UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2011/2012

January 2012

EBB 511/3 – Materials Characterisation Techniques

Duration : 3 hours

Please ensure that this examination paper contains FIVE printed pages before you begin the examination.

This paper consists of SEVEN questions.

Instruction: Answer **FIVE** questions. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.

The answers to all questions must start on a new page.

All questions must be answered in English.

1. [a] Based on your understanding on structure factor derive the following equation for diamond cubic structure

$$F = \left[f_c + f_c e^{\left[\pi/2\right] j(h+k+\ell)} \right] \left[1 + e^{\pi i(h+k)} + e^{\pi i[h+\ell]} + e^{\pi(\ell+k)} \right]$$

and hence deduce the selection rules.

F = structure factor
f = scattering factor
h,k ℓ , = miller indices

(50 marks)

[b] Given in Figure 1 is the x-ray diffraction pattern of chromium and their corresponding 2θ values. Index all the peaks and identify the Bravais lattice of chromium. Use the analytical method to arrive at your answer.

Figure 1

(50 marks)

2. [a] Briefly describe the characteristic information that can be assessed by electron microscopy.

(20 marks)

[b] What are the various electron – specimen interactions when a high-energy electron beam impinge on a specimen. Identify 3 most commonly used in SEM analysis and briefly describe their importance.

(40 marks)

[c] Are secondary electrons or backscattered electron to be preferred for imaging and analyzing variations in the local chemical distribution on a polished sample containing aluminum and gold. Give your reasons. Given that the atomic number of gold and aluminum are 79 and 13 respectively, calculate the natural contrast in a backscattered image.

(40 marks)

3. [a] Distinguish between mass-thickness contrast and diffraction contrast in transmission electron microscopy.

(40 marks)

[b] Write short notes on the following with respect to TEM:

(i) Spherical Aberration.

(ii) Chromatic Aberration.

(iii) Lens Astigmation.

(30 marks)

[c] With the aid of a diagram, describe the difference between bright-field an dark-field imaging modes.

(30 marks)

4. [a] In scanning probe microscopes (SPM), the probe and the sample form a single system. What physical and mechanical properties of the probe are necessary to ensure that the properties and structure of the probe do not affect the results.

(50 marks)

[b] Atomic Force Microscopy (AFM) is a very versatile technique for measuring surface topography. Describe the principle and operation of a n AFM. What is the advantage(s) and disadvantage(s) of contact mode.

(50 marks)

5. [a] Explain the basic principle of FTIR. Name the three (3) techniques available in IR spectroscopy for surface analysis. Briefly describe one that can analysis surface in the range of ~ 0.5 to 3 μm.

(50 marks)

[b] By using appropriate diagram explain the of working of a Michelson interferometer.

(30 marks)

[c] What form of samples can be analysis by Scanning Tunneling Microscope (STM) and what is/are its limitation?

(20 marks)

6. [a] Outline the principle difference between Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC). Describe briefly when you have to use DSC instead DTA and when your have to used both.

(30 marks)

[b] Outline the principle of thermogravimetry (TG) and descibe the difference between Thermogravimetry (TG) and TG-FTIR. What type of sample you choose to use TG-FTIR instead of TG alone.

(40 marks)

[c] Describe the advantages using TG/DTG–DTA in your research analysis. State factors that influence the DTA curve.

(30 marks)

7. [a] Outline the principle Laser Flash Thermal Constant Analyzer. What type of information you will obtain from this analyzer? Describe briefly how could your design this analyzer.

(30 marks)

[b] When your are required to measure the precision measurement of thermal expansion of low expansion materials such as: carbon, graphite, composites and low expansion glass, which thermal analysis instrument will you choose. Describe briefly with the reasons why you have chosen the very instrument.

(30 marks)

[c] Describe briefly the principle difference between Dynamic Mechanical Analysis (DMA) and Thermomechanical Analysis (TMA). If you are given a polymer material to be used as a component in flasks shaker instrument. Which thermal analyzer instrument will you choose and explain the reasons of your choice.

(40 marks)

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