UNIVERSITY OF GHANA

SCHOOL OF ENGINEERING SCIENCES

BSc (ENG) MATERIALS SCIENCE AND ENGINEERING

END OF FIRST SEMESTER EXAMINATIONS: 2014/2015

MTEN 309 MATERIALS ANALYSIS TECHNIQUES (3 CREDITS)

TIME ALLOWED: 2 HRS 30 Mins

Answer all Questions

1.

a) The Auger electron spectroscopy (AES) is a nondestructive core-level electron spectroscopy for semi-quantitative determination of the elemental composition of surfaces, thin films and interfaces. With the aid of a diagram, explain the KL2L3 Auger transitions showing clearly the ionization, relaxation and emission steps involved in the Auger process

b) Both X-ray photoelectron spectroscopy (XPS) and the Auger electron spectroscopy (AES) analyses the energy of electrons emitted from the surface of materials. State the difference between these two instruments in terms of the mode of the electron emission processes.

c) During an XPS measurement, an x-ray radiation from a Mg Kα source strikes a sample resulting in the emission of photoelectrons. Calculate the kinetic energy of a photoelectron emitted from the surface of the sample if the binding energy of the atomic orbital from which the electron originates is 800 eV. (Mg K_α radiation = 1253.6 eV).

d) What is the approximate kinetic energy of an Auger electron ejected when an electron beam strikes a sample surface with A, B and C energy levels? The binding energies of electrons in the A, B and C levels are 1560, 118 and 73 eV respectively.

(20 marks)

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2.

a) Figure 1 below is an X-ray diffraction (XRD) pattern of an annealed zinc oxide thin film on a glass substrate prepared from a solution growth method at the Materials Science & Engineering Deapartment of the University of Ghana. Assuming the broadening of the diffracted peaks is due to the grain sizes (dimensionless shape factor is 0.9), calculate the grain sizes oriented in the (100) and (002) directions using the Scherrer relation. The (100) and (002) peaks are diffracted at $2\theta = 31.8°$ and $34.5°$ where θ is the Bragg angle and their full width at half maxima (FWHM) are 0.5° and 0.4° respectively. The wavelength of the X-ray radiation used is 0.154 nm.

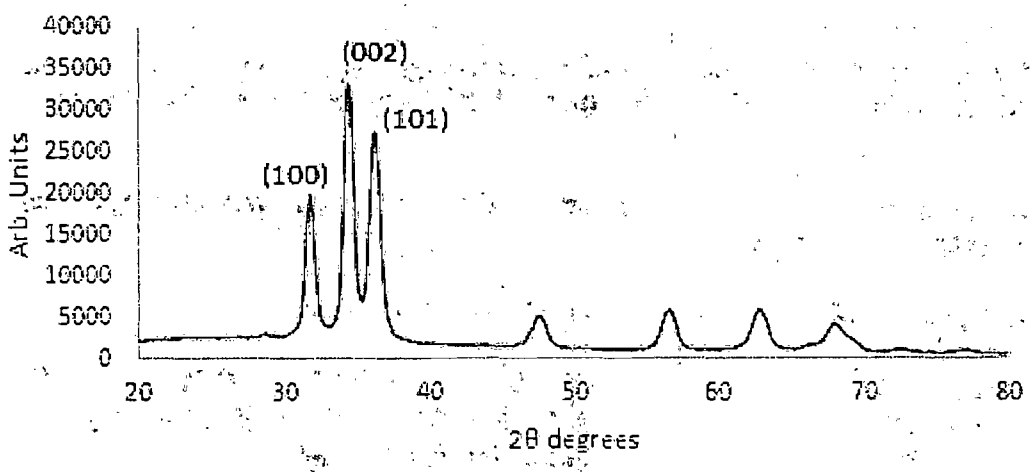

Figure 1.

b) Draw a schematic diagram of an Atomic Force Microscope (AFM) showing the essental parts of the instrument.

c) Describe the contact and non-contact modes of the AFM during the measurement of the surface roughness of a thin film.

d) In their operational mode, state the main difference between an energy dispersive spectrometry (EDS) and wavelength dispersive spectrometry (WDS).

(20 marks)

3.

a) Explain how a scanning electron microscope (SEM) in a secondary electron (SE) and backscattered electron (BE) modes can be used to form the image of a sample.

b) Describe briefly with the aid of a diagram the formation of the different signals generated when a convergent beam of electrons is made to strike a sample during an electron probe microanalysis (EPMA).

c) Write down two (2) advantages and (2) disadvantages of the secondary ion mass spectroscope (SIMS).

d) During a SIMS operation, an ion beam is constrained to move in a magnetic field with an accelerating voltage of 40 volts. If the magnetic field strength is 12 Wb / m^2 and its radius of curvature is 0.4 m^2, calculate the mass to charge ratio of the ion beam.

(20 marks)

4.

a) The magnification of the objective lens of a compound microscope is 40X. If the magnification of the ocular lens is 10X, calculate the total magnification of the compound microscope.

b) What is thermal analysis? Write down three (3) thermal analytic methods and their corresponding measurable properties.

c) State three (3) experimental methods for determining phase diagrams.

d) The diffraction pattern of a copper metal was measured with x-ray radiation of wavelength 1.315Å. The first order Bragg diffraction peak was found at an angle 2θ at 50.5 degrees. Calculate the spacing between the diffracting planes in the copper metal.

(20 marks)