Course on

Energy Materials and Devices

(Credits :2+1; Total : 3), Total hours: 45, Class room :30, Practical: 15

Instructors: Prof. G. U. Kulkarni, Dr. S. Angappane, Dr. Neena S John, Dr. Pralay K Santra, Dr. Ramakrishna Matte and Dr. A. K. Singh

Class	Sub-Topic	Content	hour	Instructor	Date	Time
1)	General introduction-I	Energy units, Energy requirements, Natural sources, Renewable and non-renewable sources, Energy generation, storage, conversion and transport, Course syllabus. Types of energy devices – generation, storage, conversion and transport, Concepts, definitions and essential performance parameters.	1.5	Prof. G. U. Kulkarni	Mar 23, 2021	11.30AM-1.00 PM
2)	General introduction-II	Types of energy devices - Electrodes and active materials, Carbon and related electrodes, Transparent conducting electrodes, generation, storage, conversion and transport, Concepts, definitions and essential performance parameters, Electrodes and active materials, Carbon and related electrodes, Transparent conducting electrodes	1.5	Prof. G. U. Kulkarni	Mar 29, 2021	11.30AM-1.00 PM
3)	General introduction-III	Thin film deposition, metals and oxides, electrode design, optical lithography and related fabrication techniques	1	Dr. S. Angappane	Apr 01, 2021	11.30AM-12.30 PM
4)	Electrocatalysis and photo electrocatalysis-I	Introduction to hydrogen as a green fuel, Water splitting technologies for hydrogen and oxygen generation, Electrochemical water splitting; free energy adsorption, volcano plot, Basic reaction mechanism and Catalyst design.	1	Dr. Neena S John	Apr 06, 2021	11.30AM-12.30 PM
5)	Batteries-I	Basic electrochemical concepts and definitions, Primary and secondary batteries, Principle of operation, Conventional batteries	1	Dr. H. S. S. R. Matte	Apr 08, 2021	11.30AM-12.30 PM
6)	Supercapacitors-I	Capacitor & supercapacitor, Concept of EDLC, Electrodes and electrolytes for supercapacitors, Fabrication processes	1	Dr. A. K. Singh	Apr 15, 2021	11.30AM-12.30 PM
7)	Supercapacitors-II	Measurements- CV and CD curves, priming & cycling, time scales, energy and power densities, coulombic efficiency, self-discharge & charge retention, long term stability, impedance	1	Dr. A. K. Singh	Apr 20, 2021	11.30AM-12.30 PM
8)	Student seminars		3	All instructors	Apr 22, 2021	10.00AM-1.00 PM
9)	Photovoltaic devices -1(a)	Working principle, Device structure and assembly, Broad classification of solar cells, Important parameters in photovoltaics (Describing J-V characteristics, Spectral response-EQE & IQE), Shockley-Queisser limit, photon management) Working Principle (Mechanisms of charge separation and transport: Junctions, energy and electron transfer)	1	Dr. P. K. Santra	Apr 27, 2021	11.30AM-12.30 PM
10)	Photovoltaic devices -1(b)	Working principle, Device structure and assembly, Broad classification of solar cells, Important parameters in photovoltaics (Describing J-V characteristics, Spectral response-EQE & IQE), Shockley-Queisser limit, photon management) Working Principle (Mechanisms of charge separation and transport: Junctions, energy and electron transfer)	1	Dr. P. K. Santra	Apr 29, 2021	11.30AM-12.30 PM

