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HW #5

3.3 What effects does recrystallization have on the properties of metals?

Recrystallization decreases the density of dislocations and lowers the strength of the metals but raises its ductility

3.6 What is the relationship between nucleation rate and the number of grains per unit volume of a metal?

When the nucleation rate is high, the number of grains in a unit volume of metal will be greater, and consequently grain size will be small.

3.16 Explain why the strength of a polycrystalline metal at room temperature decreases as its grain size increases.

The strength of a polycrystalline metal at room temperature decreases at its grain size increases because Larger grain sizes mean that there will be less dislocations due to the distance between grain boundaries. And recall that strength is increased when there are more dislocations

Web problem:

You are given a sample labeled with ASTM grain size 7. Complete the following.

a) Determine the number of grains per square inch at a magnification of 100x? In other words, what is N (ASTM, not the line-intercept method)?

b) At 100x magnification, a 0.064 mm2 area looks like a square with 1 in. sides. Draw a square with 1 in. sides and label the side length with the un-magnified (actual) length of the magnified area. Label in mm.

c) If 64 identical "square grains" were inside this box, what would be the side length of one grain? This is the average grain diameter, d.

d) What is the mathematical relationship (equation) between grain diameter, d (in mm), and N? Put in terms of N.

e) Using what you now know, solve problem 3.44 in K&S. Hint1: At 150x magnification, Dappear=Dtrue*1.5. Hint2: Solving for ntrue may not yield a whole number. Round to nearest whole
number.

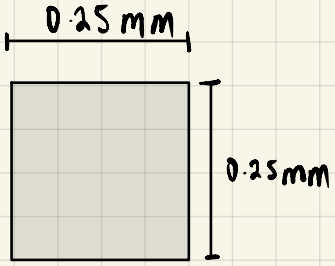
a. Given : ASTM grain size 7, $n = 7$

number of grains per sq in at a magnification of 100x? What is N?

$$N = 2^{n-1} \qquad \text{eqn (3.9)}$$

$N = 2^{7-1} = 64$ grains/in^2 ≈ 0.0992 grains/mm^2

b. Label the sides with unmagnified actual length of the magnified area



At 100x magnification, 0.064 mm^2 looks like square with lin sides so area @ 100x magnification,

$$\text{actual area} = 0.064\,\text{mm}^2$$
$$\text{actual side} = (0.064\,\text{mm}^2)^{1/2} = 0.25\,\text{mm}$$

c. 64 identical square grains inside box, what would be the side length of one grain, d?

Using $\frac{L}{N} = d$ (L = length, N = # of intersections)

$$\Rightarrow \frac{0.25}{64} = 0.0039\,\text{mm}$$

d. Mathematical relationship between grain diameter d (in mm) and N in terms of N.

Number of grains would

$$N = 2^{n-1} \times A$$

take $A = \frac{\pi d^2}{4}$

$$N = 2^{n-1} * \frac{\pi d^2}{4}$$

$$d^2 = \frac{4N}{2^{n-1}\pi}$$

$$d = \left(\frac{4N}{2^{n-1}\pi}\right)^{1/2} \quad \text{——— } *$$

e.

3.44 A technician determines that the grain size of a certain etched specimen is 4. Upon further checking, it is found that the magnification used was 150, instead of 100, the latter of which is required by ASTM standards. What is the correct grain size?

Grain-Size number = 4

using the above eqn (*)

$$d = \left(\frac{4N}{2^{n-1}\pi}\right)^{1/2}$$

Solve for n.

take $d = 0.0039\ mm$

$N_{n=4} = 2^{4-1} = 8\ grains/in^2 = 0.0124\ grain/mm^2$

at 150x magnification $D_{appear} = D_{true} \times 1.5$

$$\Rightarrow \quad d^2 = \frac{4N}{2^{n-1}\pi}$$

$$2^{n-1} = \frac{4N}{d^2\pi}$$

$$(n-1)\log 2 = \log\left(\frac{4N}{d^2\pi}\right)$$

$$n = \log\left(\frac{4N}{d^2\pi}\right) * \frac{1}{\log 2} + 1$$

$$n = 9.8$$

$$n \approx 10$$

3.47 A strip of metal is reduced in thickness by cold working from 30 mm to 15 mm. A similar strip is reduced from 25 mm to 10 mm. Which one of these strips will recrystallize at a lower temperature? Why?

Metal 1 % decrease $\frac{30-15}{30} \times 100 = 50\%$

Metal 2 % decrease $\frac{25-10}{25} \times 100 = 60\%$

Recrystal depends on the degree of prior cold work, the higher the amount of cold work, the lower the temperature required for crystallization to occur. Metal 2 (25mm - 10mm) is expected to recrystallize at a lower temperature.

3.51 The following data is obtained in tension tests of brass:

Grain size (μm)	Yield strength (MPa)
15	150
20	140
50	105
75	90
100	75

Does this material follow the Hall—Petch effect? If so, what is the value of k?

Hall- Petch equation

$$S_y = S_{y_0} + k d^{-1/2}$$

plotting the data:

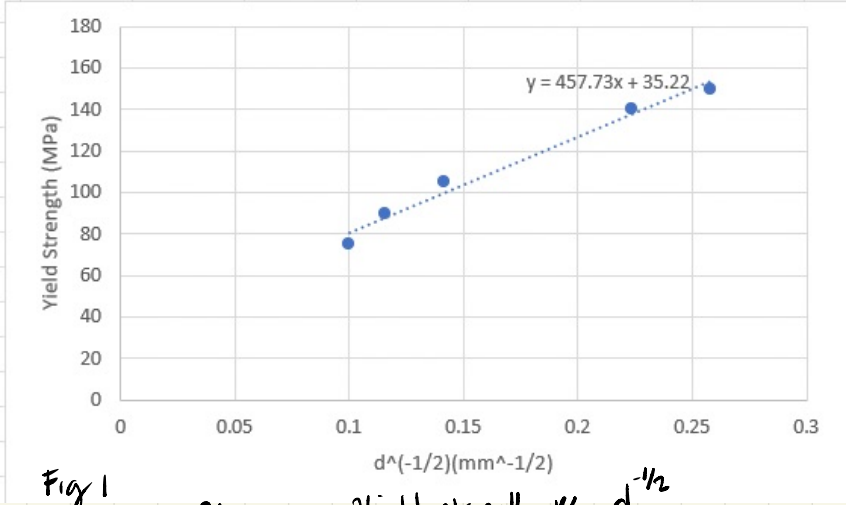


Fig 1

Plotting Yield strength vs $d^{-1/2}$

The data is not quite linear in $d^{-1/2}$. However doing a linear fit. The equation of the line is

$$y = 457.73x + 35.22.$$

testing with the provided data

Table 1

Grain size(µm)	d^(-1/2)(mm^-1/2)	Yield Strength (actual)	Yield Strength (line equation)
15	0.25819889	150	153.4053778
20	0.223606798	140	137.5715395
50	0.141421356	105	99.95279739
75	0.115470054	90	88.07410774
100	0.1	75	80.993

The provided Yield Strength does not match the yield strengths using the line equation. So this material does not follow the Hall-petch effect.