Appendix-74
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# B. Sc. Physical Science (Electronics)
## Semester 6

## DISCIPLINE SPECIFIC CORE COURSE – DSC-17
## PRINCIPLES AND APPLICATIONS OF SEMICONDUCTOR TECHNOLOGY

| Course Title & Code | Credits | Credit distribution of the course | | | Eligibility Criteria | Pre-requisite of the course |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical | | |
| Principles and Applications of Semiconductor Technology DSC – 17 | 4 | 3 | 0 | 1 | Class XII pass with Physics and Mathematics as main subjects | NIL |

## LEARNING OBJECTIVES

a) Understand the Fundamentals of Transducers including definition of transducers and understanding their role in converting one form of energy to another. Classify different types of transducers based on their operating principles and applications.

b) Learn About Micro-Electro-Mechanical Systems (MEMS): Explain the basic principles and working of MEMS devices. Understand the fabrication processes used in MEMS technology. Explore applications of MEMS in various fields such as sensors, actuators, and biomedical devices.

c) Explore Nano-Electro-Mechanical Systems (NEMS): Understand the principles behind NEMS technology and its evolution from MEMS. Discuss the unique challenges and advantages of NEMS. Investigate the applications of NEMS in advanced technological solutions.

d) Study Sensor Technology: Explain the working principles of various types of sensors (e.g., temperature, pressure, chemical, optical). Understand sensor characteristics such as sensitivity, range, accuracy, and response time. Explore the integration of sensors in modern electronic systems and IoT applications.

e) Analyze Energy Storage Systems: Understand the principles of energy storage technologies, including batteries, supercapacitors and fuel cells. Discuss the materials and design considerations for efficient energy storage. Explore the applications of energy storage systems in portable electronics, electric vehicles, and renewable energy systems.

f) Investigate Organic Electronics: Explain the basic concepts and materials used in organic electronics, including organic semiconductors and conductive polymers. Understand the

fabrication techniques for organic electronic devices. Explore applications such as organic light-emitting diodes (OLEDs), organic solar cells, and flexible electronics.

By achieving these objectives, students will gain a comprehensive understanding of the principles and applications of transducers, MEMS & NEMS, sensors, energy storage systems, and organic electronics, equipping them with the skills needed for innovative research and development in these cutting-edge technologies

## LEARNING OUTCOMES

Upon successful completion of this course the students will be able to:

a) Explain the Fundamentals of Transducers: Define transducers and describe their role in converting different forms of energy. Classify and distinguish various types of transducers based on their principles and applications.

b) Understand MEMS Technology: Explain the operating principles and fabrication processes of Micro-Electro-Mechanical Systems (MEMS). Identify and analyze applications of MEMS in sensors, actuators, and biomedical devices.

c) Explore NEMS Technology: Understand the principles and challenges associated with Nano-Electro-Mechanical Systems (NEMS). Discuss the advantages and applications of NEMS in advanced technological solutions.

d) Comprehend Sensor Technologies: Explain the working principles of various sensors, including temperature, pressure, chemical, and optical sensors. Analyze sensor characteristics such as sensitivity, range, accuracy, and response time. Integrate sensors into electronic systems and IoT

applications.

e) Analyze Energy Storage Systems: Understand the principles behind different energy storage technologies, including batteries, supercapacitors, and fuel cells. Discuss the materials and design considerations for efficient energy storage solutions. Evaluate the applications of energy storage systems in portable electronics, electric vehicles, and renewable energy systems.

f) Understand Organic Electronics: Explain the basic concepts and materials used in organic electronics, including organic semiconductors and conductive polymers. Describe the

fabrication techniques for organic electronic devices. Explore applications such as organic light-emitting diodes (OLEDs), organic solar cells, and flexible electronics.

By achieving these outcomes, students will gain a comprehensive understanding and practical skills in transducers, MEMS & NEMS, sensors, energy storage systems, and organic electronics. They will be equipped to innovate and contribute to advancements in these cutting-edge technologies.

