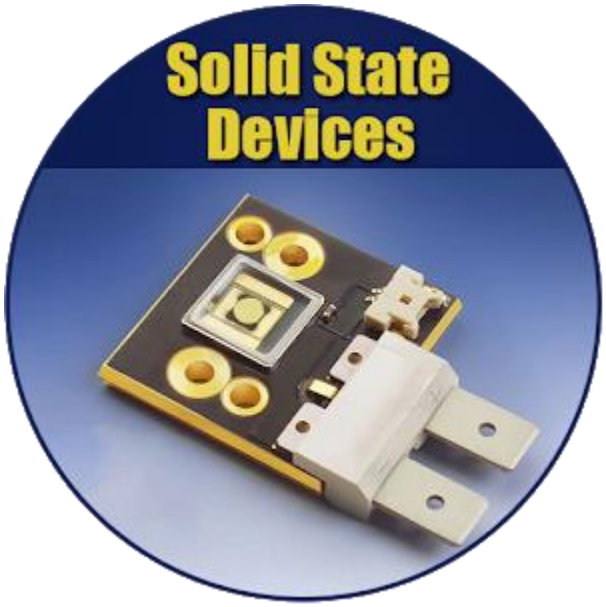
# MUZAFFARPUR INSTITUTE OF TECHNOLOGY, Muzaffarpur

**COURSE FILE**

**OF**

# SOLID STATE PHYSICS AND DEVICES

# (041308)




**Faculty Name:**

**Mr. RAVI KUMAR**

**ASSISTANT PROFESSOR,**

# DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

## Content

## VISION OF DEPARTMENT

The department is committed for high quality teaching and pursuit of excellence in research. We pledge to serve the nation and society by providing skilled and well developed human resource through brilliance in technical education and research.

**MISSION OF DEPARTMENT**

- To encourage innovation and research through projects and developmental activities with industries, institutions and government.
- To inculcate moral and ethical values with a sense of competitiveness, self-confidence and sincerity among the students to make them a good human and a good citizen.
- To produce excellent engineers, innovators, entrepreneurs and academicians for the growth of the society.

**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

After successful completion of program, graduates will be able to

**PEO1:** Work in the infrastructure development projects.

**PEO2:** Pursue higher studies.

**PEO3:** Contribute in teaching, research and other developmental activities of electronics & communication engineering and its allied fields.

**PEO4:** Work in the multicultural and multidisciplinary groups for the sustainable development and growth of electronics and communication engineering projects and profession.

**PROGRAMME OUTCOMES (PO)**

| | |
|---|---|
| PO1 | **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| PO2 | **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| PO3 | **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. |
| PO4 | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| PO5 | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| PO6 | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| PO7 | **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development. |
| PO8 | **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities |

| | |
|---|---|
| | and norms of the engineering practice. |
| PO9 | **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO10 | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| PO11 | **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| PO12 | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

## COURSE OBJECTIVE AND COURSE OUTCOMES:

| | | | |
|---|---|---|---|
| **Institute / College Name :** | MUZAFFARPUR INSTITUTE OF TECHNOLOGY | | |
| **Program Name** | **B.Tech. ECE** | | |
| **Course Code** | 041308 | | |
| **Course Name** | **SOLID STATE PHYSICS AND DEVICES** | | |
| **Lecture / Tutorial / Practical (per week):** | 3 – 0 - 3 | **Course Credits** | 5 |
| **Course Coordinator Name** | Mr. RAVI KUMAR | | |

### Course objective:

This course provides the student with the fundamental skills to analyze and solve solid state devices. It will build basic background for how semiconductor devices work. Students equipped with the knowledge and training provided in the course will be able to participate in design and development, installation and operation of a wide spectrum of applications in the field of solid state device. Solid state device is the basic fundamental of electronics industry.

