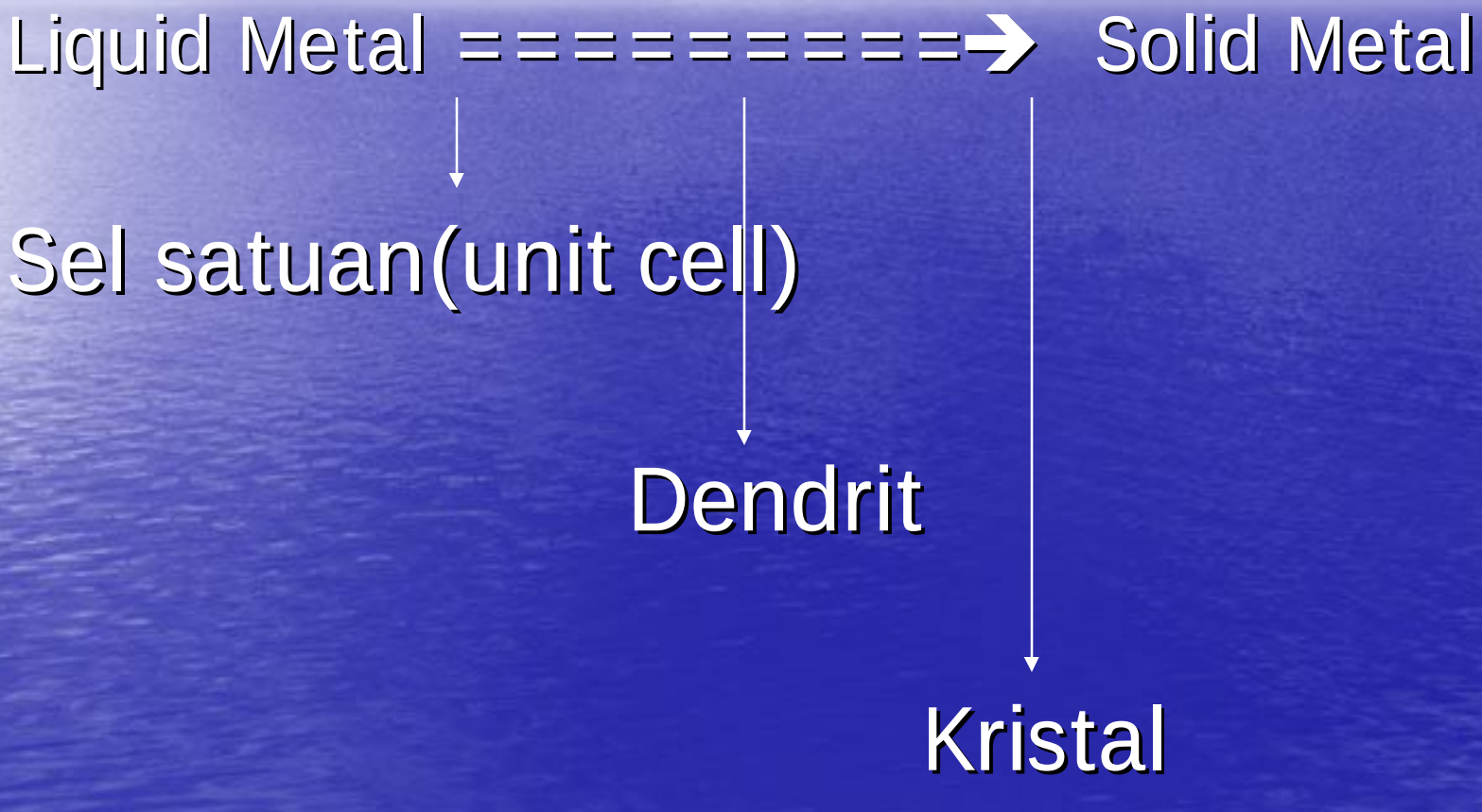
↓

Fasa (Phase) → fraksi dan jenis

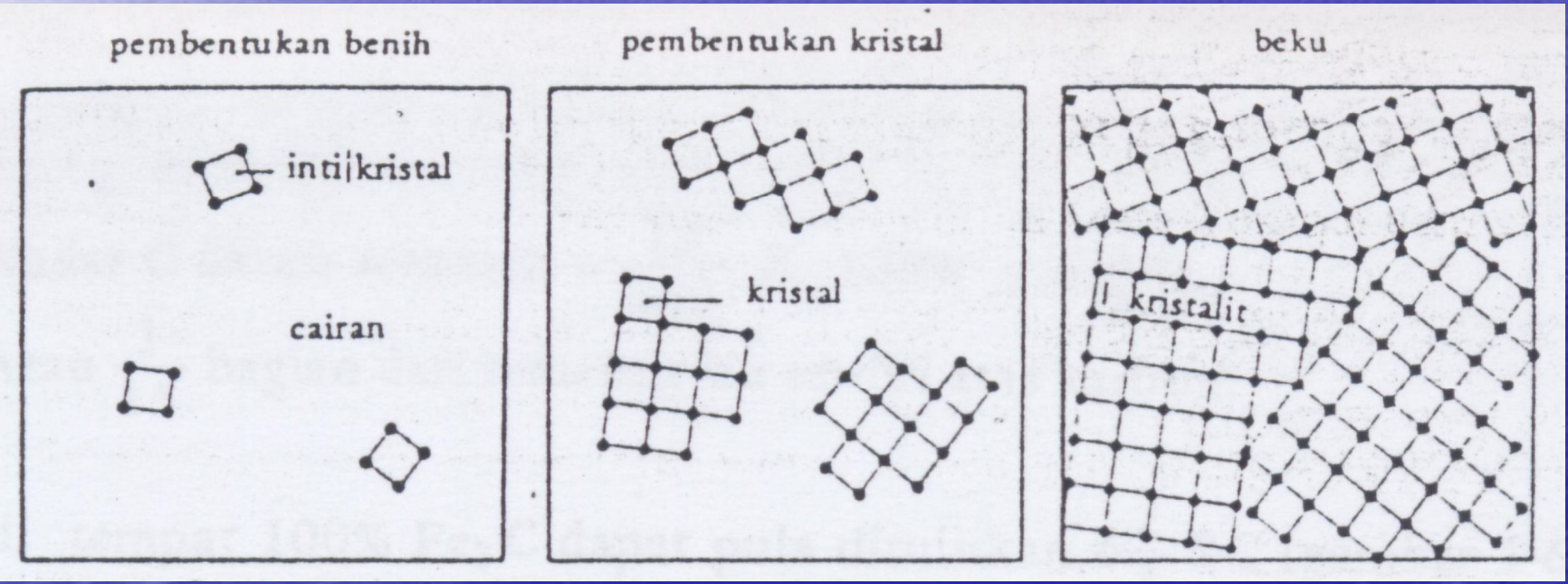
↓

Struktur Mikro

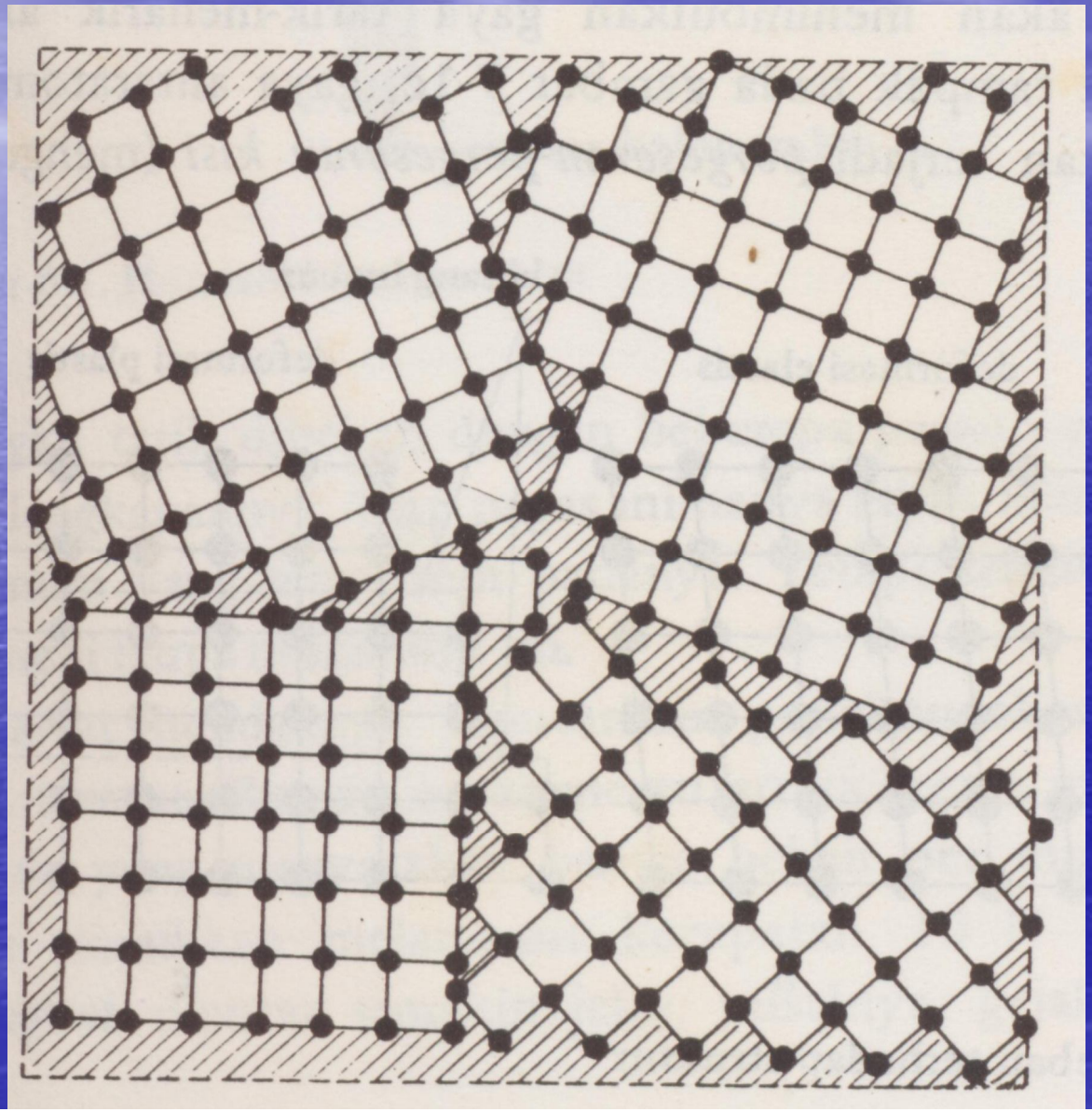
Struktur Mikro



Pembentukan Kristal



Kristal yang saling bertemu



Formation of Grains

from a molten state:

- The growth starts from the nuclei of crystallization, and the crystals grow toward each other (*A-E*).
- When two or more crystals collide, their growth is stopped.
- Finally, the entire space is filled with crystals (*F*).

- Each growth crystal is called a "grain". Grains contact each other at "grain boundaries".

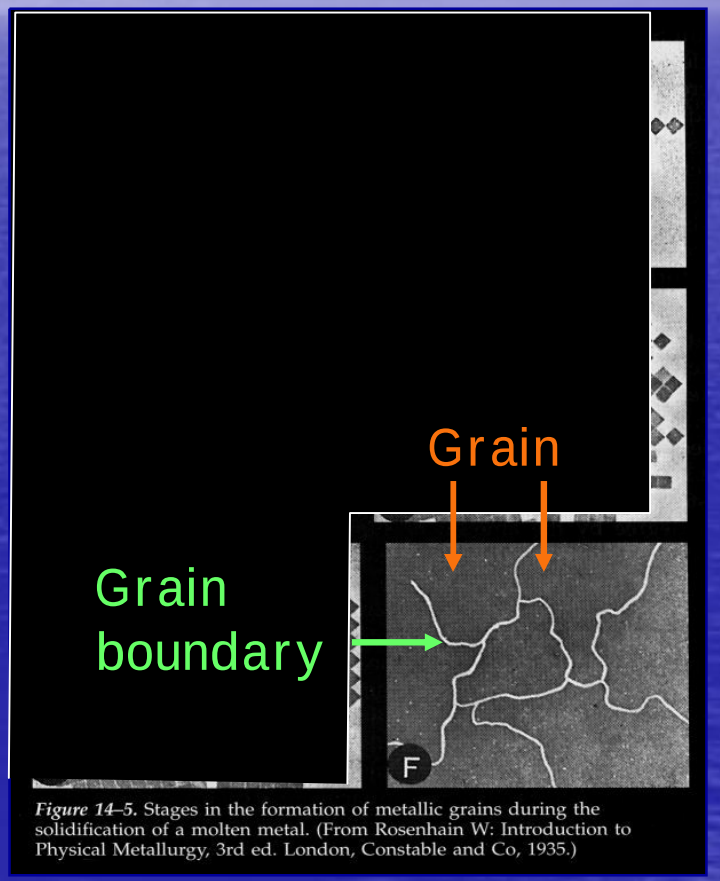
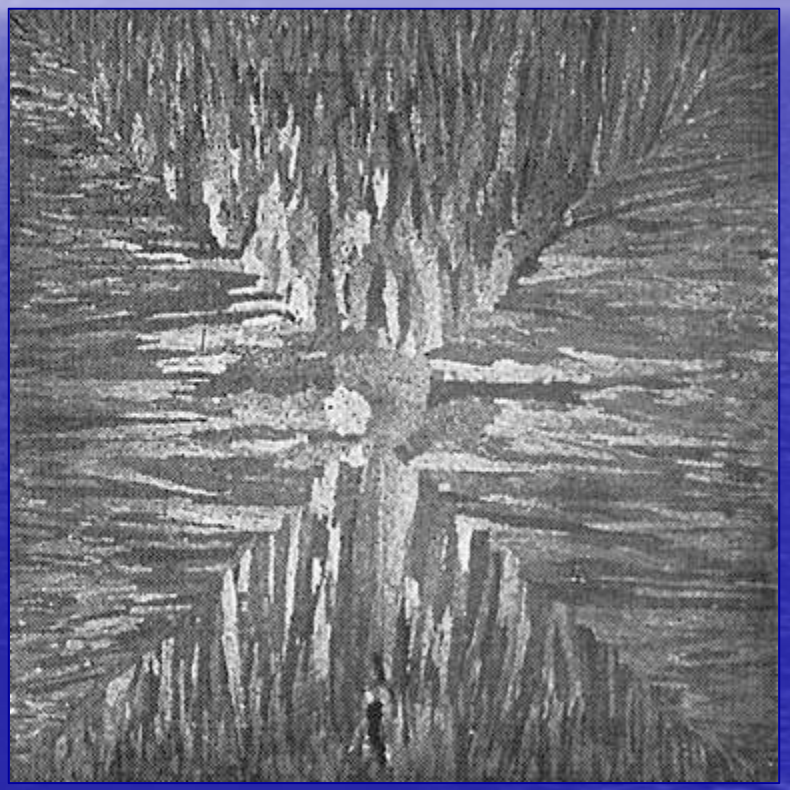


