

UNIT IV

Radiation Sensors and Electro-Analytical Sensors

Topics Covered

- Radiation Sensors
- Photoresistors & Photodetectors
- X-ray & Nuclear Radiation Sensors
- Fibre Optic Sensors
- Electrochemical Sensors
- Reference & Sensor Electrodes
- Electroceramics in Gas Media

Image: Radiation detector and electrochemical sensor collage.

RADIATION SENSORS

Introduction to Radiation Sensors

Introduction to Radiation Sensors

Definition

Radiation sensors detect electromagnetic or particle radiation and convert it into electrical signals.

Applications

- Medical imaging
- Nuclear power plants
- Environmental monitoring
- Industrial inspection
- Communication systems

Image: Electromagnetic spectrum showing radiation regions.

Applications of Magnetic Sensors

Automotive

Aerospace

Robotics

Healthcare

Industrial Automation

Consumer Electronics

Image: Application sectors infographic

Recommended Images to Download

Use image searches for:

- 1.Magnetic field lines around magnet
- 2.Hall Effect diagram
- 3.AMR sensor structure
- 4.Magnetoresistance graph
- 5.Eddy current sensor working
- 6.Inductive proximity sensor
- 7.Rotary encoder
- 8.Synchro transmitter and receiver
- 9.Automotive Hall sensor applications
- 10.Industrial magnetic sensors

Basic Characteristics of Photoresistors

- High sensitivity to visible light.
- Low cost and simple construction.
- Nonlinear response.
- Slow response time compared to photodiodes.
- High resistance in darkness and low resistance in light.

Applications:

- Automatic street lights
- Camera exposure control
- Light intensity measurement

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1. Types of Photoresistors

2. Example: Silicon, Germanium.

1. Extrinsic Photoresistors

1. Doped semiconductor material.
2. Greater sensitivity to specific wavelengths.

Comparison Table:

Intrinsic	Extrinsic
Pure material	Doped material
Less sensitive	More sensitive
Limited spectral range	Wider spectral range

Photodetectors

- Devices that convert optical signals into electrical signals.
- Operate through photoelectric effect.

Types:

- Photodiode
- Phototransistor
- Avalanche Photodiode (APD)
- Photomultiplier Tube (PMT)

Applications:

- Optical communication
- Imaging systems
- Medical instruments

Slide 7: X-Ray Sensors

- Detect X-ray radiation and convert it into electrical signals.
- Used in:
 - Medical imaging
 - Industrial inspection
 - Security scanning

Working:Working:

interact with sensing material.

Generate electron-hole pairs.

Electrical signal proportional to radiation intensity.

Nuclear Radiation Sensors

Types:

1. Geiger-Muller Counter
2. Scintillation Detector
3. Semiconductor Radiation Detector

Features:

- Detect alpha, beta, gamma radiation.
- High sensitivity.
- Used for radiation monitoring and nuclear safety.

Applications:

- Nuclear power plants
- Medical radiation therapy
- Research laboratories

Fiber Optic Sensors – Introduction

- Sensors using optical fibers as sensing elements.
- Detect changes in light intensity, phase, wavelength, or polarization.

Advantages:

- Immune to electromagnetic interference.
- Lightweight.
- High sensitivity.
- Long-distance sensing.

Types of Fiber Optic Sensors

1. Intrinsic Fiber Optic Sensors

1. Sensing occurs inside the fiber.

2. Extrinsic Fiber Optic Sensors

1. Fiber only transmits light to and from sensing region.

Applications:

- Structural health monitoring
- Aerospace systems
- Biomedical instruments
- Oil and gas industries

Electroanalytical Sensors

- Sensors based on electrochemical principles.
- Measure electrical parameters related to chemical reactions.

Applications:

- Environmental monitoring
- Clinical diagnostics
- Industrial process control

Main Components:

- Electrochemical cell
- Reference electrode
- Working electrode
- Electrolyte

The Electrochemical Cell

Definition:

- System where chemical energy is converted into electrical energy.

Components:

- Anode (oxidation)
- Cathode (reduction)
- Electrolyte
- External circuit

Cell Reaction:

Oxidation + Reduction \rightarrow Electrical Signal

Cell Potential and Standard Hydrogen Electrode (SHE)

Cell Potential (E_{cell}):

- Voltage produced by electrochemical cell.

Standard Hydrogen Electrode:

- Reference electrode with potential defined as 0 V.
- Conditions:
 - H_2 gas at 1 atm
 - 1 M H^+ concentration
 - Temperature 25°C

Importance:

- Basis for measuring electrode potentials.

Liquid Junction and Other Potentials

Liquid Junction Potential:

- Develops when two electrolyte solutions of different concentrations meet.

Causes:

- Different ion mobilities.

Effects:

- Measurement errors in electrochemical systems.

Methods to Reduce:

- Salt bridges
- Reference electrolytes

Polarization and Concentration Polarization

Polarization:

- Change in electrode potential due to current flow.

Types:

- Activation Polarization
- Concentration Polarization
- Resistance Polarization

Concentration Polarization:

- Caused by ion concentration changes near electrode surface.
- Reduces sensor accuracy and efficiency.

Reference Electrodes and Sensor Electrodes

Reference Electrodes:

- Stable and known potential.
- Examples:
 - Standard Hydrogen Electrode (SHE)
 - Saturated Calomel Electrode (SCE)
 - Ag/AgCl Electrode

Sensor Electrodes:

- Respond to analyte concentration.
- Convert chemical information into electrical signals.

Examples:

- pH electrode
- Ion-selective electrode

Electroceramics in Gas Media

Electroceramics:

- Ceramic materials exhibiting electrical properties.

Examples:

- Zirconia (ZrO_2)
- Tin Oxide (SnO_2)

Applications:

- Oxygen sensors
- Gas leakage detectors
- Automotive exhaust monitoring

Advantages:

- High-temperature operation
- Chemical stability
- Fast response

Conclusion

- Photoresistors and photodetectors are important optical sensors.
- X-ray and nuclear radiation sensors ensure safety and imaging applications.
- Fiber optic sensors offer high sensitivity and EMI immunity.
- Electroanalytical sensors play a critical role in chemical and biological measurements.
- Electroceramic gas sensors are widely used in environmental and industrial monitoring.