Experiment No.1

Microstructure of Materials

Exp.1-A:Metals

Exp.1B:Composite Materials

Experiment 1-A

Metallic Materials Microstructure

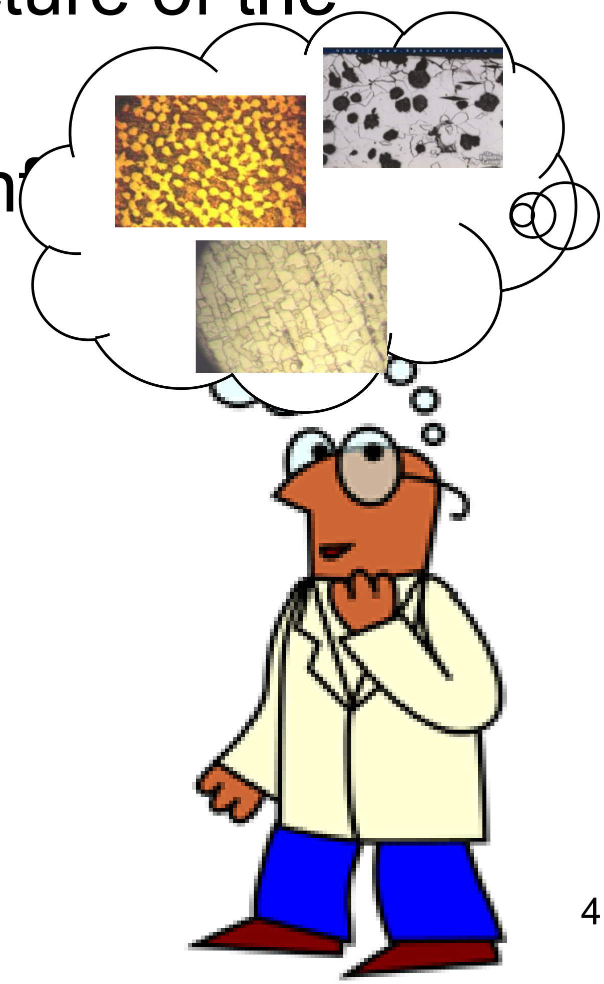
Objectives

- The objective of this experiment is to prepare a specimen cut from the cross section of a steel bar for micro structural examination in order to determine the following:

1. The average grain size number n-ASTM
2. The average grain size in mm.
3. The average aspect ratio of the grains AAR.

Theory

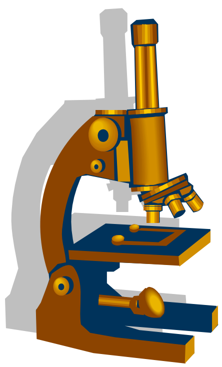
- Microstructure examination of metallic materials is used to reveal the grain size as well as different phases existing within the microstructure of the metal.
- Material microstructure has a great in different material properties



- Grain size
- Different phases

Procedure

- Specimen preparation



- Microscopic Examination

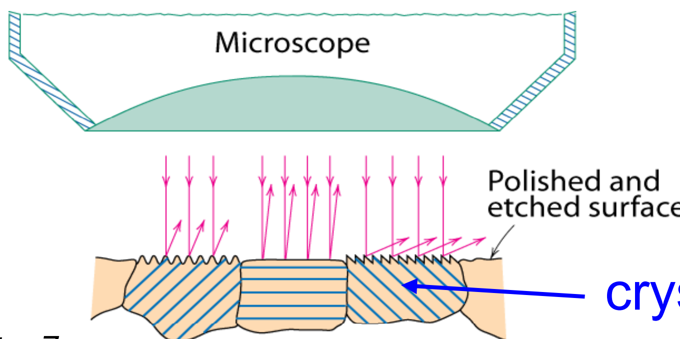
- Data Analysis

Microscopic Examination

- Crystallites (grains) and grain boundaries. Vary considerably in size. Can be quite large
  - ex: Large single crystal of quartz or diamond or Si
  - ex: Aluminum light post or garbage can - see the individual grains
- Crystallites (grains) can be quite small (mm or less) – necessary to observe with a microscope.

Optical Microscopy

- Useful up to 2000X magnification.
- Polishing removes surface features (e.g., scratches)
- Etching changes reflectance, depending on crystal orientation.



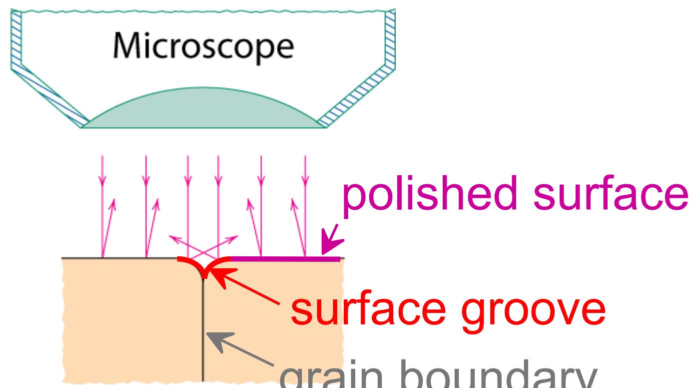
Adapted from Fig. 4.13(b) and (c), *Callister 7e.* (Fig. 4.13(c) is courtesy of J.E. Burke, General Electric Co.

