ENGR 1600 Materials Science for Engineers Section 7.
4th quiz, Wednesday, February 22, 2006.

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LAST NAME, FIRST NAME

1. An x-ray diffraction experiment, using x-rays (Cu-source) with a wavelength λ = 0.154056 nm is done on Si, which has a cubic (diamond) structure. The following peaks, labeled A-D were detected. (Formulas: $2d\sin\theta = \lambda$; $d = a/\sqrt{h^2 + k^2 + l^2}$)

A: $2\theta = 28.440$
B: $2\theta = 47.302$
C: $2\theta = 56.121$
D: $2\theta = 69.130$

(a) *(16 points)* Calculate the d-spacings corresponding to these four peaks.
(b) *(8 points)* The plane causing peak C is the (311). Calculate the lattice constant.
(c) *(16 points)* Can you figure out which planes correspond to the peaks A, B, and D? *(Hint: calculate for each peak the value of $(h^2+k^2+l^2)$, and then guess the Miller indices)*

2. Mechanical Properties-macroscopic
   (a) (*15 points*) Give technical names for (A), (B) and (C) and explain why the point (D) has a lower stress value than the point (C) in the Figure.
   (b) (*15 points*) An iron wire of length 1 m and diameter 1 mm was subjected to an uniaxial tensile stress. The wire stretched 0.1 % in length. Calculate the change in diameter when Poisson's ratio is 0.30.
   (c) (*10 points*) Among a metal, a ceramic and a polymer, which material is likely to have a low elastic modulus and high ductility?

$\nu = - \varepsilon_x/\varepsilon_z = - \varepsilon_y/\varepsilon_z$

3. Mechanical Properties-microscopic.

(a) (10) What is the dislocation? What role does it play in the mechanical properties of a solid?

(b) (10) On which crystallographic plane of FCC, can a slip (plastic deformation) take place most easily?

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1. An x-ray diffraction experiment, using x-rays (Cu-source) with a wavelength λ = 0.154056 nm is done on Si, which has a cubic (diamond) structure. The following peaks, labeled A-D were detected. (Formulas: $2d\sin\theta = \lambda$; $d = a/\sqrt{h^2 + k^2 + l^2}$)

A: 2θ = 28.440°
B: 2θ = 47.302°
C: 2θ = 56.121°
D: 2θ = 69.130°

(a) *(16 points)* Calculate the d-spacings corresponding to these four peaks.

A: θ = 14.220° sin θ = 0.2456 d = 0.154056/(2x0.2456) = 0.3136 nm
B: θ = 23.651° sin θ = 0.4012 d = 0.154056/(2x0.4012) = 0.1920 nm
C: θ = 28.061° sin θ = 0.4704 d = 0.154056/(2x0.4704) = 0.16375 nm
D: θ = 34.565° sin θ = 0.5673 d = 0.154056/(2x0.5673) = 0.1358 nm

(b) *(8 points)* The plane causing peak C is the (311). Calculate the lattice constant.

$0.16375\text{ nm} = a/\sqrt{3^2 + 1^2 + 1^2} = a/\sqrt{11}$; $a = 0.16375\sqrt{11} = 0.54310$ nm

(c) *(16 points)* Can you figure out which planes correspond to the peaks A, B, and D? *(Hint: calculate for each peak the value of $(h^2+k^2+l^2)$, and then guess the Miller indices)*

$a/d = \sqrt{h^2 + k^2 + l^2}$

A: $h^2 + k^2 + l^2 = (1.7318)2 = 2.999 \approx 3$ (111)
B: $h^2 + k^2 + l^2 = (2.8286)^2 = 8.001 \approx 8$ (220)
D: $h^2 + k^2 + l^2 = (3.9993)^2 = 15.995 \approx 16$ (400)

2. Mechanical Properties

(a) (*15 points*) Give technical names for (A), (B) and (C) and explain why the point (D) has a lower stress value than the point (C) in the Figure.

(A) Young's modulus
(B) Yield strength
(C) Ultimate tensile strength
(D) Because of the reduction of the cross-sectional area due to necking.

(b) (*15 points*) An iron wire of length 1 m and diameter 1 mm was subjected to an uniaxial tensile stress. The wire stretched 0.1 % in length. Calculate the change in diameter when Poisson's ratio is 0.30.

The length stretched by 0.001 m or the strain $\varepsilon_z = 0.001$

$\nu = - \varepsilon_x / \varepsilon_z = - \varepsilon_y / \varepsilon_z = 0.3$

$\varepsilon_x = - 0.3 \times 0.001 = \Delta d/d$ where d is the diameter.

$\Delta d = - d \times 0.0003 = - 0.0003$ mm.$= -0.3 \mu m$

(c) (10 *points*) Among a metal, a ceramic and a polymer, which material is likely to have a low elastic modulus and high ductility?

polymer

3. Mechanical Properties-microscopic.

(a) (10) What is the dislocation? What role does it play in the mechanical properties of a solid?

The boundary line between the slipped portion and unslipped portion.

It makes the plastic deformation (slip) easier.

(b) (10) On which crystallographic plane of FCC, can a slip (plastic deformation) take place most easily?

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