25SC811 FABRICATION OF PHOTODETECTORS 4 0 0 4

Prerequisites: Basic understanding of semiconductor physics, solid-state electronics, and material synthesis techniques.

Course Objectives

The course is designed to:

1. Equip doctoral scholars with an in-depth understanding of fabrication techniques for various photodetectors.
2. Provide material-specific knowledge for II–VI semiconductors in UV-visible photodetection.
3. Explore advanced fabrication routes for flexible, quantum-dot-based, and self-powered detectors.
4. Address the synthesis, integration, and process challenges of nanowire and plasmonic photodetectors.
5. Train scholars to design, fabricate, and characterize next-generation photodetectors for targeted applications.

Course Outcomes (COs)

By the end of the course, the doctoral scholar will be able to:

- CO1: Explain and compare fabrication methodologies for different photodetector architectures.
- CO2: Fabricate and characterize II–VI semiconductor-based photodetectors for UV and visible ranges.
- CO3: Apply solution-based, flexible substrate, and QD integration methods for advanced detector fabrication.
- CO4: Synthesize and incorporate nanowires and plasmonic structures into photodetector devices.
- CO5: Develop CMOS-compatible and organic photodetector prototypes for practical applications.

UNIT 1: Fundamentals of Photodetectors (12 Hours)

Introduction to photodetection mechanisms: Photoconductive, photovoltaic, and photogating effects. Basic performance parameters: Responsivity, detectivity, noise equivalent power (NEP), quantum efficiency, Diode junctions and heterojunctions in detectors. Classification of photodetectors: Photodiodes, phototransistors, photoconductors, avalanche photodiodes. Material selection criteria for photodetectors

UNIT 2: II–VI Semiconductor Photodetectors for UV-Visible Spectrum (12 Hours)

Electronic band structure and optical properties of II–VI semiconductors. Material systems: CdTe, CdS, CdSe, ZnS, ZnSe, ZnTe. Spectral response and detection mechanisms in visible and UV range. Thin film and bulk growth techniques (CVD, MBE, CBD) for II–VI materials. Case studies on II–VI based photodetector devices

UNIT 3: Advanced Functionalities in II–VI Photodetectors (12 Hours)

Self-powered photodetectors: Mechanisms and device structures. Flexible and wearable photodetectors: Materials, substrates, and bendability issues. Solution-processed photodetectors: Spin coating, inkjet printing, ligand exchange. Quantum dots (QDs) of II–VI semiconductors: Synthesis, surface modification, and optical properties. Integration of QDs into photodetector devices

UNIT 4: Nanowire-Based Photodetectors and Plasmonics (12 Hours)

Synthesis of semiconductor nanowires (VLS, CVD, electrochemical methods). Charge transport and photoconduction in nanowires. Fabrication challenges: Alignment, contact formation, scalability. Multispectral nanowire photodetectors and their working principles. Plasmon-enhanced photodetection: Metal–semiconductor hybrid structures

UNIT 5: Emerging Photodetector Architectures and Applications (12 Hours)

Organic semiconductors and polymer-based photodetectors. CMOS-integrated photodetectors: Design, advantages, and challenges. Waveguide-integrated photodetectors for on-chip photonic systems. Real-world applications: Environmental sensing, biomedical imaging, optical communication. Future trends: Neuromorphic photodetectors, AI-integrated detection systems

EVALUATION PATTERN

Component	**Weightage**
Mid-Semester	30
Final Exam	50
Assignments, Tutorials, and Activities	20

REFERNCES

1. Photodetectors Devices, Circuits and Applications Second Edition Silvano Donati University of Pavia, John Wiley & Sons, Inc.,2021
2. Handbook of II-VI Semiconductor-Based Sensors and Radiation Detectors Volume 2, Photodetectors, Ghenadii Korotcenkov, Springer,2023
3. Photodetectors Materials, Devices and Applications, Woodhead Publishing Series in Electronic and Optical Materials: Number 84, Bahram Nabet