

SULIT



KSCP Examination
2024/2025 Academic Session

September 2025

EBB511 – Materials Characterization Techniques

Duration : 2 hours

Please check that this examination paper consists of SIX (6) pages of printed material before you begin the examination.

Instructions: Answer **FOUR (4)** questions. **Part A is COMPULSORY.** Answer **ONE (1) questions from Part B.** All questions carry the same marks.

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

All questions must be answered in English.

Should any candidate be caught cheating or in possession of materials not authorised to be brought into the Examination Hall during the examination, appropriate disciplinary action will be taken against the candidate concerned. In the event a candidate is found guilty of cheating, he/she can be expelled from the University.

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PART A

- (1). Fourier Transform Infrared (FTIR) spectroscopy can be used to observe the presence of chemical bonding in molecules in a sample. Answer all questions below

- (a). You are given an FTIR spectrum as below. Explain steps that need to be done in order to analyze the FTIR spectrum.

(10 marks)

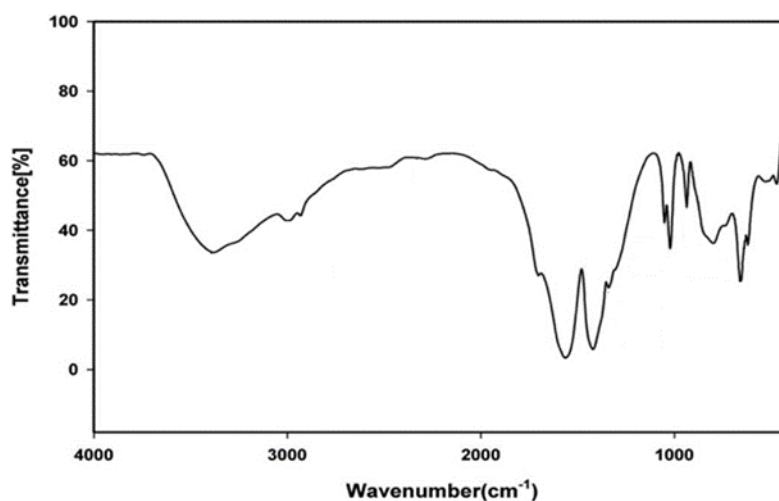


Figure 1: FTIR spectrum of an unknown sample

- (b). With the help of an appropriate diagram, explain working principle of Fourier Transform Infrared (FTIR) spectroscopy.

(10 marks)

- (c). With the help of appropriate diagrams, describe **FOUR (4)** types of vibration in Fourier Transform Infrared (FTIR) spectroscopy.

(5 marks)

- (2). (a). Thermogravimetric Analysis (TGA) provides three different modes to analyse the sample. Discuss each type of TGA mode and explain your answer using suitable mass versus time/temperature curves to illustrate the differences.

(8 marks)

- (b). Weight loss profile during TGA measurement is strongly influenced by the heating rate. Using a suitable diagram of weight loss against temperature, illustrate and explain clearly the effect of increasing heating rate on a typical weight loss profile

(8 marks)

- (c). Consistency of specimen size in Differential Scanning Calorimetry (DSC) is crucial in getting an accurate result. Discuss this matter and illustrate the effect using suitable heat flow versus temperature curve.

(9 marks)

- (3). (a). X-ray photoelectron spectroscopy (XPS) is a surface-sensitive quantitative spectroscopic technique that measures the elemental composition, empirical formula, chemical state, and electronic state of the elements that exist within a material. Relate how a three-step model is used to understand the photoemission process involved in XPS analysis.

(15 marks)

- (b). Auger electron spectroscopy (AES) analysis is an analytical technique used specifically in determining the depth profiling of the material surfaces. Therefore, discuss the depth profiling process involved in AES analysis. You need to include an appropriate schematic diagram to support your discussion.

(10 marks)

PART B

(4). ZnO film has been deposited on the SiC substrate for sensor application. Answer the following questions:

- (a). You need to observe the morphology of ZnO thin film using a transmission electron microscopy. Explain sample preparation for this sample for Transmission Electron Microscope (TEM) analysis. What are information you can obtain from TEM and High Resolution TEM (HRTEM) of this sample?

