Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
400 level 1st Semester Examination – May / July 2017
SCT 446-2 Semiconductors and Nano Materials

Uva Wellassa University

Instructions to candidates
Duration: Two (02) hours
Number of questions: Four (04)
Question to be answered: Four (04)
Mark allocated: 400
Symbols contain usual meaning

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1. i. Semiconductors can be classified into two major groups by considering purity of the material. What are they?

   ii. What do you mean by "doping"?

   iii. What are the two types of sub groups of semiconductors formed by doping?

   iv. What are the minority carriers in n-type semiconductor?

   v. Calculate the minority carrier concentration in a piece of silicon that has been doped with 5×10^{16} acceptor atoms per cm^3 ? (Intrinsic carrier concentration of silicon at room temperature is $1.4 \times 10^{10}\ cm^{-3}$.)

   vi. Donor concentration and acceptor concentration of Gallium is $5 \times 10^{13}\ cm^{-3}$ and zero. Determine the electron and hole concentrations of Gallium for a given doping conditions at thermal equilibrium. Intrinsic carrier concentration is $2.4 \times 10^{13}\ cm^{-3}$ at T= 300K.

   vii. What do you mean by the term "indirect band" gap?

   viii. Write an equation for variation of the band gap of a semiconductor with doping concentration and label all terms in the equation.

   ix. Prove that the doping concentration of Silicon (ε_r =11.9) must be greater than $10^{18}\ cm^{-3}$ to observe significant change of the band gap of Silicon.

   x. What do you mean by the "Fermi level" of a semiconductor?

(100 marks)

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2. i. What do you mean by effective mass of an electron?

ii. Write an equation for the intrinsic carrier concentration in the Conduction band (n_i) for any temperature and non-degenerate semiconductor from the terms of m_e, E_F, E_c, h, K and T.

iii. Write an equation for the effective density state of the Conduction band (N_C) from the terms of m_e, h, K and T.

iv. Prove that $E_F = E_C + KTln\left(\frac{n_i}{N_C}\right)$ from the results of section ii and iii in the same question.

v. Write similar type of equation for the Fermi level of semiconductor (E_F) from the terms of E_V, p_i, K, N_V and T.

vi. Proove that the intrinsic carrier concentration (n_i) at equilibrium

$$n_i = \sqrt{N_V N_C} e^{\frac{E_g}{2KT}}$$

vii. A Si sample is doped with boron atoms with the concentration of 10^{16} molecules/cm^3.

a. What is the electron concentration in the Conduction band of the sample?

(Intrinsic electron concentration at 300K is 1.5×10^{10} molecules/cm^3)

b. Where is the Fermi level lies related to intrinsic Fermi level, at 300K?

(100 marks)

3. i. Define the term fullerene.

ii. Name sub groups of Fullerenes.

iii. Write four properties of carbon bucky balls.

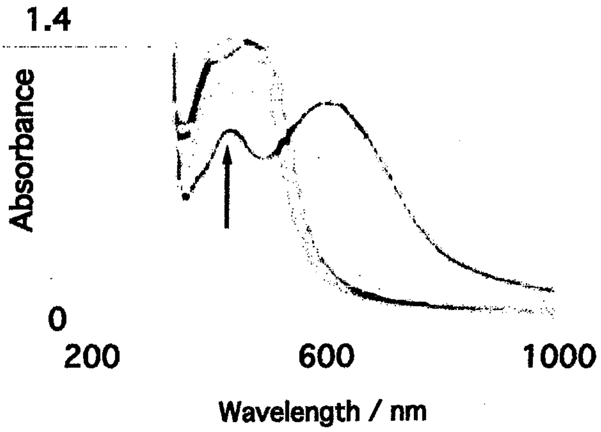
iv. What is the importance of "Lycurgus cup" in nano-technology?

v. What is the colour of "Lycurgus cup" under reflected light?

vi. What is the colour of "Lycurgus cup" under transmitted light?

vii. Explain why "Lycurgus cup" shows two different colors under reflected and transmitted light.

viii. The absorption spectra for silver solutions are shown in the diagram.



What is the peculiar property of the solution that you can expect by the peak indicated by an arrow?

ix. What are the two basic methods to prepare nano-structures?

x. Write two examples for each method.

(100 marks)

4. i. Write two advantages of electron beam lithography technique in the preparation of integrated circuits.

ii. Write four methods can be used to prepare thin films.

iii. Write main disadvantage of Langmuir-Blodgett technique in preparation of thin films.

iv. Write a characteristic property of amphiphilic molecules.

v. What should be the substrate, if you want to deposit several mono-layers of fatty acid by the Langmuir-Blodgett technique?

vi. Write two types of aggregations that could be observed in dye molecules.

vii. What are the three types of electron beam microscope?

viii. What are the types of carbon nano-tubes?

ix. What are the three types of single wall carbon nano-tubes?

ix. Why we have to take special care while working with nano-powders. Give four reasons.

(100 marks)