Micrograph of brass (a Cu-Zn alloy)

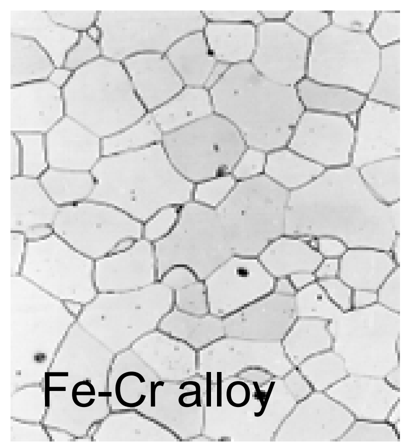
Optical Microscopy

Grain boundaries...

- are imperfections,
- are more susceptible to etching,
- may be revealed as dark lines,
- change in crystal orientation across boundary.



(a)



(b)

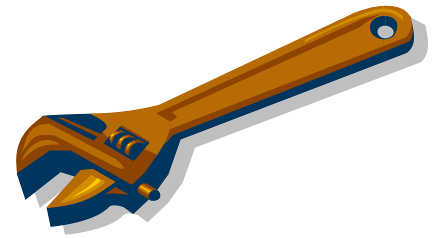
Adapted from Fig. 4.14(a) and (b), *Callister 7e.* (Fig. 4.14(b) is courtesy of L.C. Smith and C. Brady, the National Bureau of Standards, Washington, DC [now the National Institute of Standards and Technology, Gaithersburg, MD].)

ASTM grain size number → n

$$N = 2^{n-1}$$

N ← number of grains/in^2 at 100x magnification

Apparatus



1. Cutting machine: to acquire a specimen sample.
2. Phenolic powder: to facilitate the handling (Glue).
3. Rotary grinder & Grinding papers :to grind the specimen surfac .

   rough: 240-400,fine: 600-2400

4. Polishing machine: to polish the specimen surface.

   Polishing machine and diamond paste

5. Etching solution: to reveal the grain boundaries.

   2% natal (2% nitric acid and 98% Ethanol)

6. Optical microscope’ to examine the specimen.
7. Digital camera: to capture image.
8. Computer: to save image.

Specimen preparation

The following steps should be carried out in order to prepare a mild steel specimen for microscopic examination these steps are:

- Sampling
- Mounting
- Grinding
- Polishing
- Etching

Sampling

Grinding & polishing

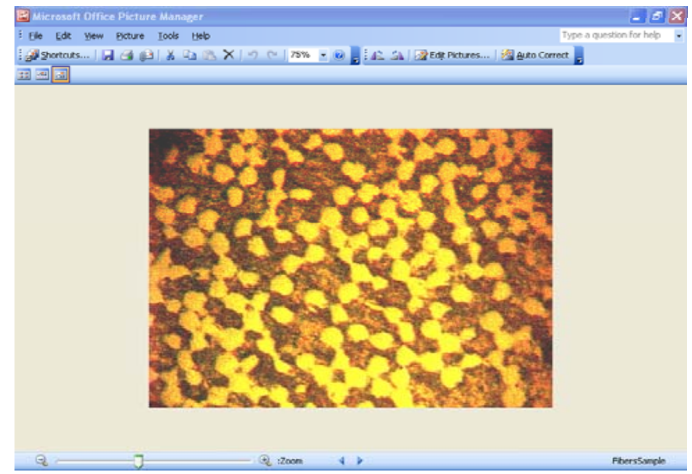
Mounting

A- Specimen preparation:

The following steps should be carried out in order to prepare a mild steel specimen for microscopic examination these steps are:

1. Sampling: Specimens are cut carefully from the steel bar in a way that it does not affect the material microstructure.
2. Mounting: It is achieved to facilitate the handling of the specimen. Phenolic powder (thermoplastic resin) is used to form a mount around the steel specimen by the hot pressing technique.
3. Grinding: Rough and fine sand grinding papers are used to grind the specimen surface. Water and alcohol are used to clean and remove the debris.
4. Polishing: Diamond pastes with diamond particles having diameters of 1 μm and 0.25 μm are used to polish the specimen surface.
5. Etching: 2% natal solution is used to reveal the grain boundaries of the specimen.