Figure 14–5. Stages in the formation of metallic grains during the solidification of a molten metal. (From Rosenhain W: Introduction to Physical Metallurgy, 3rd ed. London, Constable and Co, 1935.)

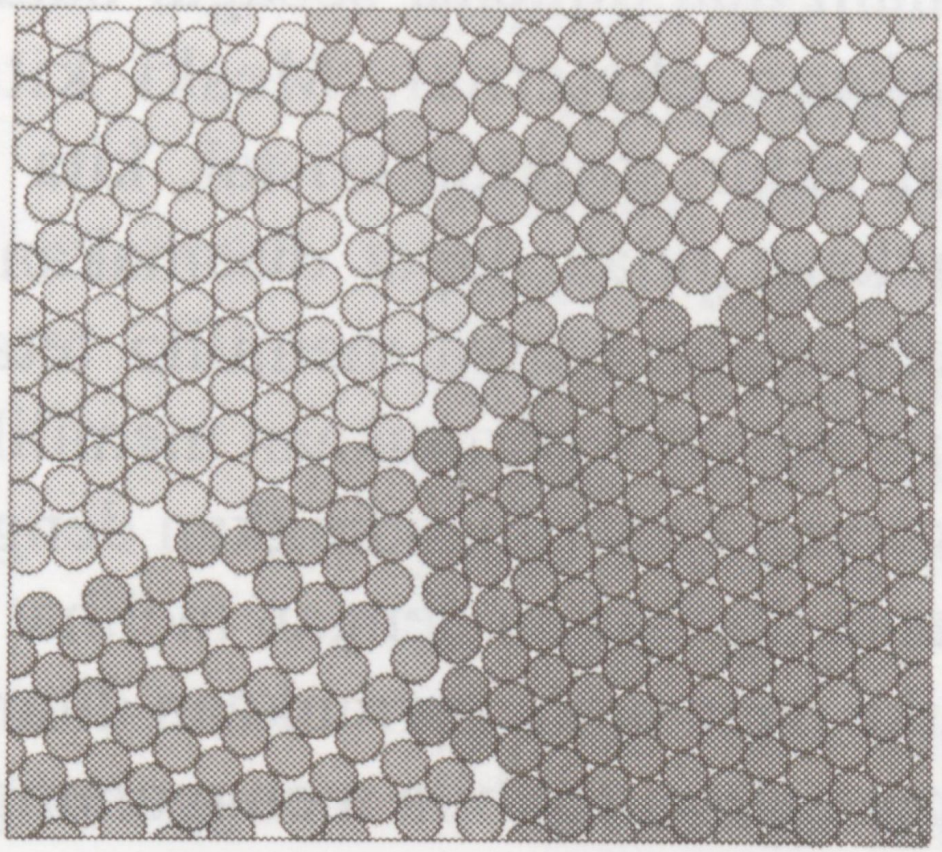
Grain Size

- In general, the smaller the grain size of the metal, the better its physical properties.
- Control of Grain Size
  - Number of nuclei of crystallization
    - The more rapidly the liquid state can be changed to the solid state, the smaller or finer the grains will be.
  - Rate of crystallization
    - If the crystals form faster than do the nuclei of crystallization, the grains will be larger.
    - Slow cooling results in large grains.

