State University of New York
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MAE 589 Diffraction, Microscopy and Spectroscopy Techniques
Professor D.D.L. Chung **April 1, 2004**

Test No. 2
Closed Book

This test consists of 4 problems on 3 pages. Answer all questions in the blue book provided.

Problem 1 (15%)

Briefly explain each of the following techniques by giving the type of material structural information that can be obtained.

(3%) (a) Electron energy loss spectroscopy

(3%) (b) Dark-field transmission electron microscopy

(3%) (c) Laue method of x-ray diffraction

(3%) (d) Pole figure determination in relation to x-ray diffraction

(3%) (e) X-ray spectroscopy in relation to scanning electron microscopy

Problem 2 (42%)

(3%) (a) Give the main advantage of scanning electron microscopy using back-scattered electrons compared to scanning electron microscopy using secondary electrons.

(3%) (b) What is the cause of the grey background around the central spot of an electron diffraction pattern?

(3%) (c) Give the main advantage of the back-reflection Laue method compared to the transmission Laue method.

(3%) (d) Give the main advantage of transmission electron microscopy over scanning electron microscopy.

(3%) (e) Explain why there is rotation of a TEM image as the magnification in increased.

(3%) (f) How can the CuK_β radiation from a Cu x-ray tube be removed so that the CuK_α radiation alone is available for use in x-ray diffraction?

(3%) (g) Why is a TEM with a high acceleration voltage advantageous compared to one with a low acceleration voltage?

(3%) (h) What is the cause of Kikuchi lines in a TEM image?

(3%) (i) What is the function of the objective aperture of a TEM?

(3%) (j) What is the function of the condenser aperture of a TEM?

(3%) (k) What is the function of the projector lens of a TEM?

(3%) (l) Auger electron spectroscopy cannot be performed in a typical scanning electron microscope. Why?

(3%) (m) Why is mechanical polishing typically performed for a specimen for optical microscopy but not for a specimen for scanning electron microscopy?

(3%) (n) Why are streaks rather than spots observed in a RHEED pattern of a thin film on a substrate?

Problem 3 (30%)

(5%) (a) Sketch the (111) pole figure of an FCC material that exhibits a (100) fiber texture.

(5%) (b) Sketch the (111) pole figure of an FCC material that exhibits a (100) cube texture.

(5%) (c) Sketch the electron diffraction pattern of polycrystalline FCC material with no preferred orientation. Index the pattern.

(5%) (d) Sketch the electron diffraction pattern of an FCC single crystal in the (100) orientation. Index the pattern.

(5%) (e) Sketch the x-ray diffraction pattern of an FCC powder with no preferred orientation. Index the pattern.

(5%) (f) Sketch the x-ray diffraction pattern of an FCC single crystal with a (111) orientation. Index the pattern.

Problem 4 (13%)

A transmission Laue pattern is made of an aluminum crystal with 40 kV tungsten radiation. The film is 5 cm from the crystal. How close to the center of the pattern can Laue spots be formed by reflecting planes of maximum spacing, namely (111)? The lattice parameter of aluminum is 4.0497 Å.

Hint:

$$\lambda_{\mathrm{SWL}} = \frac{12.4 \times 10^3 \ \mathring{\mathrm{A}}}{\text{voltage}}$$