PARVATHANENI BRAHMAYYA
SIDDHARTHA COLLEGE OF ARTS & SCIENCE
Autonomous
Siddhartha Nagar, Vijayawada–520010
Re-accredited at 'A+' by the NAAC

Course Code				**23ELMAL234**			
Title of the Course				**SEMICONDUCTOR DEVICES & MATERIALS**			
Offered to:				B.Sc. (H) Electronics			
L	**4**	**T**	**0**	**P**	**0**	**C**	**3**
Year of Introduction:	**2024-25**			**Semester:**			**3**
Course Category:	Major			**Course Relates to:**	Global		
Year of Revision:	**N/A**			**Percentage:**	**N/A**		
Type of the Course:				Employability			
Crosscutting Issues of the Course :				Professional Ethics			
Pre-requisites, if any				Familiarity with basic electronic components			

Course description:

This course offers an in-depth exploration of semiconductor devices and materials, focusing on their properties, fabrication techniques, and applications in modern electronics. Topics include the physics of silicon, germanium, and compound semiconductors, as well as emerging materials like graphene. Key devices such as diodes, BJTs, and FETs are studied in detail, along with advanced topics like power devices, optoelectronics, MEMS, and quantum devices. Through lectures, lab experiments, and simulations, students will develop practical skills in device characterization and fabrication, preparing them for careers in the semiconductor industry and research.

Course Aims and Objectives:

S.NO	COURSE OBJECTIVES
1	To understand the basic concepts, terminology, and classification of semiconductor materials. To explore the crystal structure, bonding, and energy bands in semiconductors.
2	To understand the applications of diodes, including Zener diodes and LEDs.
3	To comprehend the structure, operation, and characteristics of BJTs.
4	To study the structure, operation, and characteristics of JFETs and MOSFETs.
5	Gain insight into the fabrication processes of semiconductor devices.

Course Outcomes

At the end of the course, the student will be able to…

CO NO	COURSE OUTCOME	BT L	PO	PS O
CO1	Students will be able to explain the basic concepts, classification, and history of semiconductor materials.	K1		
CO2	They will understand the applications of diodes, Zener diodes, and LEDs in electronic circuits.	K4		
CO3	Students will be able to describe the structure, operation, and characteristics of BJTs.	K4		
CO4	Students will be able to explain the structure, operation, and characteristics of JFETs and MOSFETs.	K2		
CO5	Students will be knowledgeable about semiconductor fabrication techniques, including crystal growth, doping methods, and photolithography.	K2		

For BTL: K1: Remember; K2: Understand; K3: Apply; K4: Analyze; K5: Evaluate; K6: Create

CO-PO MATRIX									
CO NO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
CO1				2				2	
CO2					3				1
CO3				3					3
CO4					3			1	
CO5				2					2

Use the codes 3,2,1 for High, Moderate and Low correlation Between CO-PO-PSO respectively

Course Structure:

Unit – I

Semiconductors and Semiconductor physics: Classification of semiconductor materials, Crystal structure and bonding in semiconductors, Energy bands and charge carriers, Intrinsic and extrinsic semiconductors, Carrier transport: drift, diffusion, and recombination.

Examples/Applications/Case Studies:

- Used in the fabrication of integrated circuits (ICs) for computers, smartphones, and other electronic devices.
- Used in RF (radio frequency) devices, such as microwave amplifiers and mobile phone transmitters.

Exercises/Projects:

- Calculate the intrinsic carrier concentration of silicon at room temperature (300 K). Given the intrinsic carrier concentration for silicon at 300 K is approximately 1.5×10^{10} cm^{-3}.

Specific Resources: (web)

MIT OpenCourseWare - Integrated Microelectronic Devices

Unit - II

PN Junctions: Formation and properties of PN junction's, forward and reverse bias characteristics, Junction capacitance and breakdown mechanisms, Applications: diodes, Zener diodes, LEDs.

Examples/Applications/Case Studies:

- PN junction diodes are used in power supply units (PSUs) to convert AC from the mains supply to DC, like computers, televisions, and chargers.
- LEDs are widely used in display screens, indicator lights, and general lighting solutions due to their energy efficiency, long life, and bright illumination. They are found in products such as televisions, smartphones, traffic lights, and household lighting.

Exercises/Projects:

- Project 1: Designing and Building a Full-Wave Rectifier
- Project 2: Building and Characterizing an LED Display

Specific Resources: (web)
PN Junction Theory (Electronics Tutorials).

Unit - III
Bipolar Junction Transistors (BJTs): Structure and operation of BJTs, I-V characteristics and regions of operation, Small signal and large signal models, BJT applications in amplification and switching.