– The shape of the grains may be influenced by the shape of the mold in which the metal solidifies.



Square mold



GAMBAR 4–1.7

Batas Butir. Ketidakteraturan pada batas butir (Dikutip seizin Clyde W. Mason, *Introduction to Physical Metallurgy,* American Society for Metals, Bab 3.)

Batas Butir :

Permukaan singgung dari dendrit yang berkembang

Kristal / Grain :

Dendrit yang berkembang dan dibatasi oleh batas butir

Pendinginan lambat :

Dendrit Gemuk ===➔ Butir Kasar

Pendinginan Cepat :

Dendrit Kurus ===➔ Butir Halus

Sel Satuan :

Geometri terkecil yang membentuk pola berulang

Butir / Grain :

Kumpulan sel satuan yang mempunyai orientasi sama

Fasa (Phase) :

Bagian dari struktur mikro yang mempunyai sifat fisik sama

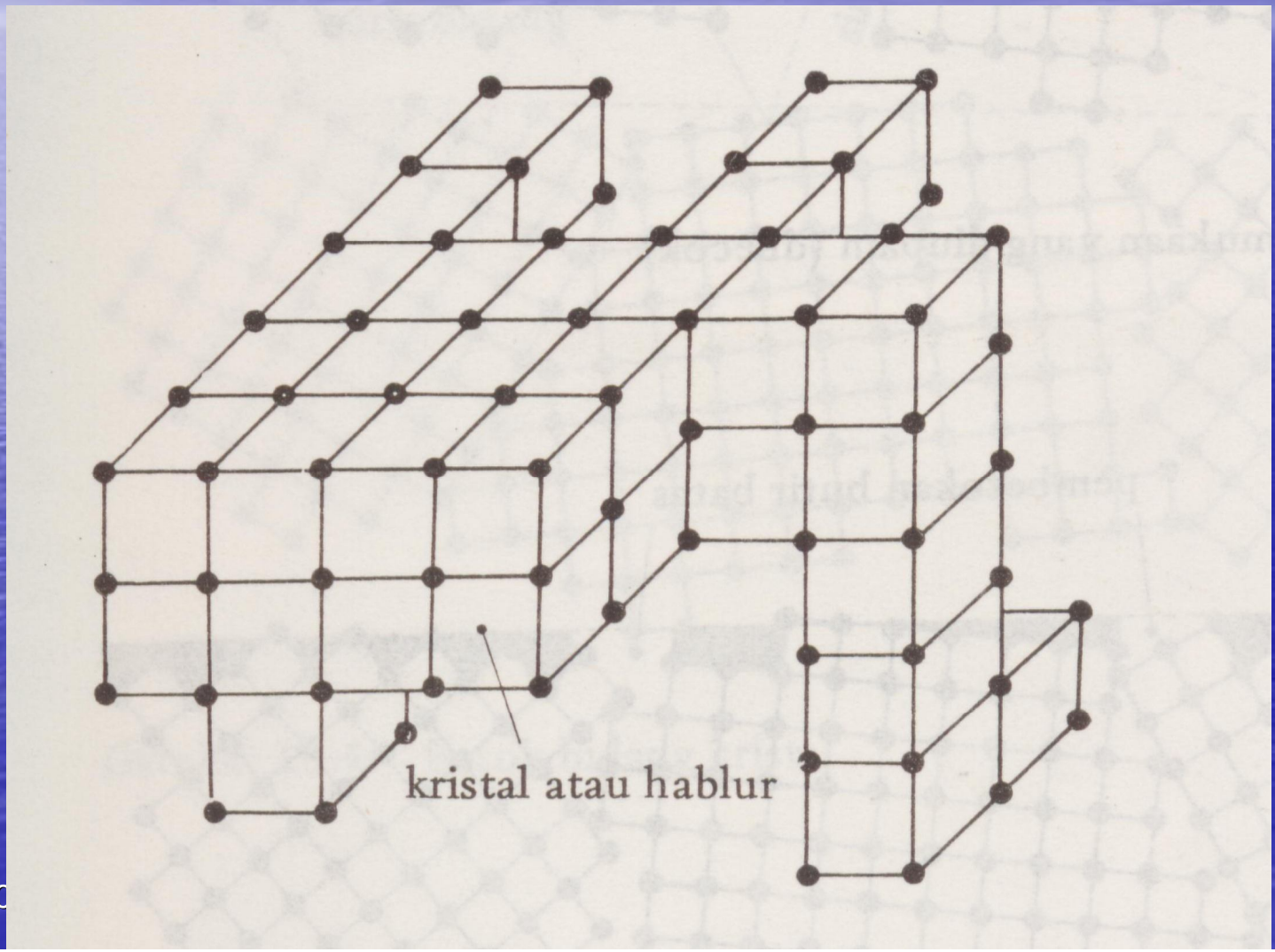
1 Fasa : - sel satuan sama

- Kristal tunggal (fasa memiliki 1 butir)
- Kristal banyak (fasa berbutir banyak)

2 Fasa : - sel satuan tidak sama

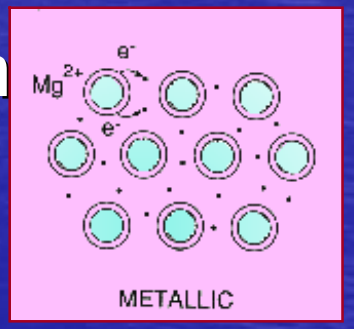
- butir lebih dari satu
- bila % fasa tidak sama (fraksi fasa beda)

Struktur Kristal

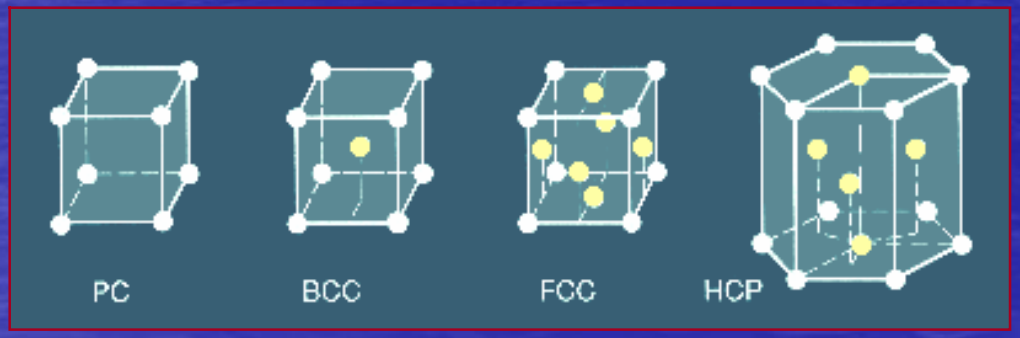


Atomic Structure

- "Cloud" of electrons
- The metal ions are held together by their mutual attraction to the electron cloud. ➔ "Metallic Bond"
  - Excellent electrical and thermal con



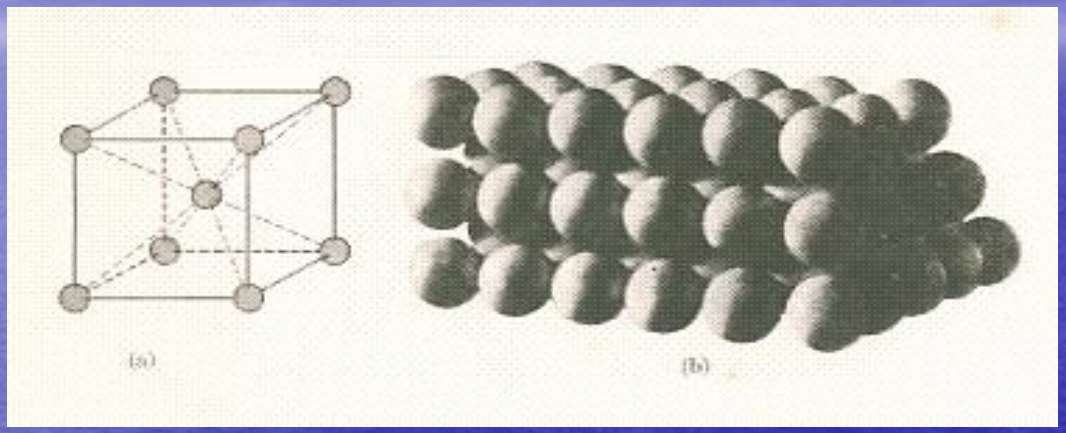
- Metals exist in one of the 14 crystal structures at room temperature.
- Examples
  - Body-centered cubic (BCC): e.g. Cr
  - Face-centered cubic (FCC): e.g. Ag, Au, Pd, Co, Cu, Ni
  - Hexagonal closed-pack (HCP): e.g. Ti