Magnification factor=



Microscope magnification factors

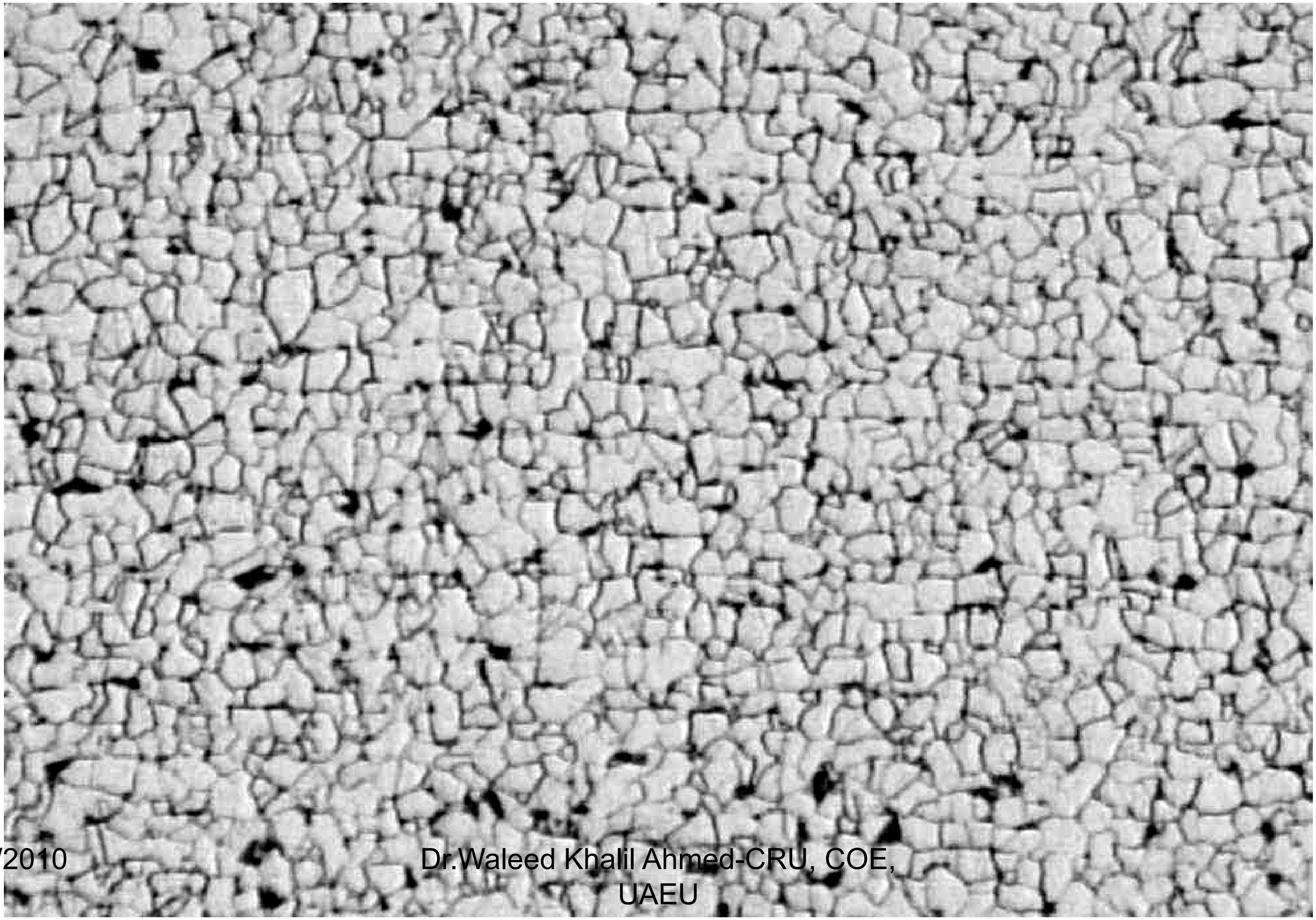
X

Camera zoom factor

X

Software enlargement factor

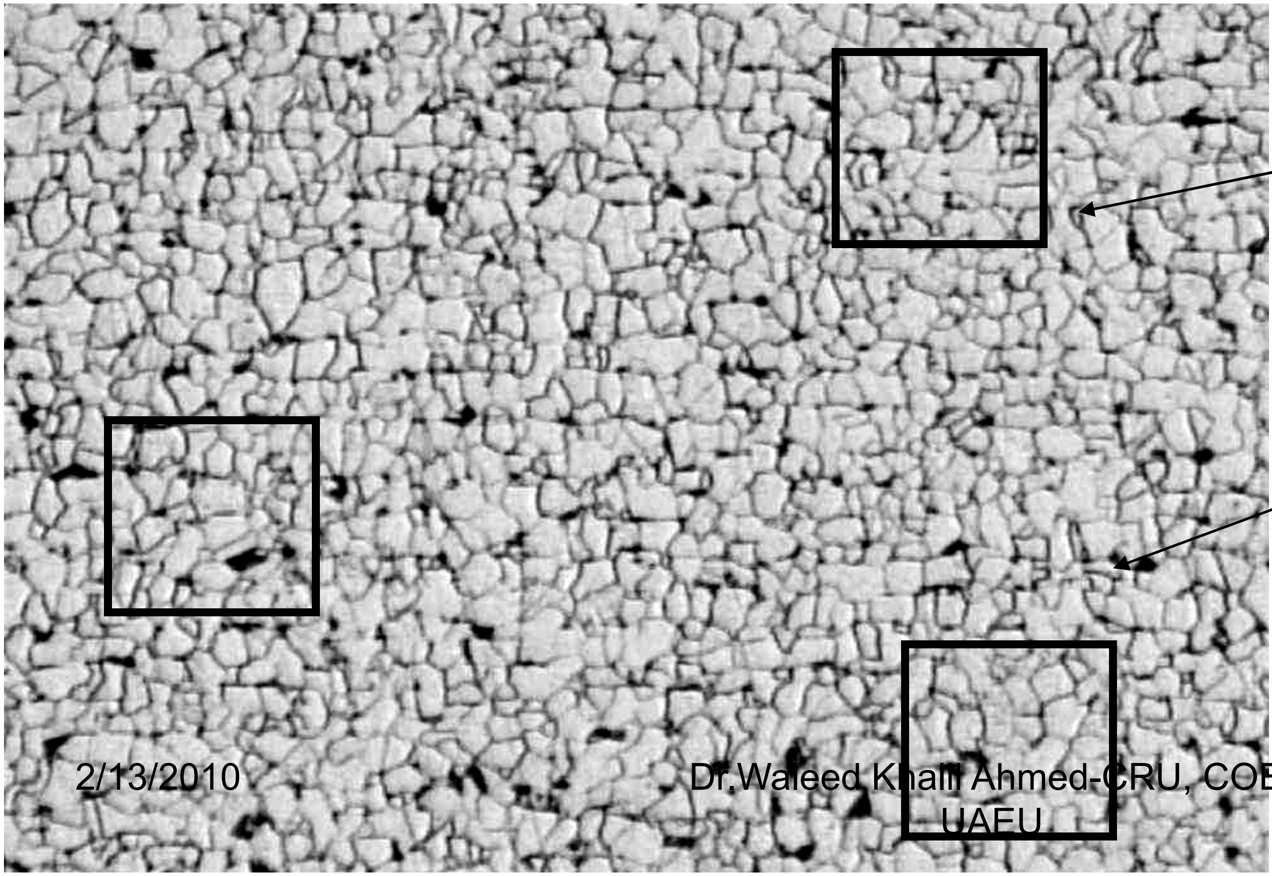
Photomicrograph of the mild steel showing the dark grain boundaries



Data Analysis

1.The average grain size number

- **Draw 1” X 1” frame on the saved image**
- **Count the number of grains included within the frame, N_{mag} do not include any uncompleted grains within the frame.**
- **Count the number of partial grains included within the frame and divided by two and then added to the full no. of grains (ASTM E112 Section 9).**