Examples/Applications/Case Studies:

- **Case Study 1:**Design and Implementation of a BJT Amplifier
- **Case Study 2:** BJT as a Switch in Digital Circuits

Exercises/Projects:

- **Exercise 1:** Analyzing the Characteristics of an NPN BJT
- **Exercise 2:** Designing a BJT Amplifier

Specific Resources: (web)
Introduction to Electronics, Signals, and Measurement - BJT (MIT OpenCourseWare).

Unit - IV
Field Effect Transistors (FETs): Junction FET (JFET) and Metal-Oxide-Semiconductor FET (MOSFET), MOSFET structure, operation, and characteristics, Scaling of MOSFETs and challenges in modern technology, Advanced FETs: HEMT, FinFET.

Examples/Applications/Case Studies:

- **Example 1:** Digital Audio Transmission Using Pulse Modulation
- **Example 2:** Television Broadcasting Using Frequency Division Multiplexing (FDM)

Exercises/Projects:

- Analyze and design a pulse modulation system for transmitting an audio signal.
- Design an FDM system for transmitting multiple signals and analyze its performance.

Specific Resources: (web)
Electronics Tutorials - Field Effect Transistors (FETs)

Unit - V

Semiconductor Fabrication Techniques: Crystal growth and wafer preparation, Doping methods: diffusion and ion implantation, Photolithography, etching, and deposition techniques, Packaging and testing of semiconductor devices.

Examples/Applications/Case Studies:

- **Application 1:** Integrated Circuit (IC) Fabrication.
- **Application 2:** Solar Cell Manufacturing

Exercises/Projects:

- **Exercise 1:** Photolithography Process Simulation
- **Exercise 2:** Doping Semiconductor Materials using Diffusion

Specific Resources: (web)

(Thermo Fisher) (SemiconSociety Blogs)

Text Books

1. Donald A. Neamen, 2003, Semiconductor Physics and Devices BasicPrinciples, 3/e. McGraw-Hil.
2. S. M. Sze and Kwok K. Ng, 2013, Physics of Semiconductor Devices, 2/e, Wiley.

Reference Books

1. B.G. Streetman and Sanjay Banerjee, 2006, Solid State Electronic Devices, 6/e, Prentice Hall.
2. Anok Singh,2004,Principles of Communication Engineering, 4/e, Sathyaprakasam Publications.
3. M. Hussa, A. Dimoulas and A. Molle, 2016, 2D Materials for NanoElectronics, CRC press.
4. M.S.Tyagi, 2008, Introduction to Semiconductor Materials and Devices, Student Edition, Willey.

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MODEL PAPER

23ELMAL234: SEMICONDUCTOR DEVICES & MATERIALS

SECTION-A

Answer the following: **5 x 4 = 20M**

1. **(a)**Explain the difference between intrinsic and extrinsic semiconductors. **K1**

   Or

   (b) Describe the process of electron-hole recombination in semiconductors.**K1**

2. **(a)** What is the role of a PN junction diode in a rectifier circuit? **K3**

   Or

   (b) Describe the working principle of a Zener diode and its application in voltage regulation.**K3**

3. **(a)** Explain the structure and operation of an NPN Bipolar Junction Transistor (BJT).**K3**

   O**r**

   (b) What is the Early effect in BJTs and how does it influence the transistor's operation?**K3**

4. **(a)** Outline the basic steps involved in the photolithography process. **K2**

   Or

   (b) Discuss the significance of doping in modifying the electrical properties of semiconductors.**K2**

5. **(a)** Describe the concept of power semiconductor devices with an example. **K2**

   Or

   (b) Explain the working of an optoelectronic device like a Light Emitting Diode (LED).**K2**

SECTION-B

Answer the following: **5x10=50M**

6.(a) Discuss in detail the energy band structure of semiconductors and its implications for electronic properties. **K1**

Or

(b) Explain the carrier generation and recombination processes in semiconductors with relevant equations. **K1**

7.(a) Compare and contrast the characteristics and applications of PN junction diodes and Schottky diodes. **K3**

Or

(b) Analyze the working of a full-wave rectifier circuit and derive expressions for its output voltage and efficiency. **K3**

8.(a) Describe the input and output characteristics of a common-emitter BJT configuration. Include diagrams and explain the significance of each region. **K3**

Or

(b) Discuss the design and operation of a BJT amplifier, including biasing techniques and gain calculation. **K3**

9.(a) Explain the construction and operation of JFET and describe its input and output characteristics.**K2**

Or

(b) Discuss the operation and applications of advanced semiconductor devices such as MOSFETs and IGBTs. **K2**

10.(a) Explain the various semiconductor fabrication techniques such as ion implantation, oxidation, and metallization.**K2**

Or

(b) Describe the process of Chemical Vapor Deposition (CVD) and its application in semiconductor manufacturing.**K2**