### Course outcomes (CO):

**CO1**: learn the history of development of electronics devices.

**CO2**: fabrication process for semiconductor devices.

**CO3**: analytical and mathematical modelling of semiconductor devices.

**CO4**: Compare design issues, advantages, disadvantages and limitations of solid state devices.

**MAPPING OF COs AND POs**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | | 2 | | 2 | 3 | 2 | | | 3 | | 3 |
| CO2 | 2 | 1 | 2 | 2 | 3 | 2 | 1 | | | 2 | | 1 |
| CO3 | 1 | 3 | 3 | 2 | 3 | | | | | | | 3 |
| CO4 | 1 | 2 | 2 | 3 | | | | | | 2 | | 2 |

Correlation level: 1- slight (Low) 2- moderate (Medium) 3-substantial (High)

**COURSE SYLLABUS:**

| Topics | Number of Lectures | Weightage (%) |
|---|---|---|
| **History**<br>Brief about history of development of electronics devices. Start from vacuum tubes diode to application specific integrated chip i.e. vacuum diodes, triode, solid state era, microprocessor era, integrated circuit era. | 2 | **4** |
| | | |
| **Review of device physics**<br>Photo ionic emission, thermionic emission, gas discharge tube, vacuum tube diode, triode, tetrods and pentods. | 3 | 10 |
| | | |
| **Crystal growth**<br>Bulk and epitaxial growth | 2 | 5 |
| | | |
| **IC Technology**<br>Oxidation, diffusion, ion implantation, lithography, thin film deposition, process integration flow for P-N junction, BJT and MOSFET fabrication. | 4 | 10 |
| | | |
| **Physics and technology of classical diodes**<br>Semiconductor carrier modelling, bonding model, energy band model, band gap, carrier properties, density states, Fermi function, equilibrium carrier concentration, carrier action drift mobility, diffusion current, recombination and generation, continuity equation, minority carrier diffusion equation, junction diode step function, built in potential, P-N junction, depletion approximation, ideal diode equation, deviation from ideal, junction breakdown, junction capacitance, turn off and turn on transients. | 12 | 20 |
| | | |

| | | |
|---|---|---|
| **Physics and technology of BJT**<br>Operation consideration, modes and configuration**,** base transport factor, performance parameters, common base current gain, small scale modelling, common emitter gain, base width modulation, qualitative approach to understand switch response. | 7 | 20 |
| | | |
| **Physics and technology of FET**<br>Junction FET theory of application, I-V characteristics, mos capacitor, MOSFET theory of operation, non ideal MOSFET. | 5 | 15 |
| | | |
| **Properties and technology of UJT and SCR**<br>Silicon controlled rectifier, uni junction transistor (theory of operation) | 2 | 6 |
| | | |
| **Photonics**<br>Photo diode, solar cell, solid state LASER diodes | 3 | 6 |
| | | |
| **CCD and CCD camera** | 2 | 4 |

# MUZAFFARPUR INSTITUTE OF TECHNOLOGY

**B.Tech. 5th (Fifth) Semester TIME TABLE**

**WITH EFFECT FROM 10.07.2018**

## 3th Semester Electronics and Communication Branch

| | 09:00 | 10:00 | 11:00 | 12:00 | R E C E S S | 2:00 | 3:00 | 4:00 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | 5 | 6 | 7 |
| MON | | | ECE | | | Weekly Test | | |
| TUES | | ---ECE LAB--- | | | | | | |
| WED | | | | | | | | |
| THUR | ECE | | | | | | | |
| FRI | | | | | | ECE | | |
| SAT | | | | | | | | |

# MUZAFFARPUR INSTITUTE OF TECHNOLOGY

**B.Tech. 5th (Fifth) Semester TIME TABLE**

**WITH EFFECT FROM 10.07.2018**

| 3rd Semester Information and Technology Branch | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 09:00 | 10:00 | 11:00 | 12:00 | R | 2:00 | 3:00 | 4:00 |
| | 1 | 2 | 3 | 4 | E | 5 | 6 | 7 |
| MON | | | | | | | | Weekly Test |
| TUES | EE | | | | C | | | |
| WED | | | | EE | E | --- EE LAB --- | | |
| THUR | | | | | | | | |
| FRI | | | | | S | | | |
| SAT | | ---EE LAB--- | | | S | | EE | |

