

Do all Problems
(101/100 Total Points)

QUIZ #2b
MSEG 302

Name: Key

Write your answers below the question on this paper. If extra room is required use the back of the page on which a specific question resides.

8-1 (15 pts) Explain the three stages of annealing of metallic materials.

Terms: +3/each
Det: +2/each

1. **Recovery:** A low-temperature treatment that removes the residual stresses due to cold working without causing a change in dislocation density. The original cold-worked microstructure is composed of deformed grains containing a large number of tangled dislocations. When the metal is first heated, the additional thermal energy permits the dislocations to move and form the boundaries of a polygonized subgrain structure.
2. **Recrystallization:** A medium-temperature annealing heat treatment rapid recovery eliminates residual stresses and produces the polygonized dislocation structure. New small grains then nucleate at the cell boundaries of the polygonized structure, eliminating most of the dislocations. Because the number of dislocations is greatly reduced, the recrystallized metal has low strength but high ductility.
3. **Grain Growth:** A higher-temperature annealing heat treatment, both recovery and recrystallization occur rapidly, producing a fine recrystallized grain structure. If the temperature is high enough, the grains begin to grow, with favored grains consuming the smaller grains.

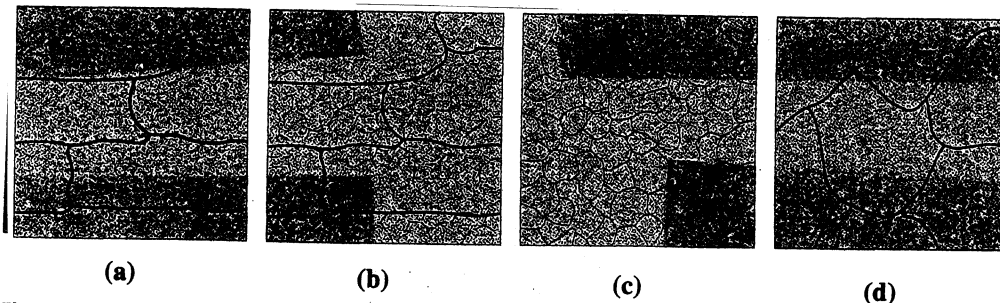


Figure 8-16 The effect of annealing temperature on the microstructure of cold-worked metals. (a) cold-worked, (b) after recovery, (c) after recrystallization, and (d) after grain growth.

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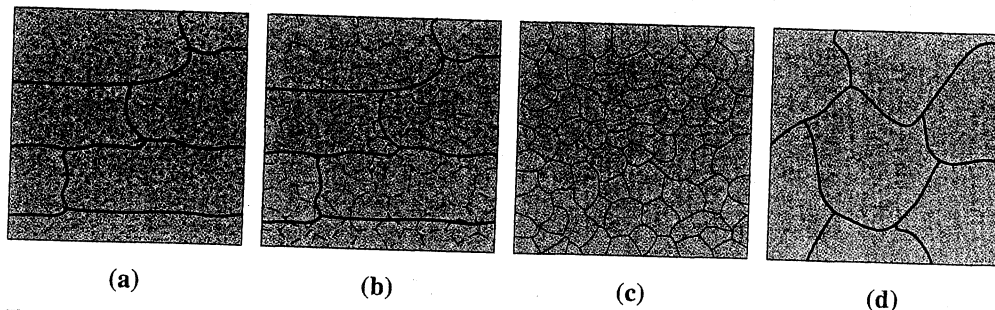


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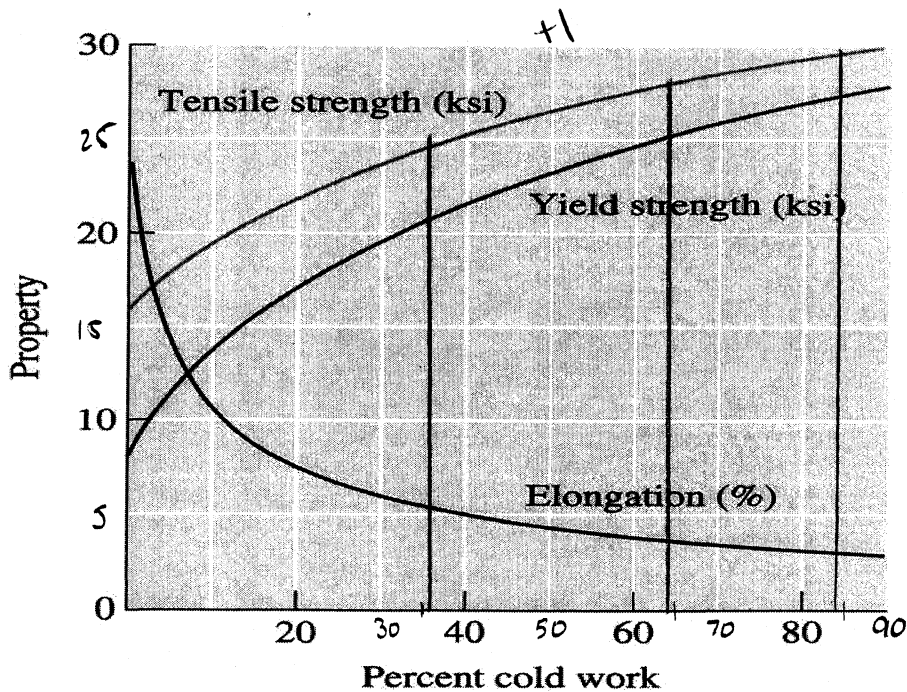
8-2 (15 pts) A 3105 aluminum bar is reduced from a 2 inch diameter, to a 1.6 inch diameter, to a 1.2 inch diameter to a final 0.8 inch diameter. Calculate the % cold-work and the properties after each step of the process. Use the figure to estimate properties. Draw the lines you use to estimate the properties on the figure.