1”x1”

Calculate No. of grains in the frame

<u>ASTM grain size number</u> (n)

- the number of grains counted in step2 should be at a magnification of 100 X. the number of grains at 100X magnification can be calculated from:

Actual No. of grains at real magnification

$$N_{100} = N_{mag} \times \left(\frac{mag}{100} \right)^2$$

Magnification factor

No. of grains at 100X magnification according to ASTM rules

- The specimen grain size number, n, can be calculated from:

$$N_{100} = 2^{n-1}$$

Where

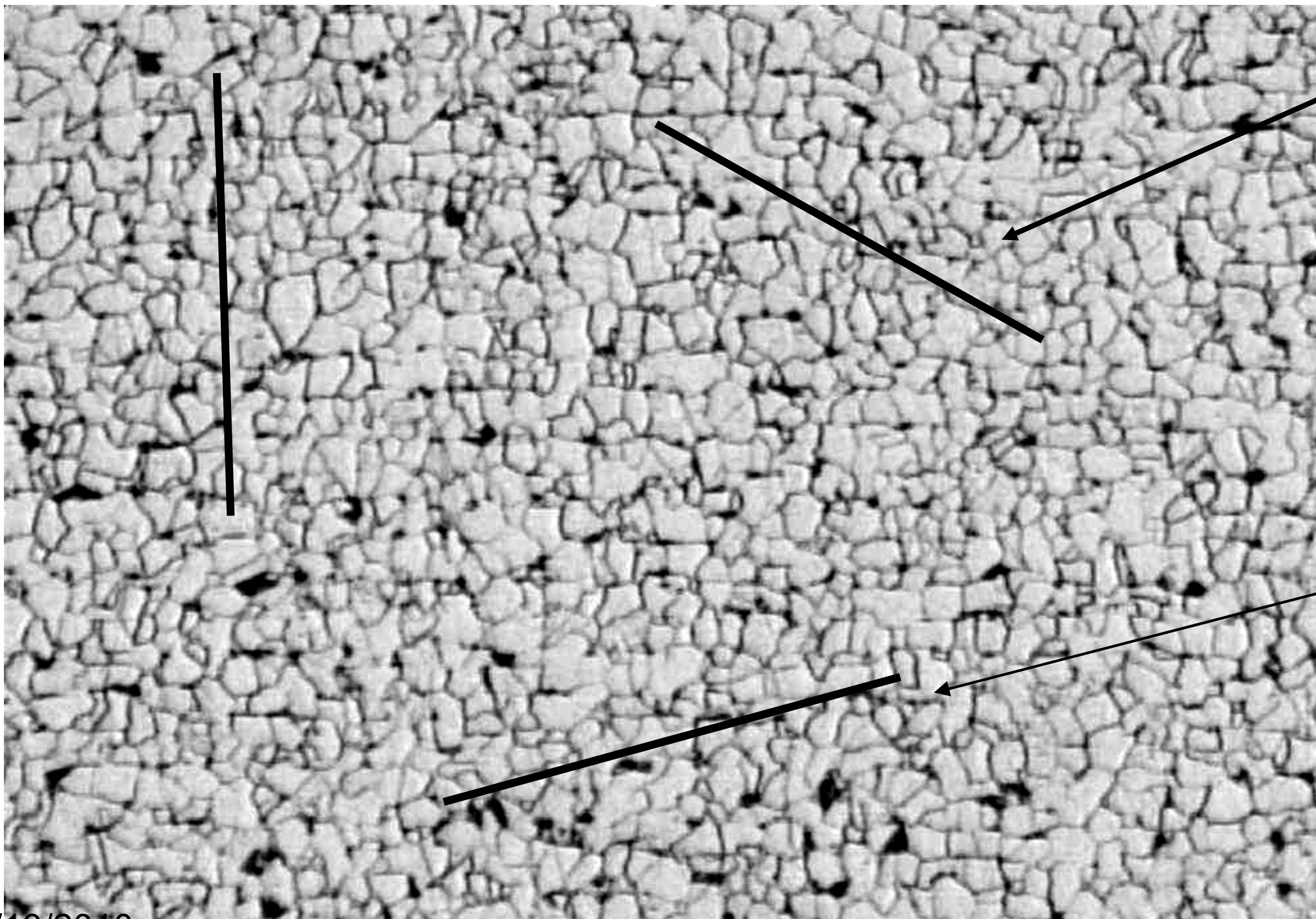
N_{100}: number of grains at 100 X per square inch