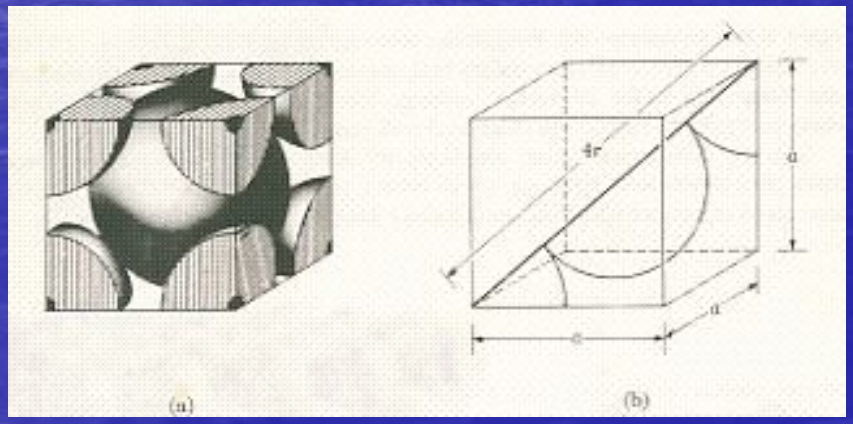


a unit cell

Sel satuan /Geometri kristal:

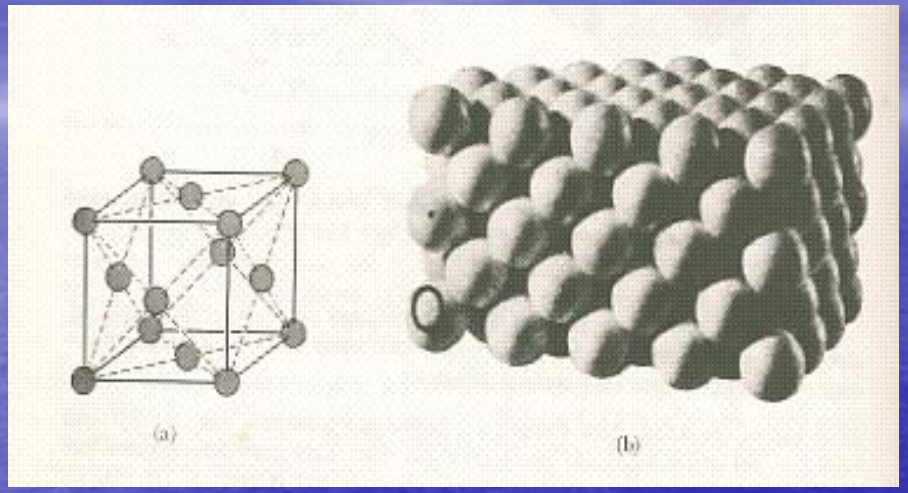
1. Body Centered Cubic (BCC)

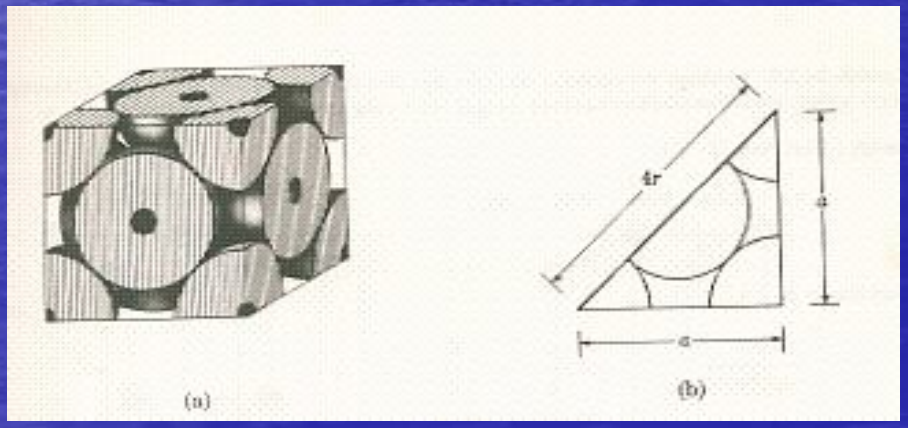




Gambar 1: Struktur Kubik pemusatan ruang

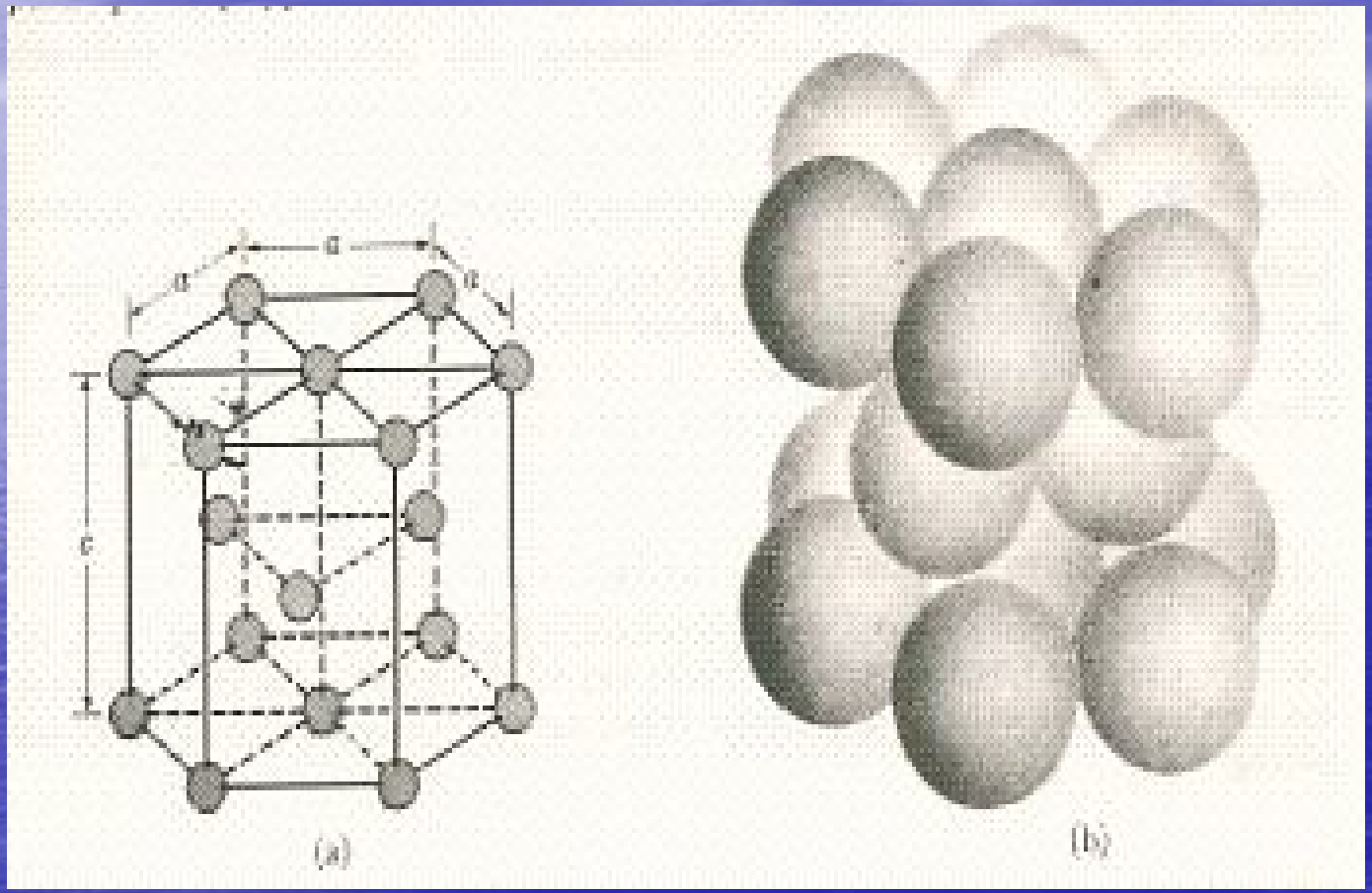
2. Face Centered Cubic (FCC)