$+2 \text{ Area} = \pi r^2 = \frac{\pi}{4} d^2$

	CW (%)	Tensile Strength (ksi)	Yield Strength (ksi)	Elongation (%)
$\frac{\frac{\pi}{4}(2^2 - 1.6^2)}{\frac{\pi}{4}(2^2)} \times 100\% =$	+1 36	+1 25	+1 21	+1 5
$\frac{(2^2 - 1.2^2)}{2^2} \times 100\% =$	+1 64	+1 28	+1 25	+1 4
$\frac{(2^2 - 0.8^2)}{2^2} \times 100\% =$	+1 84	+1 30	+1 27	+1 3

Total % Cold Work = 84 %

Percent cold work = $(A_0 - A_f) / A_0 \times 100\%$



9-3 (15 pts) Define the following terms:

- a) nucleation**
- b) embryo**
- c) heterogeneous nucleation**
- d) homogeneous nucleation**
- e) inoculants**

- x3** a) Nucleation: The physical process by which a new phase is produced in a material. In the case of solidification, this refers to the formation of tiny, stable solid particles in the liquid.
- x3** b) Embryo: A tiny particle of solid that forms from the liquid as atoms cluster together. The embryo may grow into a stable nucleus or redissolve.
- x3** c) Heterogeneous nucleation: Formation of a critically sized solid from the liquid on an impurity surface.
- x3** d) Homogeneous nucleation: Formation of a critically sized solid from the liquid by the clustering together of a large number of atoms at a high undercooling (without an external interface).
- x3** e) Inoculants: Materials that provide heterogeneous nucleation sites during the solidification of a material.

10-4 (16pts) Determine the phases present, the compositions of each phase, and the amount of each phase in wt.% for the following MgO-FeO ceramics at 2000°C

(a) MgO-25 wt% FeO

(b) MgO-45 wt% FeO

(c) MgO-60 wt% FeO

(d) MgO-80 wt% FeO

Draw the lines you use to estimate the answers on the figure.

(a) S: 25% FeO⁺¹

100% S⁺¹

(b) S: 39% FeO

$$\%S = \frac{65-45}{65-39} \times 100\% = 76.9\% \quad +2$$

L: 65% FeO

$$\%L = \frac{45-39}{65-39} \times 100\% = 23.1\% \quad +2$$

(c) S: 39% FeO

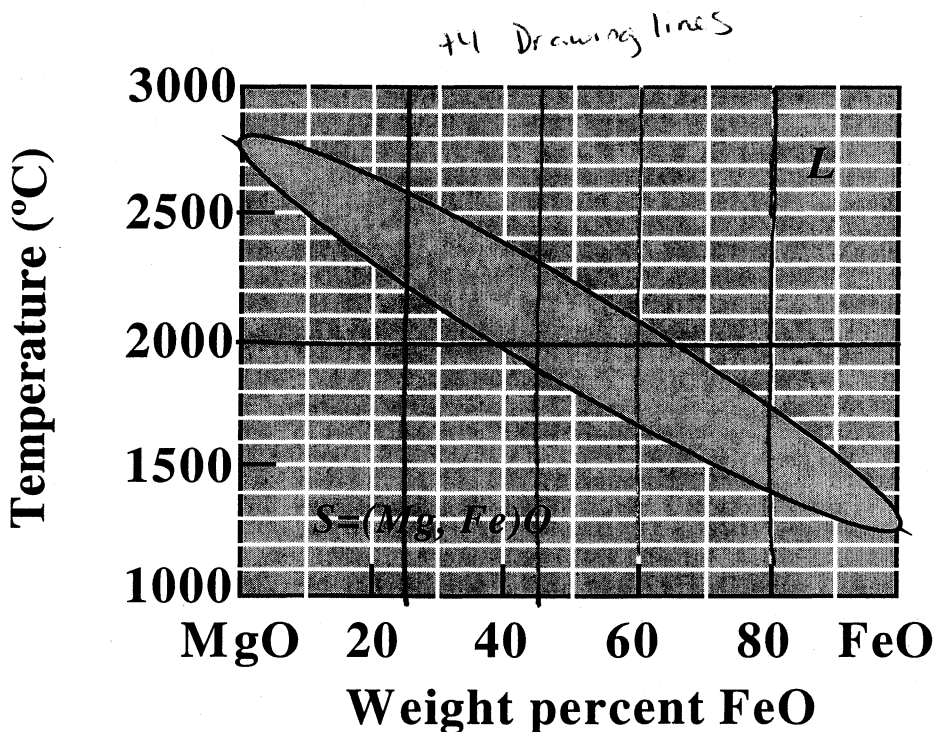
$$\%S = \frac{65-60}{65-39} \times 100\% = 19.2\% \quad +2$$