(8 marks)

- (b). With the help of an appropriate diagram, explain the working principle of scanning electron microscope (SEM). What is the information you can obtain for SEM and Energy Dispersive Xray Spectroscopy of ZnO thin film on a SiC substrate?

(10 marks)

- (c). Imaging of ZnO thin film on a SiC substrate can be done using an Atomic Force Microscope (AFM) and Scanning Electron Microscope. Compare the differences of these two methods.

(7 marks)

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- (5). (a). Describe the principle of Dynamic Mechanical Thermal Analysis (DMTA). Explain what DMTA could measure for a material and how the molecular structure of the material could be related to the properties using information obtained.

(9 marks)

- (b). Dynamic Mechanical Analysis (DMA) is a thermal analysis technique that measures the mechanical properties of materials as they are deformed under periodic stress. One of typical application of DMA is to determine the glass transition of polymers from tangent modulus and tan delta ($\tan \delta$). Explain with a suitable example, how the measurement is taken.

(8 marks)

- (c). Describe and comment on four major artefacts in Thermogravimetric Analysis (TGA) measurement. Suggest and propose how these artefacts could be minimised.

(8 marks)

- (6). (a). **Figure 2** shows the X-Ray Diffraction (XRD) patterns of cerium oxide (CeO_2) sintered at different sintering temperatures. Discuss the results that might be obtained based on the XRD patterns in **Figure 2**.

(13 marks)

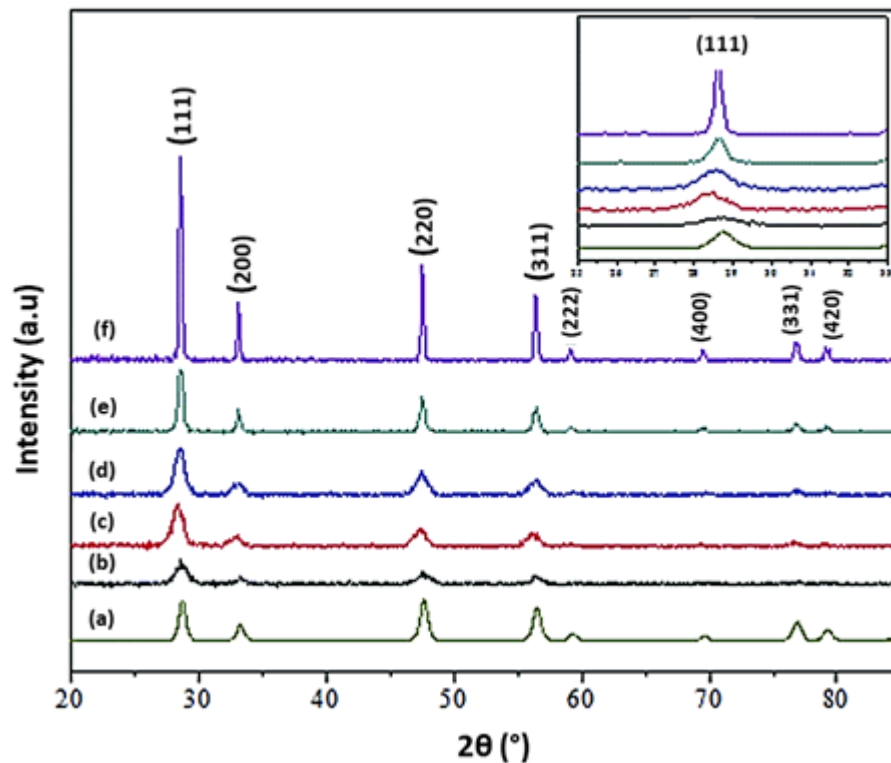


Figure 2: XRD patterns of (a) Cerium oxide (control) and cerium oxide sintered at (b) 500°C, (c) 600°C, (d) 700°C, (e) 800°C and (f) 900°C.

- (b). X-Ray Diffraction (XRD) analysis can be used to determine an unknown compositional phase presence in the ceramic powder specimen. Describe the expected properties that you can obtain from this phase analysis. Also, elaborate on the factors that should be considered during sample preparation when performing XRD analysis using this specimen.

(12 marks)