
UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

EBB 511/3 – Materials Characterisation Techniques

Duration : 3 hours

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

This paper consists of SEVEN questions.

Instruction: Answer **FIVE** questions. If 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] The secondary electron image is the most commonly used for routine examination in the scanning electron microscope. Why?
(20 marks)
- [b] What signals are generated from a solid sample by an incident beam of high energy electrons? Which signals are used in TEM, and which are used in SEM? How does the resolution in SEM micrograph depend on the type of signal that is collected?
(30 marks)
- [c] Are secondary electrons or backscattered electrons to be preferred for imaging and analyzing variations in local chemical distribution on a polished sample containing aluminum and gold. Give your reasons.
(30 marks)
- [d] Draw a schematic diagram of a conventional SEM and briefly describe the role of each component.
(20 marks)
2. [a] Briefly explain what do you understand by the term structure factor in the context of x-ray diffraction technique.
(30 marks)
- [b] Diamond has an FCC structure, but with additional forbidden reflections. Determine the first three additional forbidden reflections and explain their origin.
(30 marks)

- [c] Given in Figure 1 is the x-ray diffraction pattern of chromium. Index the all the peaks and identify the Bravais lattice of Chromium. Use the analytical method for your calculation.

Figure 1

(40 marks)

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3. [a] Electromagnetic lens systems employ very small angular apertures, primarily because of their large spherical aberration. Explain why the spherical aberration and other lens defects limit the resolving power of a transmission electron microscope.
(40 marks)
- [b] What are the three primary contrast mechanisms in TEM and describe any TWO (2) of them.
(40 marks)
- [c] Describe the difference between bright field and dark field imaging modes.
(20 marks)
4. [a] Explain the basic principle of Infra Red (IR) spectroscopy. What is the difference between IR and FTIR spectrometer.
(50 marks)
- [b] Write briefly on THREE (3) applications of FTIR.
(50 marks)

5. [a] Explain the underpinning principles of Atomic Force Microscopy (AFM). Use appropriate diagram to illustrate your answer. (30 marks)
- [b] Scanning Probe Microscopy (SPM) consists of a family of microscopy that measures the morphology and surface properties on atomic scale. Scanning Tunneling Microscope (STM) is one of them. Give a schematic diagram of an STM. (30 marks)
- [c] Describe the working principle of an STM. The explanation should include the basic principles such as tunneling effect, tip-sample distance and how images are produced. (40 marks)
6. [a] Schematically illustrate the method to measure the inflection temperature in a TG plot. (20 marks)
- [b] Mathematically describe the procedure to calculate the rate of mass change involved in a TG experiment. (30 marks)
- [c] Explain in brief the basic requirements that must be fulfilled while designing the furnace for a TG-DTA set up. (30 marks)
- [d] What are the effects of heating rate and sample mass on the results obtained from a TG-DTA experiment? (20 marks)

7. [a] Consider the reduction reaction of pure liquid FeO by carbon supplied through a carbon saturated liquid iron bath at three different constant temperatures. Assume that the reaction follows a first order reaction rate model. Also assume that the change in weight of the sample is only through the evolution of carbon monoxide (CO). Illustrate the steps involved to calculate the reaction rate and the activation energy by employing the integral method of kinetic analysis.
- (40 marks)
- [b] Outline the mechanism of a LASER dilatometer and mention its advantages over a conventional dilatometer.
- (30 marks)
- [c] Explain the importance of thermal conductivity of the sample and crucible and the role it plays on the results from a TG-DTA experiment.
- (30 marks)