**STUDENT LIST:**

**3rd semester Electronics and Communication department**

| SL. NO. | ROLL NO. | AKU REG. NO. | NAME |
|---|---|---|---|
| 1 | 16EC39 | 16104107012 | ANMOL SHRIVASTAVA |
| 2 | 16EC25 | 16104107014 | MD REHAN |
| 3 | 17EC23 | 17104107001 | PRINCE KUMAR |
| 4 | 17EC37 | 17104107002 | RAVI KUMAR SINGH |
| 5 | 17EC35 | 17104107003 | RAJESH DAS |
| 6 | 17EC34 | 17104107004 | GAUTAM KUMAR |
| 7 | 17EC32 | 17104107005 | VICKY KUMAR |
| 8 | 17EC11 | 17104107006 | SACHIN KUMAR |
| 9 | 17EC39 | 17104107007 | BRAJESH KUMAR |
| 10 | 17EC04 | 17104107008 | AUSHUTOSH KUMAR |
| 11 | 17EC15 | 17104107009 | PRADEEP KUMAR |
| 12 | 17EC13 | 17104107010 | SHABAB ANWAR |
| 13 | 17EC01 | 17104107011 | ASHMITA KUMARI |
| 14 | 17EC14 | 17104107012 | ASTITVA ANAND |
| 15 | 17EC20 | 17104107013 | AKASH DEEP |
| 16 | 17EC03 | 17104107014 | SHILPA SONALI |
| 17 | 17EC24 | 17104107015 | GULFISHAN SHARAFAT |
| 18 | 17EC33 | 17104107016 | APARNA RANI |
| 19 | 17EC05 | 17104107017 | SUPRIYA BHARTI |
| 20 | 17EC43 | 17104107018 | NIDHI SINGH |
| 21 | 17EC29 | 17104107019 | PUJA KUMARI |
| 22 | 17EC12 | 17104107020 | SUNNY SAURAV |
| 23 | 17EC10 | 17104107021 | BIPUL KUMAR |
| 24 | 17EC41 | 17104107022 | ABHISHEK RANA |
| 25 | 17EC22 | 17104107023 | GAURAV KUMAR |
| 26 | 17EC21 | 17104107024 | NANDAN KUMAR |
| 27 | 17EC26 | 17104107025 | PRINCE KUMAR |
| 28 | 17EC40 | 17104107027 | MANISHA PRAKASH |
| 29 | 17EC28 | 17104107028 | SHREYA SWARAJ |
| 30 | 17EC25 | 17104107029 | AMBRIN FATMA |
| 31 | 17EC36 | 17104107030 | KARSHNI KANT PATHAK |
| 32 | 17EC30 | 17104107031 | AMMAR NAJUM |
| 33 | 17EC27 | 17104107032 | MD SARFARAZ IQBAL |
| 34 | 17EC46 | 17104107033 | NIRBHAY KUMAR PANDEY |
| 35 | 17EC47 | 17104107034 | BANTY KUMAR |
| 36 | 17EC44 | 17104107035 | KUSH KUMAR |
| 37 | 17EC16 | 17104107036 | BITTU KUMAR |
| 38 | 17EC48 | 17104107037 | SURAJ KUMAR |
| 39 | 17EC19 | 17104107039 | SRIJAN SINGH |

| | | | |
|---|---|---|---|
| 40 | 17EC45 | 17104107040 | MD SHERIQUE ANWAR |
| 41 | 17EC42 | 17104107041 | ROHIT KUMAR |
| 42 | 17EC38 | 17104107042 | AADIL RAZA |
| 43 | 17EC06 | 17104107043 | SUPRIYA KUMARI |

**3rd semester Electrical Engineering department**

| SL. NO. | ROLL NO. | AKU REG. NO. | NAME |
|---|---|---|---|
| 1 | 16E47 | 16103107020 | SHUBHAM KUMAR |
| 2 | 17E01 | 17103107001 | SHIVANGI |
| 3 | 17E24 | 17103107002 | PRAGYA KUMARI |
| 4 | 17E04 | 17103107003 | KANNU PRIYA |
| 5 | 17E08 | 17103107004 | VIDYA KUMARI |
| 6 | 17E07 | 17103107005 | APARNA SINGH |
| 7 | 17E13 | 17103107006 | KHUSHBOO ANAND |
| 8 | 17E09 | 17103107007 | VIVEK KUMAR |
| 9 | 17E03 | 17103107008 | SHIVAM DUBEY |
| 10 | 17E17 | 17103107009 | VANDANA BHARTI |
| 11 | 17E16 | 17103107010 | SANDHYA KUMARI |
| 12 | 17E19 | 17103107011 | NEHA SINGH |
| 13 | 17E10 | 17103107013 | ABHIJEET KUMAR |
| 14 | 17E12 | 17103107014 | NIRAJ KUMAR |
| 15 | 17E02 | 17103107015 | SAURAV SINHA |
| 16 | 17E22 | 17103107016 | ABHINAV KISHORE |
| 17 | 17E25 | 17103107017 | GAUTAM KUMAR |
| 18 | 17E11 | 17103107018 | UTPAL KANT |
| 19 | 17E26 | 17103107019 | ASHUTOSH KUMAR |
| 20 | 17E21 | 17103107020 | DEPAK KUMAR |
| 21 | 17E42 | 17103107021 | RAVI PRAKASH CHOUDHARY |
| 22 | 17E06 | 17103107022 | SAURAV KUMAR |
| 23 | 17E34 | 17103107023 | PAVAN KUMAR |
| 24 | 17E23 | 17103107024 | SINTU KUMAR |
| 25 | 17E55 | 17103107025 | GHANSHYAM KUMAR |
| 26 | 17E18 | 17103107026 | SATYA PRAKASH |
| 27 | 17E48 | 17103107027 | ASHISH KUMAR |
| 28 | 17E20 | 17103107028 | MOHAMMAD EHSHANULLAH |