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Class	Sub-Topic	Content	hour	Instructor	Date	Time
11)	Photovoltaic devices –III (a)	Thin Film Solar Cells: DSSC–oxides and dyes, Perovskites and Tandem solar cells, Fabrication processes, Energy level diagrams, factors affecting the photovoltaic performance, exciton diffusion length, charge transport and band gap, Typical characteristics and spectral response, Technology limitations, Comparison of the technologies.	1	Dr. P. K. Santra	May 04, 2021	11.30AM-12.30 PM
12)	Supercapacitors-III	Pseudo and asymmetric supercapacitors, Microsupercapacitors, Li-ion capacitors, comparison of performances and application areas	1	Dr. A. K. Singh	May 06, 2021	11.30AM-12.30 PM
13)	Photovoltaic devices -II	Silicon solar cells - single & polycrystalline, Device configuration, Energy level diagram & mechanisms, Typical characteristics and spectral response, Fabrication processes & manufacturing, Technology limitations.	1	Dr. S. Angappane	May 11, 2021	11.30AM-12.30 PM
14)	Batteries-II	Li-ion and other batteries, Battery components and design of electrodes, cell and battery fabrication	1	Dr. H. S. S. R. Matte	May 13, 2021	11.30AM-12.30 PM
15)	Electrocatalysis and photo electrocatalysis-II	Measurement modes: Cyclic voltammetry, Linear sweep voltammetry, Chronopotentiometry, Chronoamperometry, Impedance spectra, Tafel plot, Electrochemical cell design, Figures of merit.	1	Dr. Neena S John	May 18, 2021	11.30AM-12.30 PM
16)	Photovoltaic devices -IV	Organic solar cells - Donor-acceptor, heterojunction and bilayer, Fabrication processes, Energy level diagrams &mechanisms of charge separation and transport- junctions, energy transfer and electron transfer, Typical characteristics and spectral response, Technology limitations.	1	Dr. H. S. S. R. Matte	May 20, 2021	11.30AM-12.00 PM
17)	Batteries-III	Measurements- CD curves, priming &cycling, time scales, energy and power densities, charge retention, long term stability, comparison of performance	1	Dr. H. S. S. R. Matte	May 25, 2021	11.30AM-12.30 PM
18)	Photovoltaic devices – III(b)	Thin Film Solar Cells: DSSC–oxides and dyes, Pervoskites and Tandem solar cells, Fabrication processes, Energy level diagrams, factors affecting the photovoltaic performance, exciton diffusion length, charge transport and band gap, Typical characteristics and spectral response, Technology limitations, Comparison of the technologies.	1	Dr. P. K. Santra	Jun 03, 2021	11.30AM-12.30 PM
19)	Batteries-IV	Building block cells, battery modules and packs, Voltage and current management, All solid state batteries & new concepts in Batteries beyond lithium, smart batteries	1	Dr. H. S. S. R. Matte	Jun 08, 2021	11.30AM-12.30 PM
20)	Electrocatalysis and photo electrocatalysis-III	Basics of the photocatalytic mechanisms of water and other related systems, Energy level diagram, Photochemical cell designs, fabrication and performance analysis, oxide and non-oxide semiconductors materials for water splitting	1	Dr. Neena S John	Jun 10, 2021	11.30AM-12.30 PM
21)	Electrocatalysis and photo electrocatalysis-IV	Photoelectrochemical water splitting; concepts, catalyst and cell design and CO_2 Reduction	1	Dr. Neena S John	Jun 15, 2021	11.30AM-12.30 AM

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22)	Supercapacitors-IV	Building supercappacks, Voltage and current management, Hybrid battery-supercap device, electric mobility	1	Dr. A. K. Singh	Jun 17, 2021	11.30AM-12.30 PM
23)	Student seminars		3	All instructors	Jun 22, 2021	10.00AM-1.00 PM
24)	Fuel cells-I	Basic concepts; Types of fuel cells, Fuels for fuel cell, Catalysts, Membranes Fuel cell design	1	Dr. S. Angappane	Jun 24, 2021	11.30AM-12.30 PM
25)	Fuel cells-II	Basic concepts; Types of fuel cells, Fuels for fuel cell, Catalysts, Membranes Fuel cell design	1	Dr. S. Angappane	Jun 29, 2021	11.30AM-12.30 PM
26)	Final Exam		1		July 22, 2021	

S. No	Lab	Instructor	Date	Duration	Time
1	**Photolithography (**Fabrication of micrometer metal electrodes using Projection lithography**)**	Dr. S. Angappane	July 1, 2021	3	2.00 PM-5.00 PM
2	**Photovoltaic devices (** Comparing the characteristics of Silicon cell vs Perovskite cell by JV and EQE**)**	Dr. P. K. Santra	July 6, 2021	3	2.00 PM-5.00 PM
3	**Battery (**Commercial battery vs Lab fabricated battery with CCD and rate capabilities)	Dr. H. S. S. R. Matte	July 8, 2021	3	2.00 PM-5.00 PM
4	**Supercapacitors (**Electrode preparation for two electrode and three electrode based supercapacitor, Preparation of electrolytes (acidic, basic and neutral medium) Measurements (CV, CCD, Impedance and cycling)**)**	Dr. A. K. Singh	July 13, 2021	3	2.00 PM-5.00 PM
5	**Electrocatalysis** (HER electrocatalysis and OER demo)	Dr. Neena S John	July 15, 2021	3	2.00 PM-5.00 PM