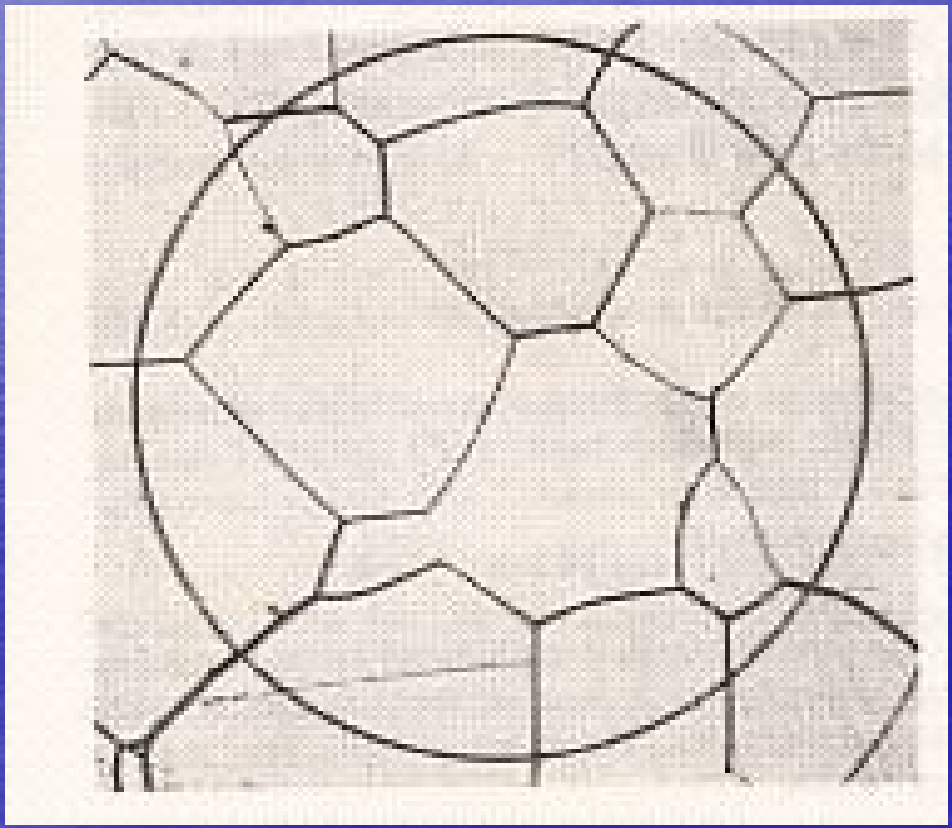


Gambar 2: Struktur Kubik pemusatan Muka

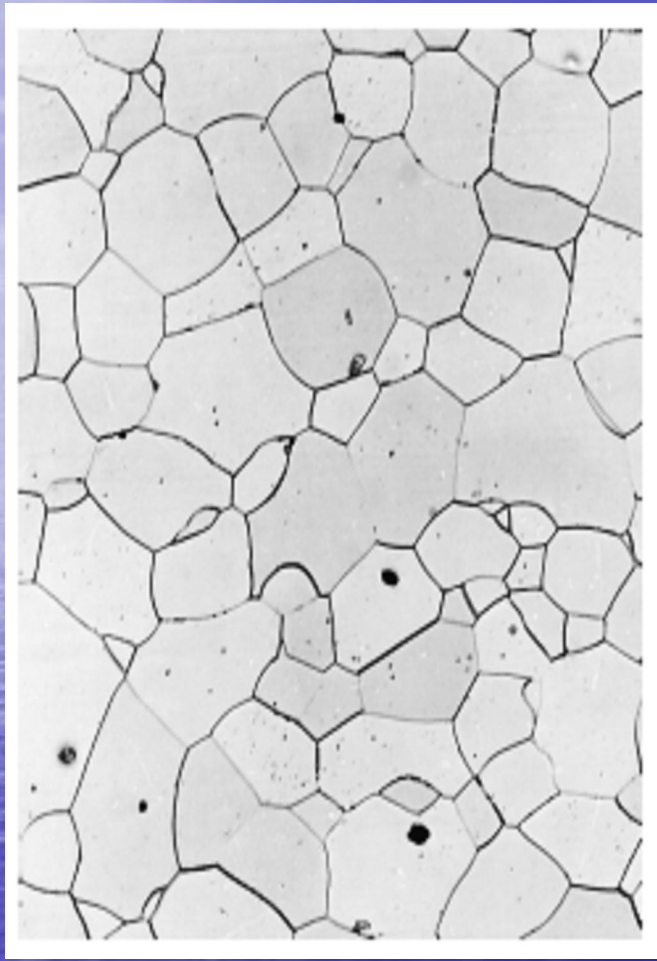
3. Hexagonal Closed Packed (HCP)



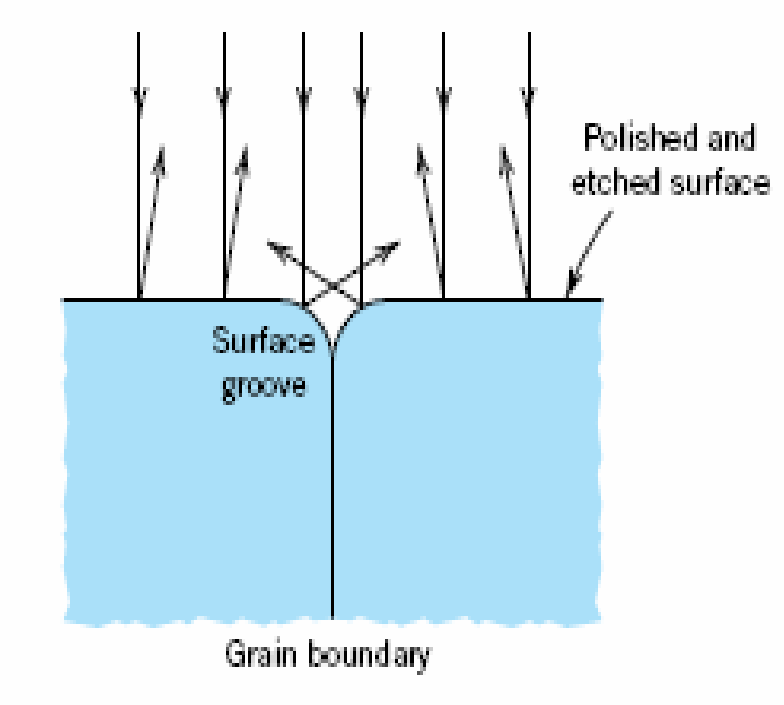
Struktur mikro (Butir dan Batas Butir)