| | | | |
|---|---|---|---|
| 29 | 17E30 | 17103107029 | MASYOOD AHMAD |
| 30 | 17E60 | 17103107030 | ABHIMANYU KUMAR SINGH |
| 31 | 17E29 | 17103107031 | SUMIT KUMAR |
| 32 | 17E44 | 17103107032 | PRIYA KUMARI |
| 33 | 17E32 | 17103107033 | NELSHAN RANI |
| 34 | 17E47 | 17103107034 | VIKASH KUMAR |
| 35 | 17E51 | 17103107035 | ROHIT KUMAR |
| 36 | 17E31 | 17103107036 | VANISHA SHARMA |
| 37 | 17E58 | 17103107037 | MANISH KUMAR |
| 38 | 17E61 | 17103107038 | SWETA KUMARI |
| 39 | 17E38 | 17103107039 | ABHISHEK RAJ |
| 40 | 17E33 | 17103107040 | SANDEEP KUMAR SINHA |
| 41 | 17E36 | 17103107041 | ANAMIKA BHARTI |
| 42 | 17E41 | 17103107042 | RAVISHANKAR KUMAR |
| 43 | 17E53 | 17103107043 | MITHUN KUMAR |
| 44 | 17E63 | 17103107044 | NAVNEET NAYAN |
| 45 | 17E28 | 17103107045 | KUMAR ARYAN |
| 46 | 17E64 | 17103107046 | AMIT KUMAR |
| 47 | 17E37 | 17103107047 | TAMANNA CHOUDHARY |
| 48 | 17E56 | 17103107048 | ASHWINI KUMAR |
| 49 | 17E39 | 17103107049 | PRAVEEN KUMAR SAFI |
| 50 | 17E35 | 17103107050 | NAVIN PUSHKAR |
| 51 | 17E52 | 17103107051 | PREM BHARTI |
| 52 | 17E59 | 17103107052 | SANTOSH KUMAR RAM |
| 53 | 17E40 | 17103107053 | ANAMIKA KAUSHIK |
| 54 | 17E43 | 17103107054 | BUNTY KUMAR PASWAN |
| 55 | 17E50 | 17103107055 | AMAN RAJ |
| 56 | 17E15 | 17103107056 | RAJ KAMAL |
| 57 | 17E45 | 17103107057 | RAMBABU BAITHA |
| 58 | 17E62 | 17103107058 | RAJSHEKHAR KUMAR GOKUL |
| 59 | 17E57 | 17103107059 | RAHAT ARAFAT |
| 60 | 17E54 | 17103107060 | SUSHIL KUMAR |

**TEXT BOOKS:**

TB1: Solid state electronic devices by Streetmen And Banerjee, Pearson:

TB2: Basic principles- semiconductor physics and devices by Nearmen,TMH

TB3: Semiconductor devices by Kano, Pearson

**REFERENCE BOOKS:**

RB1: Electronic Materials and Devices by Kasp. TMP.

RB2: Theory of Semiconductor Devices by Karl Hess, PHI.

RB3: Semiconductor Devices by Jasprit Singh, Wiley Student Edition.

