Grain Size Determination

- The grain size is often determined when the properties of polycrystalline and single-phase materials are under consideration.
- Grain size may be specified in terms of average or mean grain diameter, and a number of techniques have been developed to measure this parameter.
- Before the advent of the digital age, grain-size determinations were performed manually using photomicrographs. Two common grain-size determination techniques: (1) Linear intercept — counting numbers of grain boundary intersections by straight test lines; and (2) Comparison — comparing grain structures with standardized charts, which are based upon grain areas.

Grain Size Determination

- For the linear intercept method, lines are drawn randomly through several photomicrographs that show the grain structure (all taken at the same magnification).
- Grain boundaries intersected by all the line segments are counted. Let us represent the total length of all the lines by L_T and the sum of the total number of intersections as P. The mean intercept length $\bar{\ell}$ (bar), a measure of grain diameter, may be determined by the following expression:

$$\bar{\ell} = \frac{L_T}{PM}$$

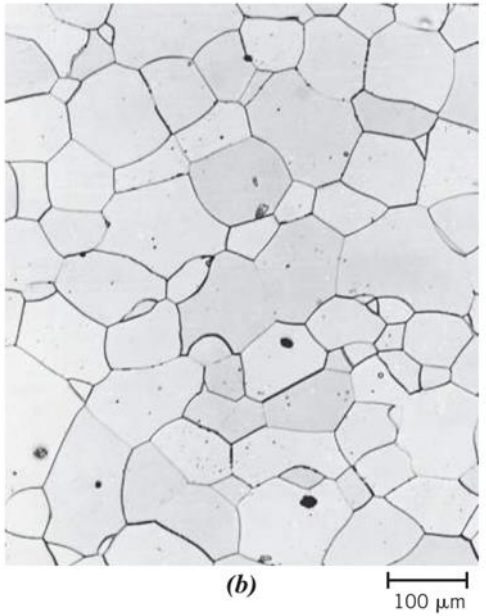
where M is the magnification

Grain Size Determination

- To compute magnification from a scale bar, the following procedure may be used:

1. Measure the length of the scale bar in millimeters using a ruler.
2. Convert this length into microns [i.e., multiply the value in step (1) by 1000 because there are 1000 microns in a millimeter].
3. Magnification M is equal to

$$M = \frac{\text{measured scale length (converted to microns)}}{\text{the number appearing by the scale bar (in microns)}}$$



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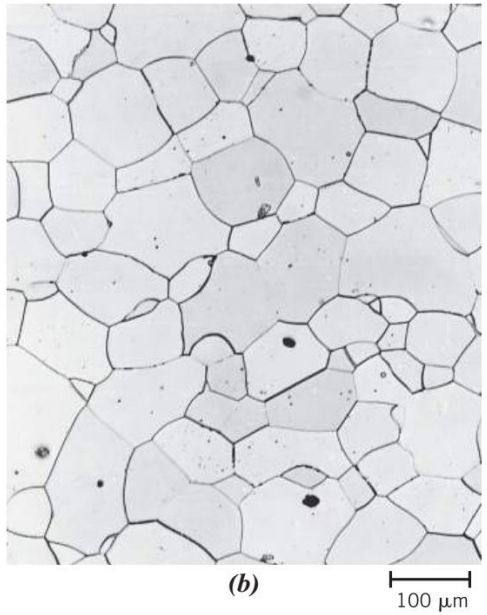
- The measured scale length is approximately 10 mm, which is equivalent to (10 mm)(1000 μm/mm) = 10,000 μm.
- The scale bar length is 100 μm, the magnification is equal to



$$M = \frac{10{,}000\ \mu m}{100\ \mu m} = 100\times$$

- The magnification is specified in the micrograph legend (e.g., "60×"); this means the micrograph represents a 60 times enlargement of the specimen in real space.

Grain Size Determination

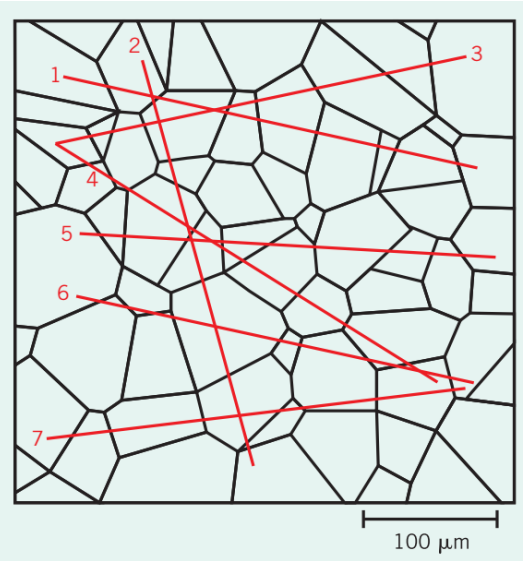
- The comparison method of grain-size determination was devised by the American Society for Testing and Materials (ASTM).
- Relationships have been developed that relate mean intercept length to ASTM grain-size number (G); these are as follows:

$$G = -6.6457 \log \bar{\ell} - 3.298 \qquad (\text{for } \bar{\ell} \text{ in mm})$$

$$G = -6.6353 \log \bar{\ell} - 12.6 \qquad (\text{for } \bar{\ell} \text{ in in.})$$

Grain Size Determination

Q. The following is a schematic micrograph that represents the microstructure of some hypothetical metal. Determine the following:



(a) Mean intercept length

(b) ASTM grain-size number, G

Grain Size Determination

- Let G represent the grain-size number, and let n be the average number of grains per square inch at a magnification of 100×. These two parameters are related to each other through the expression:

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

- For photomicrographs taken at magnifications other than 100×, use of the following modified form of Equation is necessary:

$$n_M \left(\frac{M}{100} \right)^2 = 2^{G-1}$$