Techno India NJR Institute of Technology

Course File

Session 2020-21

Electronic Devices (3EC4-07)

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For Techno India NJR Institute of Technology
पंकज पोरवाल
Dr. Pankaj Kumar Porwal
(Principal)

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

II Year - III Semester: B.Tech. (Electronics & Communication Engineering)

3EC4-07: Electronic Devices

4 Credits | **Max. Marks: 200 (IA:40, ETE:160)**

3L:1T:0P | **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Introduction to Semiconductor Physics: Introduction, Energy band gap structures of semiconductors, Classifications of semiconductors, Degenerate and non-degenerate semiconductors, Direct and indirect band gap semiconductors, Electronic properties of Silicon, Germanium, Compound Semiconductor, Gallium Arsenide, Gallium phosphide & Silicon carbide, Variation of semiconductor conductivity, resistance and bandgap with temperature and doping. Thermistors, Sensitors.	6
2	Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams. Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; sheet resistance, design of resistors.	6
3	Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode.	8
4	Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model, MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor, LED, photodiode and solar cell.	11
5	Integrated circuit fabrication process: oxidation, diffusion, ion implantation, Photolithography, etching, chemical vapor deposition, sputtering, twin-tub CMOS process.	9
	Total	40

Course Overview:

The course is designed to teach the physics behind electronic device operations and also prepare students for advanced courses in solid state and quantum electronics. The course is intended to increase knowledge gained in undergraduate level courses in electronic devices. The main emphasis is on the fundamental physics behind device operation. Topics include the background physics and the basic principles of electronic device operation with emphasis on bipolar transistors.

Course Outcomes:

CO.NO.	Cognitive Level	Course Outcome
1	Knowledge	Understanding the semiconductor physics of the intrinsic, P and N materials.
2	Knowledge	Understanding the characteristics of current flow in a bipolar junction transistor and MOSFET.
3	Application	Understand and Apply the mathematical models of semiconductor junctions and MOS transistors for circuits and systems.
4	Analysis	Analyze the characteristics of different electronic devices such as Amplifiers, LEDs, Solar cells, etc.
5	Knowledge	Theoretical as well as experimental understanding of Integrated circuit fabrication.

Prerequisites:

1. Knowledge of semiconductor Physics

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific					Domain Independent						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	0	2	1	1	0	0	0	0	0	0
CO2	3	2	1	0	0	2	0	0	0	0	0	0
CO3	2	1	0	2	0	1	2	0	0	0	0	0
CO4	3	1	1	0	0	0	2	0	0	0	0	0
CO5	3	1	1	1	1	0	0	0	0	0	0	2
1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High)												

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Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	**INTRODUCTION TO SEMICONDUCTOR PHYSICS:INTRODUCTION**
2	1	Energy band gap structures of semiconductors
3	1	Classifications of semiconductors
4	1	Degenerate and non-degenerate semiconductors
5	1	Direct and indirect band gap semiconductors
6	1	Electronic properties of Silicon
7	1	Electronic properties of Germanium
8	1	Compound SemiconductorGallium Arsenide, Gallium phosphide & Silicon carbide
9	1	Variation of semiconductor conductivity,
10	1	Resistance and bandgap with temperature and doping
11	1	Thermistors,Sensitors, Numerical
12	**2**	**REVIEW OF QUANTUM MECHANICS:**
13	2	Electrons in periodic Lattices
14	2	E-k diagrams
15	2	Energy bands in intrinsic and extrinsic silicon
16	2	Carrier transport: diffusion current, drift current
17	2	Mobility and resistivity, sheet resistance
18	2	Design of resistors, Numerical
19	**3**	**GENERATION AND RECOMBINATION OF CARRIERS:**
20	3	Poisson and continuity equation
21	3	P-N junction characteristicsI-V characteristics,
22	3	Small signal switching models
23	3	Avalanche breakdown, Zener diode
24	3	Schottky diode, Numerical
25	**4**	**BIPOLAR JUNCTION TRANSISTOR:**
26	4	(Contd.) Bipolar Junction Transistor, BJT I-V characteristics
27	4	Ebers-Moll Model, MOS capacitor
28	4	C-V characteristics
29	4	MOSFET, MOSFET I-V characteristics
31	4	Small signal models of MOS transistor
34	4	LED, photodiode, solar cell, Numerical
35	5	**INTEGRATED CIRCUIT FABRICATION PROCESS:**
36	5	Oxidation, diffusion
37	5	Ion implantation, Photolithography
38	5	Etching, chemical vapor deposition
39	5	Sputtering
40	5	Twin-tub CMOS process, Numerical

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TEXT/REFERENCE BOOKS

1. Microelectronic Circuits – Theory and Applications, Adel S Sedra, Kenneth C Smith and Arun N Chandorkar, Oxford University Press
2. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky, Pearson India Education Services Pv Ltd.
3. Electronic Devices and Circuits, J.B. Gupta, S.K. Kataria& Sons.