## SYLLABUS OF DSC – 17

## THEORY COMPONENT

**Unit – 1 [14 lectures]**

**Basics of Transducers**: Fundamentals of transducers, classification and general characteristics, displacement transducers, strain gauges, pressure and force transducers, transducers for biomedical applications (pulse / heart rate).

**Basics of MEMS and NEMS:** Introduction to design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems, Applications of MEMS (e.g. Micro-Cantilevers) and NEMS (e.g. Switches)

**Unit – 2** **[10 lectures]**

**Basics of Sensors:** Difference between sensor, transmitter and transducer - Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy. Classification of sensors: Physical, Chemical and Biological. Types of sensors: resistive, capacitive, inductive, electromagnetic, thermoelectric, piezoelectric, piezoresistive, photosensitive and electrochemical sensors

**Unit - 3** **[7 lectures]**

**Basics of Energy Storage:** Electrochemical energy storage devices - EMF, reversible and irreversible cells, free energy, thermodynamic calculations of the capacity of a battery. Types of batteries - Primary (Non-Rechargeable) Batteries: Alkaline Batteries, Zinc-Carbon Batteries, Lithium Batteries, Silver Oxide Batteries. Secondary (Rechargeable) Batteries: Lead-Acid Batteries, Nickel-Cadmium (NiCd) Batteries, Nickel-Metal Hydride (NiMH)

Batteries, Lithium-Ion (Li-ion) Batteries, Lithium Polymer (LiPo) Batteries, Sodium-Sulfur (NaS) Batteries

**Unit - 4** **[14 lectures]**

**Basics of Organic Electronics:** Need for organic materials in the semiconductor industry

Structure of Conducting Polymers, $\pi$-Conjugation and doping, conformational changes, Types of Conducting Polymers – Polyacetylene (PA), Polypyrrole (PPy), Polyaniline (PANI)

Structure of an OLED, Hole Injection Layer (HIL), Hole Transport Layer (HTL), Emissive Layer (EML), Electron Transport Layer (ETL), Electron Injection Layer (EIL), Working Principle, Charge Injection, Charge Transport, Recombination, Light Emission

Introduction to Silicon based solar cells, thin film solar cells, Dye sensitized solar cell, Organic solar cell: Structure of an Organic Solar Cell, Substrate, Anode, Hole Transport Layer (HTL), Photoactive Layer, Donor and acceptor Material, Bulk hetero junction devices, Light Absorption, Exciton Diffusion, Charge Separation, Charge Transport, Charge Collection

**PRACTICAL COMPONENT – 30 Hours**

(Any 6 to be performed)

1. Study of High Precision Resistance Strain Gauge characteristics.
2. Study of Force Sensor characteristics.
3. Study of Piezoresistive Sensor characteristics.
4. Study of Piezoelectric Sensor characteristics.
5. Study of Pulse Sensor / Heart Rate Sensor characteristics.

6. Study of gas sensor characteristics.
7. Study of solar cell characteristics.
8. Study of photodiode characteristics.
9. Study of LIDAR characteristics

**Texts/References:**


1. Suganuma Katsuaki, Introduction to Printed Electronics, Springer, 2014.
2. Stergios Logothetidis, Handbook of Flexible Organic Electronics - Materials,Manufacturing, and Applications, 1st Ed., Woodhead Publishing, 2014.
3. Eugenio Cantatore, Applications of Organic and Printed Electronics: A Technology Enabled Revolution, Springer, 2012.
4. Wolfgang Brütting and Chihaya Adachi, Physics of Organic Semiconductors, 2ndEd., Wiley-VCH, 2012.
5. Anna Köhler and Heinz Bässler, Electronics Processes in Organic Semiconductors -An Introduction, 1st Ed., Wiley-VCH, 2015.
6. Wenping Hu, Organic Optoelectronics, 1st Ed., Wiley-VCH, 2013.
7. Sam-Shajing Sun and Larry R. Dalton, Introduction to Organic Electronic and Optoelectronic Materials and Devices, 2nd Ed., CRC Press, 2015.
8. Franky So, Organic Electronics: Materials, Processing, Devices, and Applications, CRC Press, 2010.