n: ASTM grain size number (integer).

- Calculate n for three different 1"X1" and take the **average value**.

2.The average grain size (AGS)

- Draw 1 inch(25.4 mm) length ,three scattered lines.



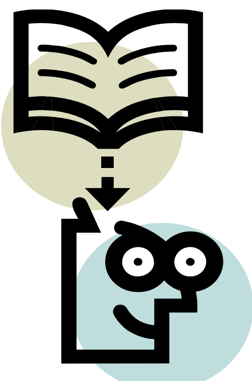
- Determine the average grain size (AGS) of the specimen by counting the number of grains a long a 1”(25.4 mm) line in the frame as:

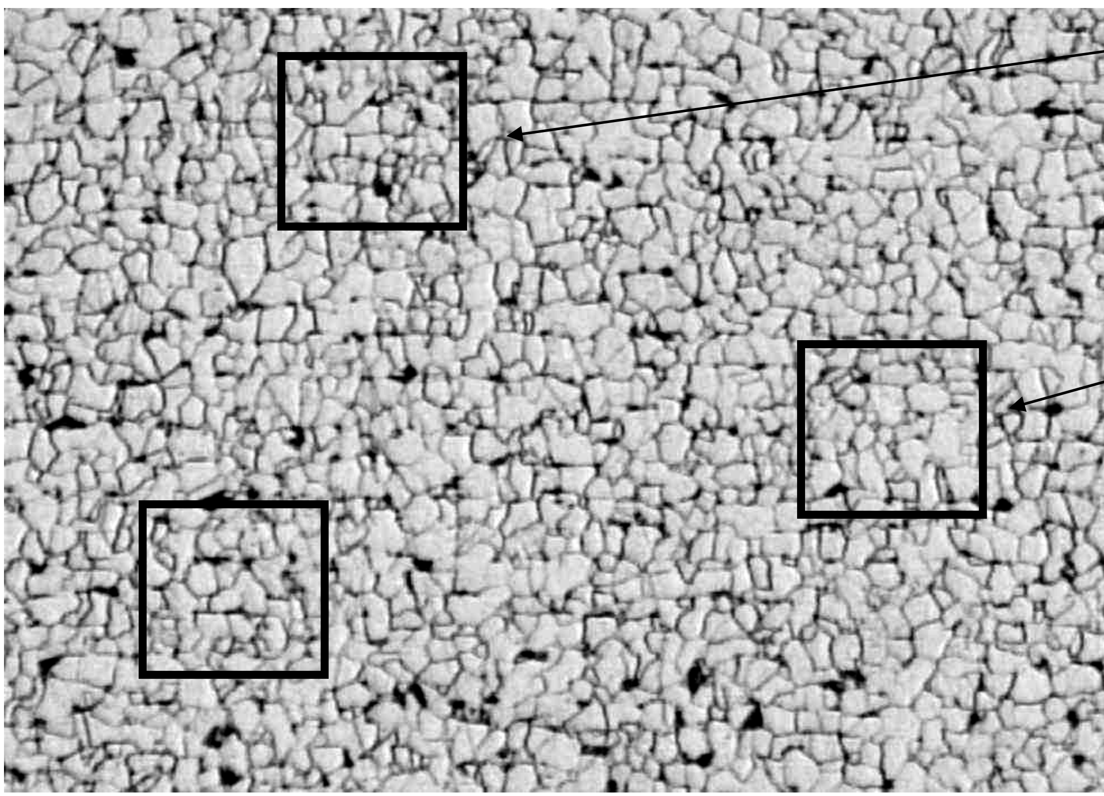
$$AGS = \frac{1/magnificat\ ion}{number\ \text{of grains a long 1'' line}}$$

- Calculate **AGS** for three different lines and take the **average value**.