Teaching and Learning resources:

MOOC (NPTEL): -

Assessment Methodology:

1. Viva and circuit design in practical lab.
2. Numerical Assignment
3. Two Midterm exams where student have to showcase subjective learning.
4. Final Exam (subjective paper) at the end of the semester.

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3E1150

Roll No. _____

Total No of Pages: 4

3E1150

B. Tech. III - Sem. (Main) Exam., Dec. - 2018

PCC Electronics & Communication Engineering

3EC4 – 07 Electronics Devices

EC, EI

Time: 3 Hours **Maximum Marks: 160**

Instructions to Candidates:

Attempt all ten questions from Part A, five questions out of seven questions from Part B and four questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL

Part A [10×3=30]

All questions are compulsory

Q.1 Show Bandgap order of GaAs, GaP and SiC in increasing order.

Q.2 Write one difference between Degenerate and non-degenerate semiconductors.

Q.3 Draw Energy band diagram of a semiconductor in thermal equilibrium condition when it's doping level is shown in fig. 3(A)

$NA = 10^{16}$ cm^{-3}	$N_D = 10^{13}$ cm^{-3}
(Si)	(Si)

fig – 3 (A)

Q.4 Draw characteristic curve of photo diode and solar cell.

Q.5 How many steps are included in one mask during IC fabrication?

Q.6 Write continuity equation under thermal equilibrium conduction and open circuit condition but exposed with photon.

Q.7 Write one difference between LED and LASER diode.

Q.8 Show diode static and dynamic resistance on its I-V characteristic.

Q.9 Define sheet resistance and write its unit.

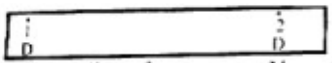
Q.10 Write the name of two recombination center in a lattice.

PART – B

(Analytical/Problem solving questions) **[5×10=50]**

Attempt any five questions

Q.1 Calculate the contact Potential between point 1 & 2 in a semiconductor, shown in fig 1(B) at room temperature.



$N_{D_1} = 10^{15}/cm^3$ $N_{D_2} = 10^{18}/cm^3$

fig – 1(B)

Assume ni = $1.5 \times 10^{10}/cm^3$

Q.2 How Zener diode is used for voltage regulation. Design such regulator in which input voltage vary in (10 – 12) volt and across load we need constant 6 volt, even the load is changed between 10 – 12 kΩ range.

Q.3 Draw input and O/P characteristics of common base (CB) configuration and show all h – parameter on it.

Q.4 Define the following fabrication process:

(i) Oxidation and

(ii) Ion implementation

Q.5 In NPN transistor the concentration of electron in base region change as shown in fig 5 (B).

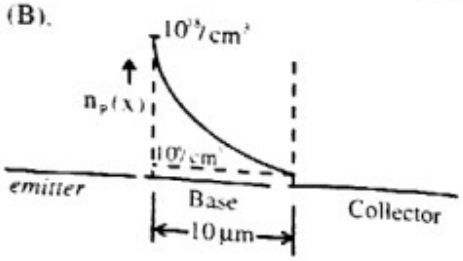
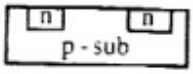


fig. – 5 B

Then calculate the diffusion current density in base region. Assume the mobility constant of electron is $fe_n = 1400 \frac{cm^2-volt}{sec}$ at room – temperature.

Q.6 Draw MOSFET VI characteristic at different gate – source (V_{GS}) voltage and show the atomic and saturation region on it. http://www.rtuonline.com

Q.7 Show all fabrication step to achieve following structure:



PART – C

(Descriptive/Analytical/Problem Solving/Design Question) **[4×20=80]**

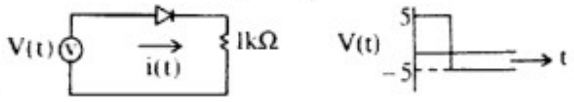
Attempt any four questions

Q.1 How compound semiconductor are superior than element semiconductor?

Design a $Ga_{1-x}As_x$ semiconductor whose sensitivity is maximum for a photon in infrared region when it is used as photodiode.

Q.2 Draw characteristic of a solar cell and define open circuit voltage and short circuit current on it. How solar cell is used in solar panel for increase in current and voltage rating?

Q.3 Draw the current in following diode circuit (fig. 3C) for the given voltage. Also define storage time, reverse recovery time on it.



(fig – 3C)

Q.4 Develop small signal MOSFET Model and draw its electrical equivalent circuit. Also define all model parameters. 12

Q.5 Write the use of the following: 10

(i) Schottky diode in TTL

(ii) Etching process in IC fabrication

(iii) Direct bandgap material in LED
