24MS804 Advanced Energy Harvesting and Storage Technologies 4-0-0-4

Course Objectives

The objective of the course is to provide an overview of various advanced energy harvesting and storage technologies. The working principles, selection of materials, parameters that are to be considered in selecting the materials and key challenges to improve performance of the energy harvesting and storage devices/techniques will be covered in the course.

On successful completion of the course, the students will be able to:

CO 1:	Evaluate the performance of different energy storage systems on the basis of capacities, energy density, power density, cycling stability etc. and compare their applicability for various applications based on performance.
CO 2:	Assess the suitability of materials and fabrication techniques for energy storage devices.
CO 3:	Select materials and process variables for hydrogen production and storage systems.
CO 4:	Illustrate design considerations and identify materials for energy harvesters for various applications.

Energy Storage: Basic principles of energy conversion and storage, Types of energy storage (chemical, electrical, mechanical, thermal, etc.), Electrochemical energy storage- Principles; Energy storage in batteries, capacitors and supercapacitors. Classification of batteries, battery materials and battery fabrication. Introduction to supercapacitors (electrochemical double-layer capacitor, pseudocapacitor and hybrid capacitors), Calculation of capacities, energy and power densitie . Comparison of various energy storage systems on the basis of power rating, discharge time, storage duration, energy efficiency, energy density, power density, cycling stability etc. Nanomaterials used for energy storage, key challenges for energy storage, Solution of key challenges.

Hydrogen Energy conversion and Storage : Introduction to hydrogen/oxygen evolution reactions (HER/OER), Mechanisms and kinetics of HER and OER, Catalysts and materials for enhancing HER/OER efficiency; Hydrogen production methods- electrolysis-Thermal Decomposition of Water-Chemical Reactions. Methods of hydrogen storage (compression, liquefaction, adsorption), Materials for hydrogen storage (metal hydrides, porous materials), Challenges and advancements in hydrogen storage technology. Transportation of Hydrogen and efficiency of different transportation techniques. Green energy and production.

Energy harvesters : Overview of energy harvesting principles and applications. Comparison of energy harvesting techniques with traditional energy sources (wind, solar), Environmental considerations and sustainability in energy harvesting. Principles, materials, working mechanism, design considerations and applications of Piezoelectric, Thermoelectric, Pyro-electric,

Electromagnetic, and Triboelectric energy harvesting. Key challenges for choosing nanomaterials for nanogenerators.

References

1. Energy Storage Systems in Electronics", Tetsuya Osaka, Madhav Datta , 1st ed., CRC Press, 2000.
2. Hydrogen Production Technologies, Mehmet Sankir, Nurdan Demirci Sankir, 1st Edn., Wiley, Scrivener Publishing LLC (2017).
3. Emerging Nanotechnologies in Recahrgeable Energy Storage Systems, L. R. Martinez and N. Omar, 1st Edition, Elsevier (2017).
4. Handbook of Hydrogen Storage: New Materials for Future Energy Storage edited by Michael Hirscher, Wiley-2010.
5. Lithium Batteries, G. A. Nazri and G. Pistoia, Springer, 2009.
6. Nanogenerators: Basic Concepts, Design Strategies, and Applications, edited by Inamuddin, Mohd Imran Ahamed, Rajender Boddula, Tariq Altalhi, CRC Press, 2023
7. S. Wazed Ali, Satyaranjan Bairagi, Shahid Ul Islam Hybrid Materials for Piezoelectric Energy Harvesting and Conversion, 1st edition Wiley; (2024)

Evaluation

Mid Term Examination : 30 marks

Continuous Assessment* : 30 marks

End Semester Examination : 40 marks

* Continuous assessment can be through assignments, quizzes, viva and course project.