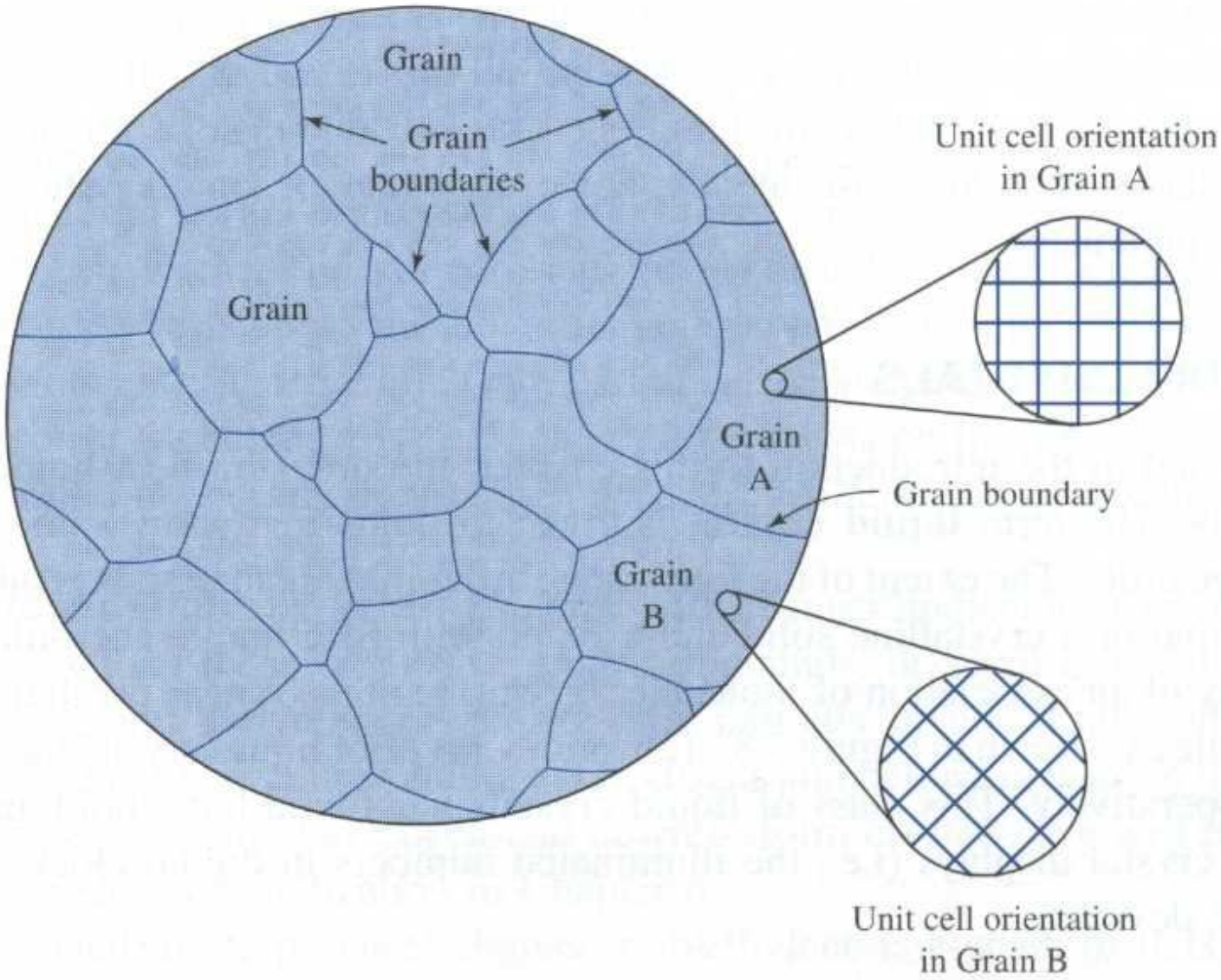
Optical Microscopy, Experiment 4



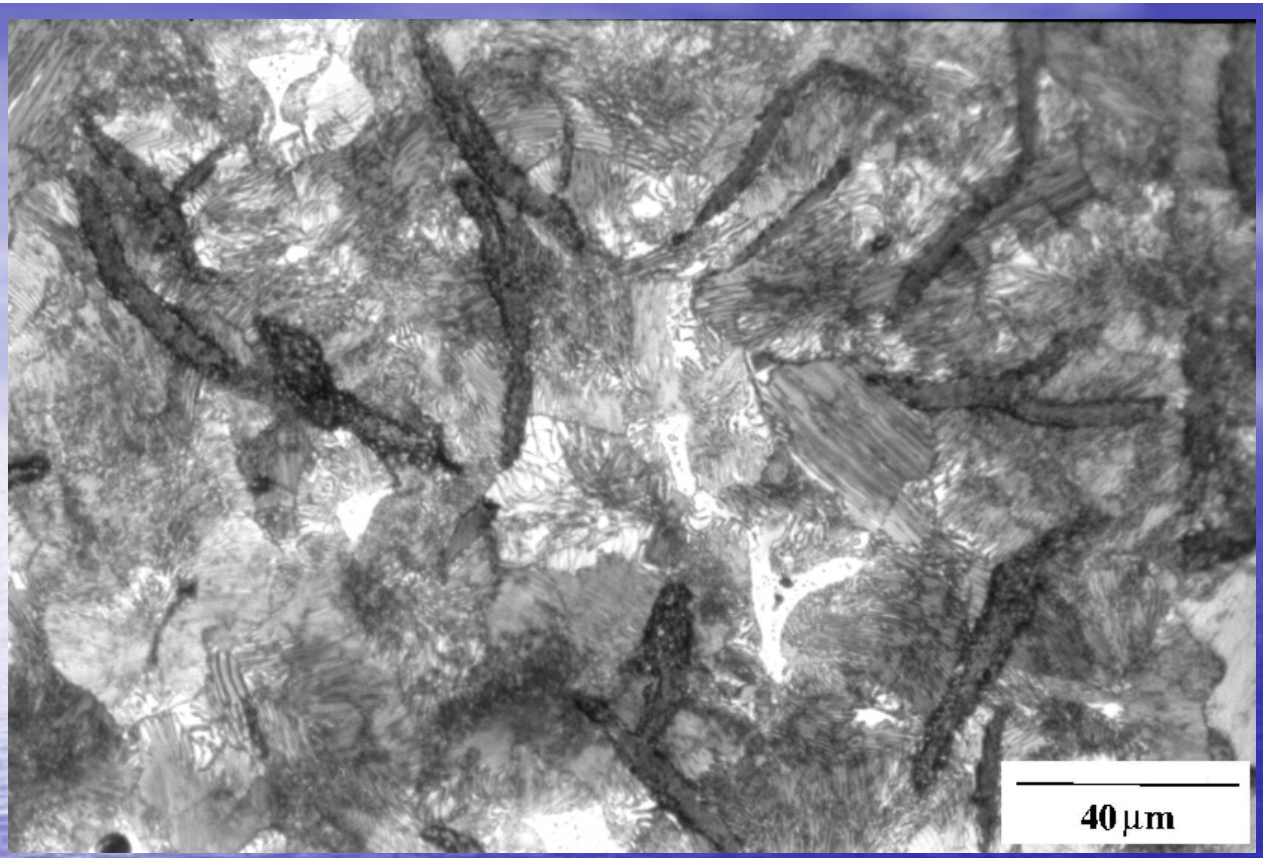
Photomicrograph an iron chromium alloy. 100X.



Callister, Fig. 4.12



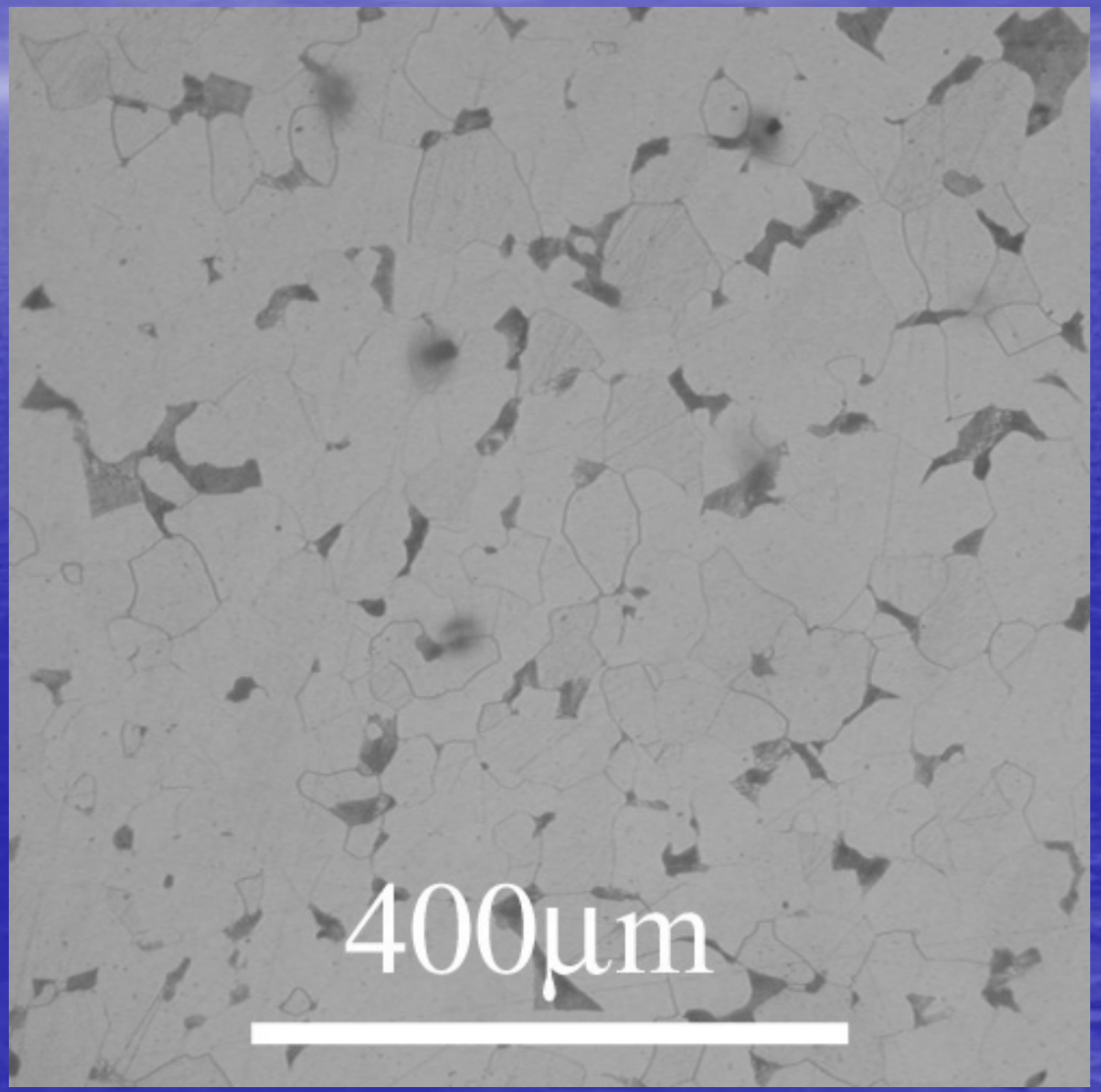
A schematic illustration of a polycrystalline sample. The polycrystal is composed of many grains separated by regions of disorder known as grain boundaries. Note that the unit cell alignment within Grain A (shown in the high magnification insert) is different from that in Grain B.