RB4: Device electronics for Integrated Circuits by Muller & Kamins, Wiley Student Edition

**COURSE PLAN**

| Lecture Number | Topics | Web Links for video lectures | Text Book / Reference Book | Page numbers of Book |
|---|---|---|---|---|
| 1-2 | **HISTORY** | | | |
| | Brief about history of development of electronics devices. Start from vacuum tubes diode to application specific integrated chip i.e. vacuum diodes, triode, solid state era, microprocessor era, integrated circuit era. | | | |
| 3-5 | **REVIEW OF DEVICE PHYSICS** | | | |
| | Photo ionic emission, thermionic emission, gas discharge tube, vacuum tube diode, triode, tetrods and pentods. | | | |
| 6-7 | **Crystal growth** | | | |
| | Bulk and epitaxial growth | | | |
| 8-11 | **IC Technology** | | | |
| | Oxidation, diffusion, ion implantation, lithography, thin film deposition, process integration flow for P-N junction, BJT and MOSFET fabrication | | | |
| 12-23 | **Physics and technology of classical diodes** | | | |
| | Semiconductor carrier modelling, bonding model, energy band model, band gap, carrier properties, density states, Fermi function, equilibrium carrier concentration, carrier action drift mobility, diffusion current, recombination and generation, continuity equation, minority carrier | | | |

| | | | | |
|---|---|---|---|---|
| | diffusion equation, junction diode step function, built in potential, P-N junction, depletion approximation, ideal diode equation, deviation from ideal, junction breakdown, junction capacitance, turn off and turn on transients. | | | |
| 24-30 | **Physics and technology of BJT** | | | |
| | Operation consideration, modes and configuration**,** base transport factor, performance parameters, common base current gain, small scale modelling, common emitter gain, base width modulation, qualitative approach to understand switch response. | | | |
| 31-36 | **Physics and technology of FET** | | | |
| | Junction FET theory of application, I-V characteristics, MOS capacitor, MOSFET theory of operation, non-ideal MOSFET. | | | |
| 36-38 | **Properties and technology of UJT and SC** | | | |
| | Silicon controlled rectifier, uni junction transistor (theory of operation) | | | |
| 38-41 | **Photonics** | | | |
| | Photo diode, solar cell, laser diode | | | |
| 41-43 | **CCD and CCD camera** | | | |
| | Charge couple device theroy | | | |

**DETAILS OF ASSIGNMENTS:**

| S.No. | Assignment | Unit wise |
|---|---|---|
| 1 | Assignment 1 | Unit 1 and unit 2 |
| 2 | Assignment 2 | Unit 3 and unit 4 |
| 3 | Assignment 3 | Unit 5 and unit 6 |
| 4 | Assignment 4 | Unit 7 unit 8 and unit 9 |

**ASSIGNMENT 1**

**ASSIGNMENT 2**

**ASSIGNMENT 3**

**ASSIGNMENT 4**

**QUESTION BANK:**

# Code : 041308



## B.Tech. 3rd Semester Exam., 2014

## SOLID-STATE PHYSICS AND DEVICES

*Time* : 3 hours *Full Marks* : 70



*Instructions* :

*(i) The marks are indicated in the right-hand margin.*

*(ii) There are* ***NINE*** *questions in this paper.*

*(iii) Attempt* ***FIVE*** *questions in all.*



*(iv) Question No.* ***1*** *is compulsory.*

**1.** Answer any *seven* from the following : 2×7=14

*(a)* What are the methods used for epitaxial growth?

*(b)* Define direct and indirect semiconductors.

*(c)* Define the effective mass and express it in terms of $(E, k)$.

*(d)* Define conductivity and mobility.

*(e)* Find the resistivity of intrinsic germanium at 300 K. Given that the intrinsic density of carriers is $2{\cdot}5\times10^{19}/m^3$, $\mu_e = 0{\cdot}39\ m^2/V.s.$, $\mu_n = 0{\cdot}19\ m^2/V.s.$

  ( Turn Over )





*(f)* What is diffusion length and mean life time?

*(g)* Define the varactor diode.

*(h)* What is emitter injection efficiency and current transfer ratio?

*(i)* What is thermionic emission?

*(j)* Define MOSFET and BJT. 

**2.** *(a)* Write short notes on *(i)* vapour-phase epitaxy and *(ii)* molecular beam epitaxy. 4×2=8

*(b)* In a very long *p*-type Si bar with cross-sectional area = $0{\cdot}5\ cm^2$ and $N_a = 10^{17}\ cm^{-3}$, we inject holes such that the steady-state excess hole concentration is $5\times10^{16}\ cm^{-3}$ at $x = 0$. What is the hole current there? Assume that $\mu_p = 500\ cm^2/V.s$ and $\tau_p = 10^{10}$ sec. 6