3.Average Aspect Ratio (AAR)

- Use three 1”X1” frames arranged randomly, as in the grain size number case.
- Measure the maximum and minimum dimension for all grains in each the frames.

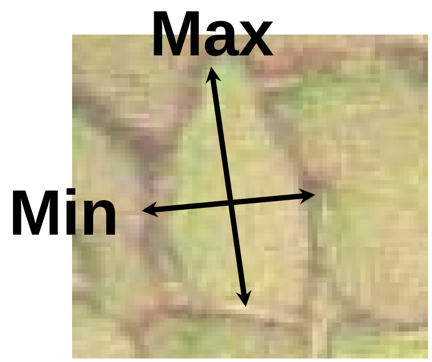




1”x1”

Calculate Max. & Min. dimension of the grains in the frame

- Calculate the average Aspect Ratio (AAR) of the specimen grains.

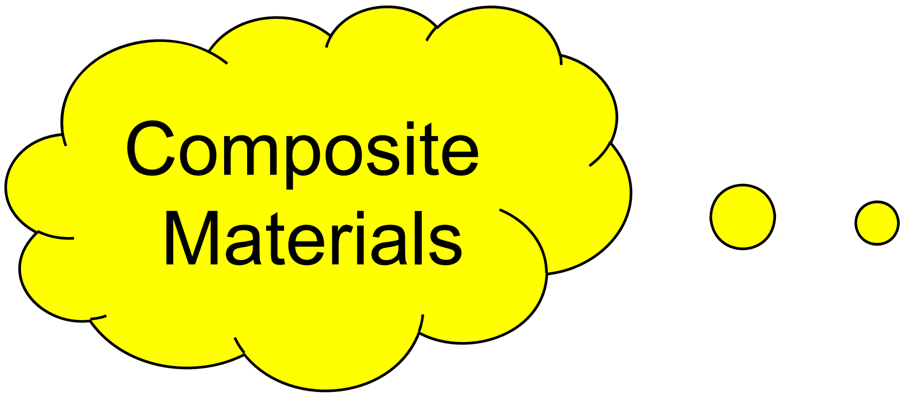


$$AAR = \frac{\text{minimum dimension of the grain}}{\text{maximam dimension of the grain}}$$

- Calculate AAS for three different frames and take the average value.

Experiment 1-B:

