THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

FINAL EXAMINATION - 2012/2013

ECX5239 – PHYSICAL ELECTRONICS **(Closed Book)**

THIS PAPER HAS TWO SECTIONS. ANSWER FIVE QUESTIONS SELECTING ATLEAST TWO QUESTIONS FROM EACH SECTION.

ADHERE TO THE USUAL NOTATIONS.

Date 14.08.2013 ***Time: 9:30-12:30 hrs.***

$q_e = 1.902 \times 10^{-19}C$, $m_e = 9.1 \times 10^{-31}kg$, $m_h = 1.08m_e$, $\tau = 2.35 \times 10^{-14}s$, $k = 1.38 \times 10^{-23}JK^{-1}$, $h = 6.63 \times 10^{-34}Js$, $C = 3 \times 10^8\ ms^{-1}$, $E_{g,Si} = 1.1eV$

SECTION A

Q1.

(a) Considering the atomic structures, clearly and completely explain why the metals, semiconductors and insulators conduct differently at room temperatures. **(6Marks)**

(b) Draw the resistivity vs. temperature graphs for metals, semiconductors and insulators. **(6Marks)**

(c) A pure Si sample has been doped with 10^{12} Boron atoms per cubic centimeter. The acceptor energy level for B in Si is $0.045eV$ above the valence band edge energy. Calculate the conductivity of this p-type sample at room temperature. Further, estimate the temperature above which the sample exhibits intrinsic semiconductor properties. $N_v = 8 \times 10^{24}\ m^{-3}$ **(8Marks)**

Q2.

(a) Differentiate the intrinsic and extrinsic semiconductors. Compare their conductivity changes with temperature. **(6Marks)**

(b) What is compensation doping? Why is it needed? **(4Marks)**

(c) What is Fermi energy level? Draw diagrams to show the Fermi level in an n-type and a p-type semiconductor. **(4Marks)**

(d) An n-type Si wafer is doped uniformly with 10^{16} Antimony atoms per cubic centimeter. Calculate the Fermi energy level with respect to that of intrinsic Si at room temperature. $N_c = 1.1 \times 10^{25}m^{-3}$ **(6Marks)**

Q3.

(a) Clearly and completely explain the Hall Effect. **(8Marks)**

(b) Compare the Hall Effect in metals and in semiconductors reasoning for the differences. **(6Marks)**

(c) At 27^0C, a pure Si sample has electron and hole concentrations each 1.5×10^{10} per cubic centimeter. Electron and hole drift mobilities 1350 and 450 $cm^2V^{-1}s^{-1}$ respectively. Calculate the Hall coefficient R_H. **(6Marks)**

Q4.

(a) Explain how different bands are created in the energy diagrams of solids. Stress how these bands have continuous energy spectrums rather than many discrete energy levels. **(7Marks)**

(b) Use energy band diagrams to explain the differences in conductivity in metals, semiconductors and insulators. Show the Fermi levels in the same diagrams. **(7Marks)**

(c) Diamond is with an energy gap $E_g = 5.6eV$. Estimate the fraction of electrons which is in the conduction band at room temperature. $N_c = 2 \times 10^{24} m^{-3}$ **(6Marks)**

SECTION B

Q5.

(a) Explain the operation of a diode using the atomic level behavior under the three bias conditions. **(8Marks)**

(a) What are the special features of a Schotkey diode? What physical construction has given it these characteristics? **(6Marks)**

(b) Explain the operation of Schotkey diode with the help of energy band diagrams. **(6Marks)**

Q6.

(a) Describe the special design features in a bipolar junction transistor. (You should state the doping concentrations and thickness of different sections in the BJT) **(6Marks)**

(b) Explain the operation of a npn BJT at an atomic level highlighting how the amplification is achieved. **(8Marks)**

(c) Draw a graph to show the minority carrier distribution in a npn transistor biased in the active region. **(6Marks)**

Q7.

(a)

i. Completely explain the operation of an n-channel MOSFET. **(5Marks)**

ii. Deduce I_D Vs. V_{DS} graph for the n-channel MOSFET from your answer to (a). **(5Marks)**

iii. What is *pinch off* in JFET? **(4Marks)**

(b) Briefly explain the hazards which are associated with the semiconductor industry. **(6Marks)**

Q8.

(a) LED is a special diode which uses *direct band gap* semiconductor materials. Explain what is meant by *direct band gap* materials. **(4Marks)**

(b) Completely explain how light is emitted in a LED with the help of energy band diagrams. **(6Marks)**

(c) In GaAs the most probable energy level for an electron is $\frac{kT}{2}$ above the conduction band edge. Similarly the most probable level for a hole is $\frac{kT}{2}$ below the valence band edge. The energy gap for GaAs is 1.4eV. Hence calculate the emitted frequency of a GaAs LED at 27^0C. **(6Marks)**

(d) Plot the Emitted frequency Vs. Temperature curve for the above LED. **(4Marks)**