**3.** *(a)* Write short notes on direct and indirect recombination in a semiconductor. 8

*(b)* What is ion implantation?  6

**4.** *(a)* Derive the diffusion equation for steady-state distribution for electron and hole. 8

*(b)* Derive Einstein relation with respect to both carriers in semiconductor. 6

  ( Continued )

5. (a) What is reverse breakdown? Describe the different reverse breakdown mechanism. 6

(b) Derive the relationship between width of transition region in terms of contact potential and doping concentrations on each side of the junctions. 8

6. (a) An abrupt Si *p-n* junction has $N_a = 10^{18}\ cm^{-3}$ on one side and $N_d = 5 \times 10^{15}\ cm^{-3}$ on the other has a circular cross-section with a diameter of 10 μm. Calculate $\chi_{no}$, $\chi_{po}$, $Q_t$ and $\xi_0$ for this junction at equilibrium (300 K). Sketch $\xi_{(x)}$ and charge density. 7

(b) Explain the operating principle of JFET using suitable sketches. 7

7. (a) For an *n*-channel MOSFET with a gate oxide thickness of 10 nm, $V_T = 0{\cdot}6$ V and $Z = 25\ \mu m$, $L = 1\ \mu m$, calculate the drain current at $V_G = 5V$ and $V_D = 0{\cdot}1$ V. Also calculate the drain current for $V_D = 7V$. Assume an electron channel mobility of $\mu_n = 200\ cm^2/V.s$. 6

(b) Draw energy band diagram of *pnn* transistor in unbiased condition. 4





(c) Draw energy band diagram of *pnp* transistor in common base mode. Discuss why the base of a transistor is thin and lightly doped. 4

8. (a) Write short notes on any *two* of the following : 4×2=8

(i) Solar cell

(ii) LED

(iii) Laser diode

(b) What is silicon controlled rectifier and unijunction rectifier? 3×2=6

9. (a) Write a short note on charge coupled devices (CCD). 4

(b) What is Schottky barrier diode? 4

(c) Define triodes, tetrads and pentodes. 6

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# Code : 041308

## B.Tech 3rd Semester Exam., 2017

### SOLID STATE PHYSICS AND DEVICES

*Time* : 3 hours *Full Marks* : 70

*Instructions* :

*(i) The marks are indicated in the right-hand margin.*

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

*(v) Symbols used (if any) have their usual meaning.*

**1.** Answer any *seven* questions : 2×7=14

*(a)* What is thermionic emission?

*(b)* How is epitaxial growth achieved?

*(c)* What do you mean by diffusion?

*(d)* What happens to the states below and above Fermi-level at absolute zero temperature ($T = 0$ K)?

*(e)* Write down any two methods used for the thin film deposition.

*(f)* What is drift current?







*(g)* What is Zener breakdown?

*(h)* What is varactor diode?

*(i)* What are the different configurations of BJT?

*(j)* Write two usages of CCD.

**2.** Write short notes on the following : 5+5+4=14

*(a)* UJT

*(b)* LED

*(c)* Photodiode

**3.** Discuss CVD, sputtering and evaporation methods in detail. 5+5+4=14

**4.** What do you mean by conduction and valence band? Derive expressions for electronic concentration in the conduction band and hole concentration in valence band. 2+12=14

**5.** What is an ideal diode model? Derive ideal diode equation. Plot ideal diode current-voltage characteristics. Why do you observe deviation from ideal diode in a real diode? 2+8+2+2=14

**6.** What is the difference between direct band-to-band recombination and indirect recombination? What is Auger process? Derive an expression for Auger life-time for strongly *n*-type and strongly *p*-type semiconductors under low-level injection. 3+3+8=14

**7.** Write short notes on the following : 5+5+4=14

*(a)* Schottky diode

*(b)* Tunnel diode

*(c)* Zener diode

**8.** What are the different operation modes of BJT? Derive an expression for common emitter current gain in BJT. 2+12=14

**9.** Describe operating principle of MOSFET. Discuss *I-V* characteristics of MOSFET. 6+8=14

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**LIST OF THE EXPERIMENT**

1. To determine the energy gap of PN junction.
2. To study of I-V characteristic of SCR.
3. To study of I-V characteristic of UJT.
4. To study of I-V characteristic of triac.
5. To study of I-V characteristic of photodiode.
6. To study of I-V characteristic of LED.
7. To study of I-V characteristic of tunnel diode.
8. To study of I-V characteristic of varactor diode.
9. To study of I-V characteristic of zener diode.
10. To study of transfer function and output characteristic of MOSFET.