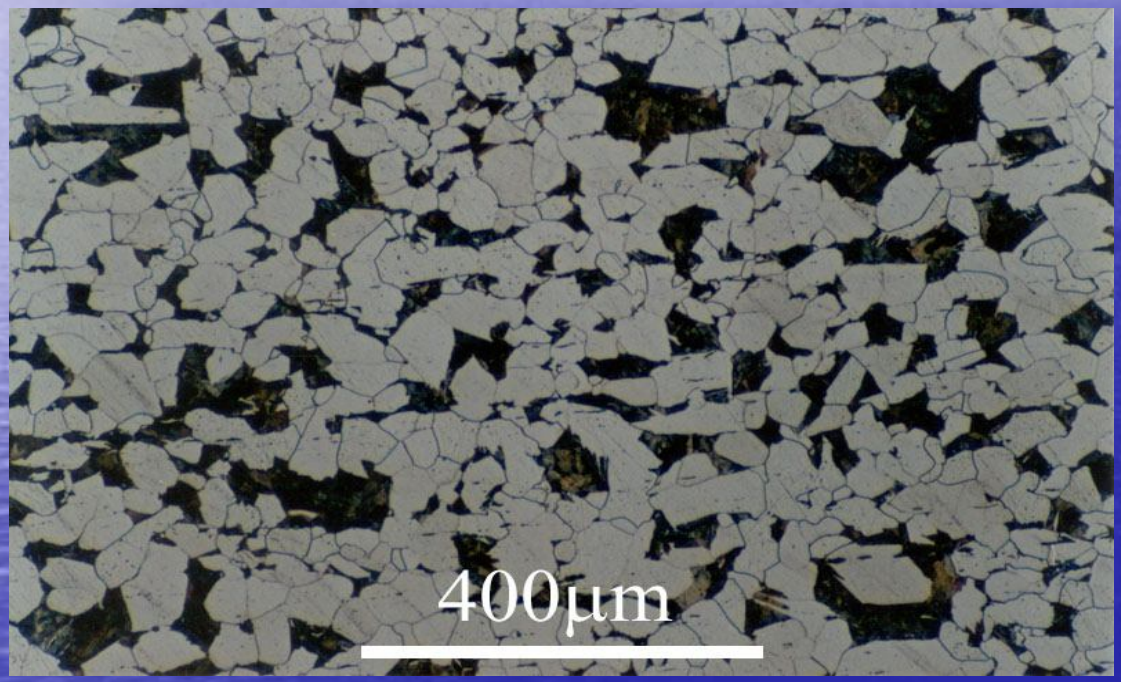
Grey cast iron showing the graphite flakes in a pearlite matrix

0.1% Carbon Steel

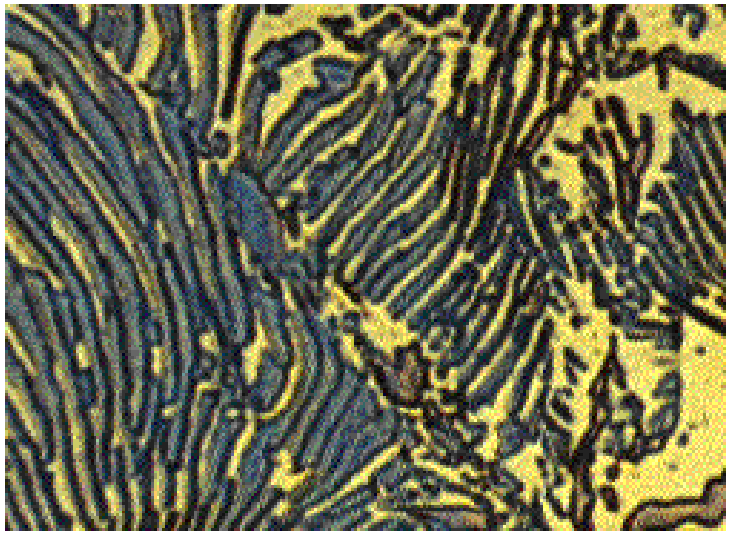
Note the small amount of pearlite in the structure



0.2% Carbon Steel

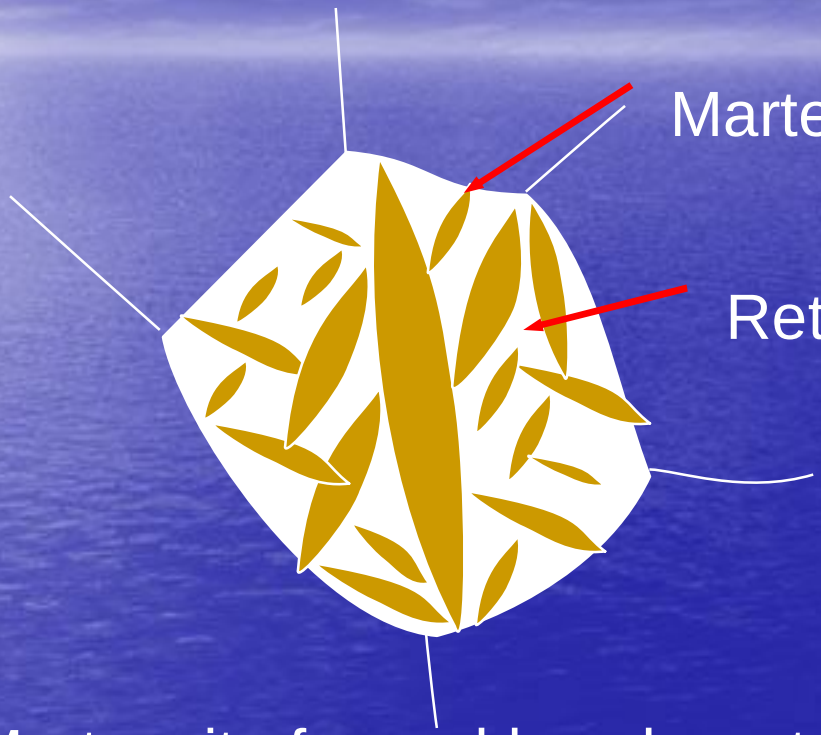


Note the increased amount of pearlite compared with the 0.1% ‘dead mild’ steel



Two-dimensional view of pearlite, consisting of alternating layers of cementite and ferrite.

