State University of New York
University at Buffalo
Department of Mechanical & Aerospace Engineering

MAE 589 **Prof. D.D.L. Chung**

Test No. 1
Closed Book

This test consists of 5 problems on 2 pages. Answer all questions in the blue book provided.

Problem 1 (20%)

A two-dimensional lattice is defined by the fundamental translation vectors

$$\vec{a}_1 = a\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$$

$$\vec{a}_2 = a(0,1)$$

(2%) (a) Sketch the vectors $\vec{a}_1$ and $\vec{a}_2$. Indicate the x and y directions on the sketch.

(2%) (b) Give the magnitudes of $\vec{a}_1$ and $\vec{a}_2$.

(3%) (c) Calculate the area of the unit cell in real space by using the cross product

$$\Omega_a = \vec{a}_1 \times \vec{a}_2$$

$$= \begin{vmatrix} a_{1x} & a_{1y} \\ a_{2x} & a_{2y} \end{vmatrix}$$

$$= a_{1x}a_{2y} - a_{1y}a_{2x}$$

(5%) (d) Obtain the fundamental translation vectors $\vec{b}_1$ and $\vec{b}_2$ for the reciprocal lattice.

(2%) (e) Sketch the vectors $\vec{b}_1$ and $\vec{b}_2$. Indicate the x and y directions on the sketch.

(3%) (f) Give the magnitudes of $\vec{b}_1$ and $\vec{b}_2$.

(3%) (g) Calculate the area of the unit cell in reciprocal space.

Problem 2 (20%)

Derive the expression for the distance between adjacent direct lattice planes perpendicular to the same reciprocal lattice vector of the orthorhombic system.

Problem 3 (20%)

Derive the structure factor of an FCC crystal and give the conditions for constructive interference. Use the cubic unit cell.

$$\underline{A}_s\left(-\vec{G}_m\right)=\sum_j \underline{S}_j \underline{A} e^{-i\vec{G}_m\cdot\vec{\rho}_j}$$

Problem 4 (20%)

Sketch the 100 electron diffraction pattern for an FCC crystal. Index the diffraction spots with the corresponding Miller indices.

Problem 5 (20%)

(4%) (a) How can the crystallite size be determined by x-ray diffraction?

(4%) (b) Describe an experimental method for distinguishing between amorphous carbon that predominantly involves sp^2 hybridization and amorphous carbon that predominantly involves sp^3 hybridization.

(4%) (c) Describe an experimental method for measuring the contact electrical resistivity between a single carbon fiber and cement.

(4%) (d) X-ray photoelectron spectroscopy can analyze the chemistry of only the surface of a material. Why?

(4%) (e) How can information on the crystallographic texture (preferred orientation) be obtained by x-ray diffraction?