L: 65% FeO

$$\%L = \frac{60-39}{65-39} \times 100\% = 80.8\% \quad +2$$

(d) L: 80% FeO⁺¹

100% L⁺¹



10-5 (20pts) For equilibrium conditions and a Nb-80 wt% W alloy, determine (a) the liquidus temperature (L to L+S transition); (b) the solidus temperature (L+S to S transition); (c) the freezing range; (d) the composition of the first solid to form during solidification; (e) the composition of the last liquid to solidify; (f) the phase(s) present, the composition of the phase(s), and the amount of the phase(s) at 3000°C; and (g) the phase(s) present, the composition of the phase(s), and the amount of the phase(s) at 2800°C.

(a) Liquidus = 3120°C +2

(b) Solidus = 2930°C +2

(c) Freezing Range = 3120°C - 2930°C = 190°C +2

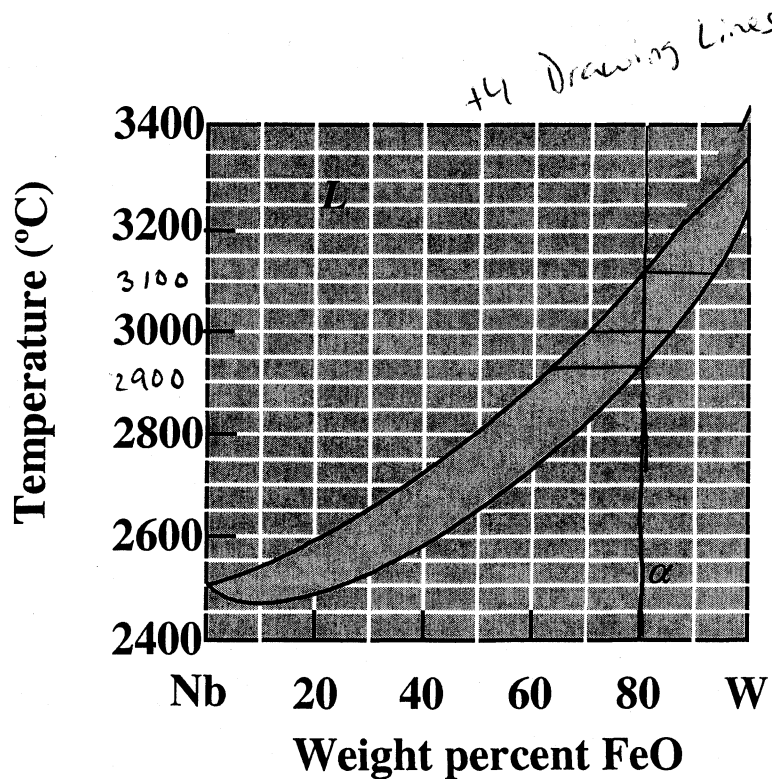
(d) First Solid: 94% W +2

(e) Last Liquid: 64% W +2

(f) L: 70% W %L = $\frac{85-80}{85-70} \times 100 = 33.3\%$ +2

α: 85% W %α = 66.7% +2

(g) α: 80% W 100% α +2



11-6 (20pts) Consider a Pb-15% Sn alloy. During solidification, determine (a) the composition of the first solid to form, (b) the liquidus temperature, solidus temperature, solvus temperature, and freezing range of the alloy, (c) the amounts and compositions of each phase at 260°C (this temp falls between liquidus and solidus temps at 15%), (d) the amounts and compositions of each phase at 183°C, and (e) the amounts and compositions of each phase at 25°C. (f) draw the isopleth that corresponds to the eutectic composition. Draw your lines used to estimate the answers on the figure.

(a) 8% Sn +2

(b) liquidus = 290°C Solidus = 240°C
 Solvus = 170°C Freezing Range = 50°C

(c) L: 30% Sn α: 12% Sn

$$\%L = \frac{15-12}{30-12} * 100\% = 17\% +2$$

$$\% \alpha = 83\% +2$$

(d) α: 15% Sn 100% α +2

(e) α: 2% Pb β: 100% Sn

$$\% \alpha = \frac{100-15}{100-2} * 100\% = 87\% +2$$

$$\% \beta = 13\% +2$$