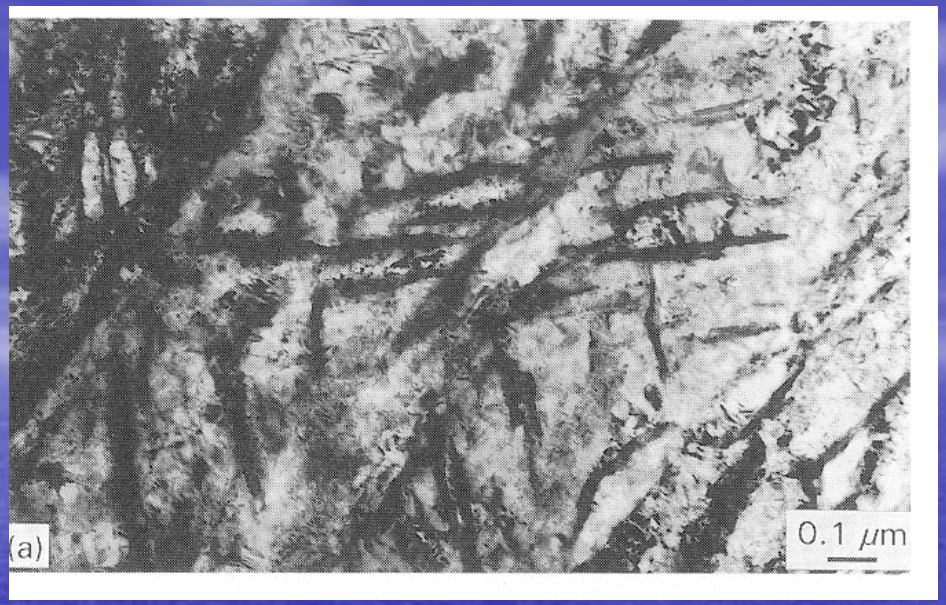
Martensite



Martensite formed by shear transformation in an austenite grain

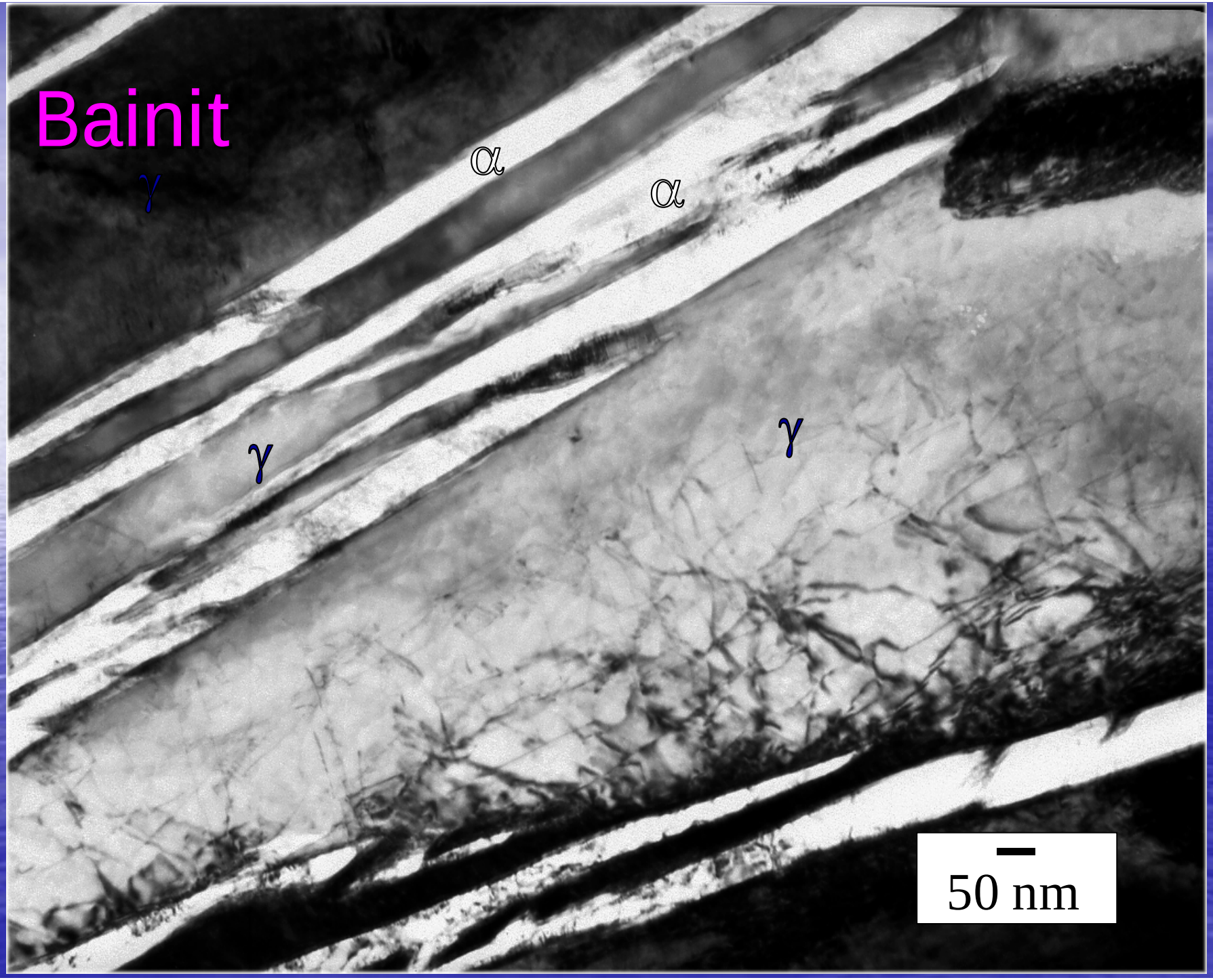
The needle-like structure of martensite, the white areas are retained austenite.

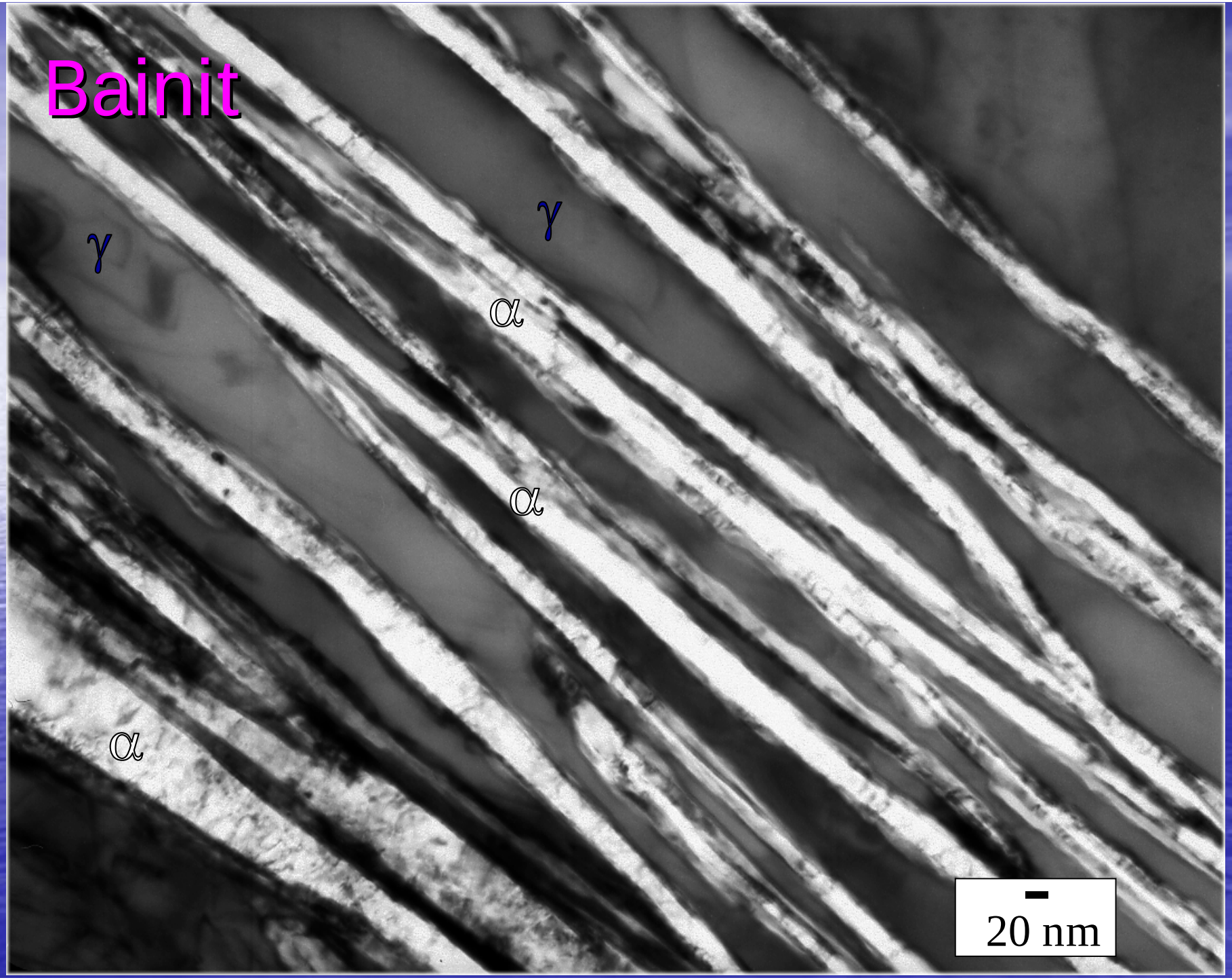
Tempered
400°C 30 min



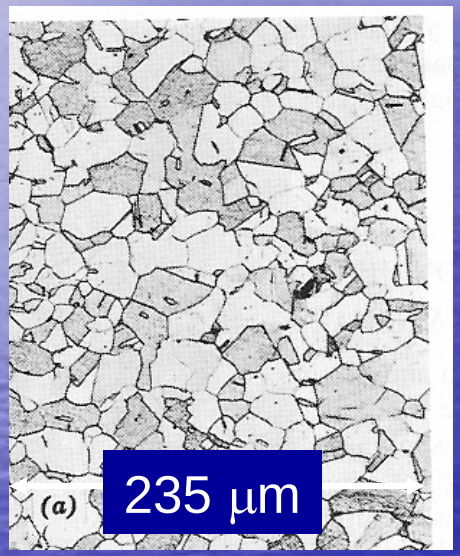
Tempered
400°C 30 min
500 MPa stress

Stewart et al., 1994


Bainit
γ
α
α
γ
γ
50 nm

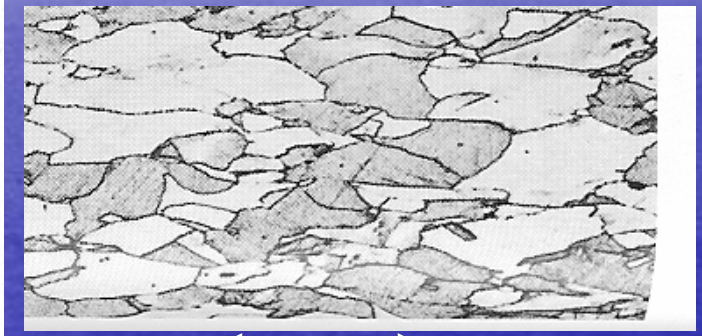

Bainit
γ
γ
α
α
α
20 nm

- before rolling



- isotropic
since grains are approx. spherical & randomly oriented.

- after rolling



rolling direction

- anisotropic
since rolling affects grain orientation and shape.

Adapted from Fig. 8.11, *Callister & Rethwisch 3e.* (Fig. 8.11 is from W.G. Moffatt, G.W. Pearsall, and J. Wulff, *The Structure and Properties of Materials*, Vol. I, *Structure*, p. 140, John Wiley and Sons, New York, 1964.)