Microstructure of Composite Materials

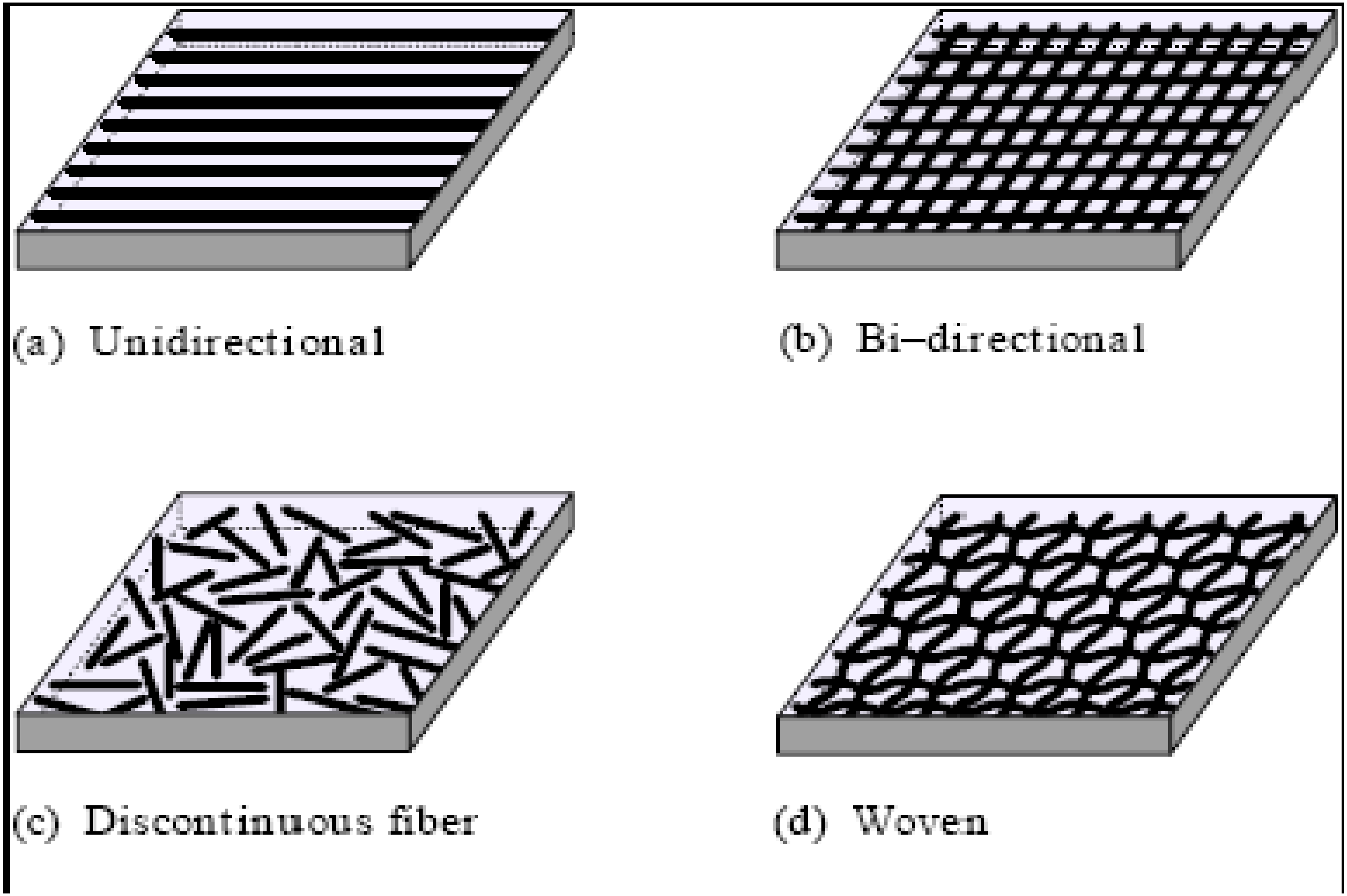


COMPOSITE MATERIALS

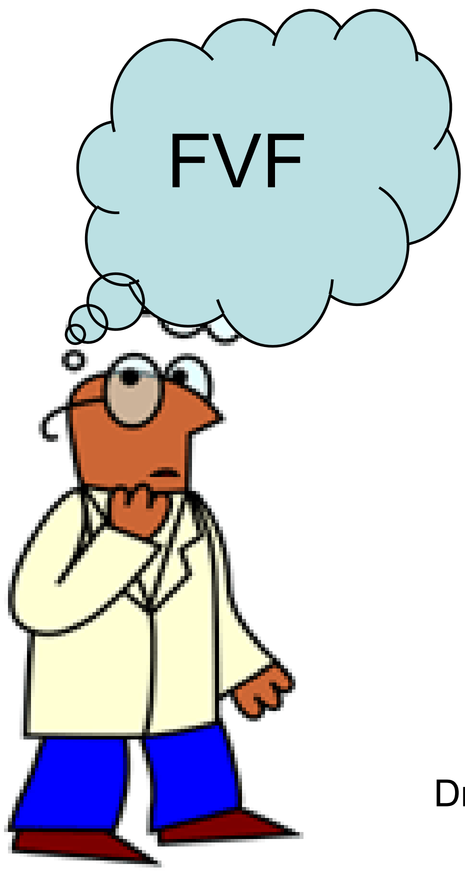
- ***Definition***: Two or more materials combined on a *macroscopic* scale to form a useful third material
- ***Properties to be Improved***: Strength, stiffness, weight, fatigue life, wear resistance, thermal insulation, thermal conductivity, corrosion resistance, acoustical insulation, etc.

CLASSIFICATION OF COMPOSITE MATERIALS

- ***Fibrous composites***: Fibers in a matrix
- ***Particulate composites***: Particles in a matrix
- ***Combinations of above***: Reinforced fiber-reinforced composite


(a) Unidirectional
(b) Bi–directional
(c) Discontinuous fiber
(d) Woven

Objective:



To determine the fiber volume fraction (FVF) for a fiber reinforced composite material.

Apparatus:

The investigation of composite microstructure is carried out using optical microscope. The required equipment are listed below:

- Optical microscope.
- Digital camera.
- Computer with image processing software.



Procedure:

The microstructure of a glass – fiber reinforced composite bar is to be examined. Sample preparation and microscopic examination are the two main steps required for composite investigation.

A) Specimen Preparation:

- Sampling.
- Grinding.

These steps are described in experiment 1-A.

B) Microscopic Examination:

Follow the steps from 1 to 7 explained in microscopic examination section for specimen (described in experiment 1-A).

Data Analysis:

Since the examined specimen is a continuous fiber composite the ratio of the total fiber volume to the composite volume (FVF) is equivalent to the ratio of the total fiber area to the composite cross sectional area as follows:

$$\mathrm{FVF} = \frac{\text{Total fiber cross sectional area}}{\text{Total cross sectional area of the frame } [1\,\mathrm{in}^2]}$$

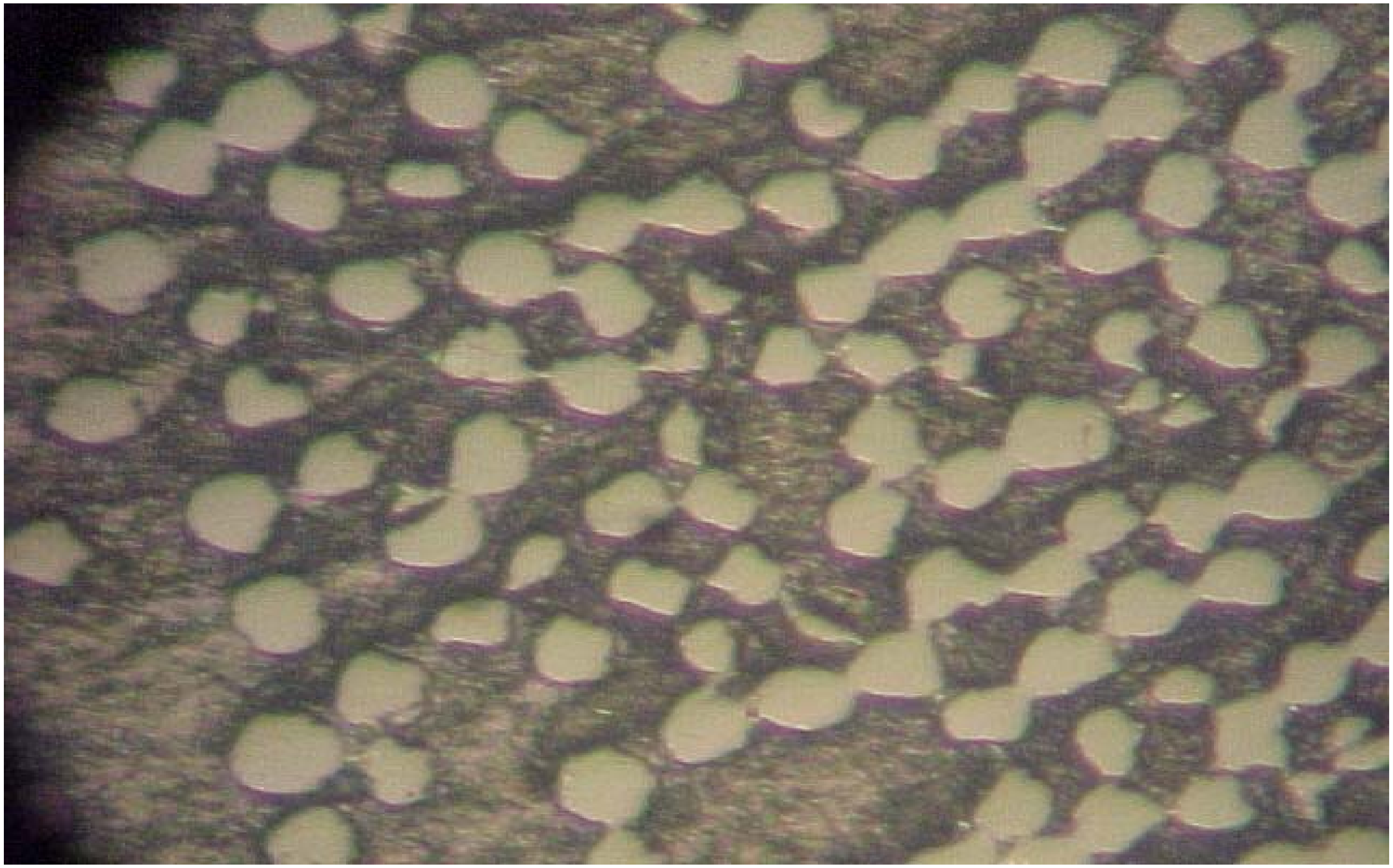


Figure 1 Typical appearance of a cross section of a fiber glass reinforced composite

FVF calculation steps:

- Draw a 1” * 1” frame on the saved image which should look similar to that given in figure 1.
- Count the number of fibers within the frame. Do not consider uncompleted fibers within the frame.
- Measure the diameter of each fiber within the frame in two perpendicular directions. Record the measurements in a table similar to the following table.
- Calculate the average diameter and actual average diameter (taking into account the magnification factor) for each fiber.
- Calculate the FVF of the examined glass fiber composite specimen

Fiber #	Min Diameter	Max Diameter	Avg Diameter		Cross sec. Area of fiber
Fiber(1) Fiber(2) . . .					
Total fiber cross sectional area					$\Sigma =$

Discussion and conclusion:

Write a concise account of the experiment and the result obtained.

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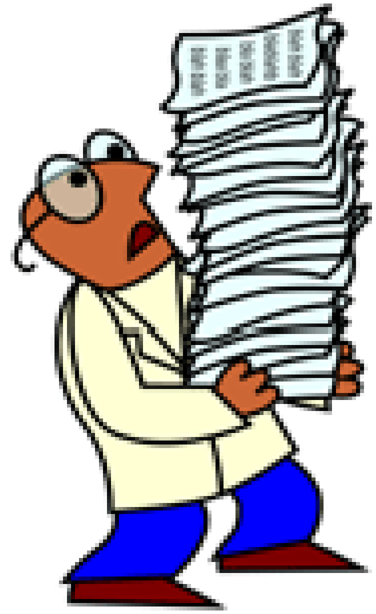

Report and Assignment

The Reports should be received by

Next Week