

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

Course Code: CeNS-ED

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	1	Prof. G. U. Kulkarni	28 Jan 2020	11.30AM-12.30 PM
2)	General introduction-II(a)	Types of energy devices – generation, storage, conversion and transport, Concepts, definitions and essential performance parameters, Electrodes and active materials, Carbon and related electrodes, Transparent conducting electrodes	1	Prof. G. U. Kulkarni	30 Jan 2020	11.30AM-12.30 PM
3)	General introduction-II(b)	Types of energy devices – generation, storage, conversion and transport, Concepts, definitions and essential performance parameters, Electrodes and active materials, Carbon and related electrodes, Transparent conducting electrodes	1	Prof. G. U. Kulkarni	4 Feb 2020	11.30AM-12.30 PM
4)	General introduction-III	Thin film deposition, metals and oxides, electrode design, optical lithography and related fabrication techniques	1	Dr. S. Angappane	6 Feb 2020	11.30AM-12.30 PM
5)	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	13 Feb 2020	11.30AM-12.30 PM
6)	Photovoltaic devices - I(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	18 Feb 2020	11.30AM-12.30 PM
7)	Supercapacitors-I	Capacitor & supercapacitor, Concept of EDLC, Electrodes and electrolytes for supercapacitors, Fabrication processes	1	Dr. A. K. Singh	20 Feb 2020	11.30AM-12.30 PM
8)	Thermoelectrics-I	Introduction to Electrical Conductivity, Seebeck Coefficient, Thermal Conductivity, Lattice Thermal Conductivity, Figure of Merit. Types of Thermoelectric Materials, Concept of Charge Carriers, Phonons Scattering.	1.5	Prof. K. Biswas	25 Feb 2020	11.30AM-1.00 PM
9)	Thermoelectrics-II	Materials synthesis, Measurements, Device Fabrication and Applications	1.5	Prof. K. Biswas	27 Feb 2020	11.30AM-1.00 PM
10)	Student seminars		1	All instructors	5 Mar 2020	11.30AM-12.30 PM
11)	Batteries-I	Basic electrochemical concepts and definitions, Primary and secondary batteries, Principle of operation, Conventional batteries	1	Dr. H. S. S. R. Matte	10 Mar 2020	11.30AM-12.30 PM
12)	Photovoltaic devices - I(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	12 Mar 2020	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	17 Mar 2020	11.30AM-12.30 PM

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14)	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	19 Mar 2020	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	24 Mar 2020	11.30AM-12.30 PM
16)	Batteries-II	Li-ion and other batteries, Battery components and design of electrodes, cell and battery fabrication	1	Dr. H. S. S. R. Matte	31 Mar 2020	11.30AM-12.30 PM
17)	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	2 April 2020	11.30AM-12.30 PM
18)	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	7 Apr 2020	11.30AM-12.00 PM
19)	Supercapacitors-III	Pseudo and asymmetric supercapacitors, Microsupercapacitors, Li-ion capacitors, comparison of performances and application areas	1	Dr. A. K. Singh	9 Apr 2020	11.30AM-12.30 PM
20)	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	16 Apr 2020	11.30AM-12.30 PM
21)	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	23 April 2020	11.30AM-12.30 PM
22)	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	5 May 2020	11.30AM-12.30 PM
23)	Supercapacitors-IV	Building supercappacks, Voltage and current management, Hybrid battery-supercap device, electric mobility	1	Dr. A. K. Singh	12 May 2020	11.30AM-12.30 PM
24)	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	14 May 2020	11.30AM-12.30 PM
25)	Electrocatalysis and photo electrocatalysis-IV	Photoelectrochemical water splitting; concepts, catalyst and cell design and CO ₂ Reduction	1	Dr. Neena S John	19 May 2020	11.30AM-12.30 AM
26)	Student seminars		1.5	All instructors	21 May 2020	11.30AM-1.00 PM

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27)	Fuel cells-I	Basic concepts; Types of fuel cells, Fuels for fuel cell, Catalysts, Membranes Fuel cell design	1	Dr. S. Angappane	26 May 2020	11.30AM-12.30 PM
28)	Fuel cells-II	Basic concepts; Types of fuel cells, Fuels for fuel cell, Catalysts, Membranes Fuel cell design	1	Dr. S. Angappane	28 May 2020	11.30AM-12.30 PM
29)	Final Exam		1		2 June 2020	

S.No	Lab	Instructor	Date	Duration	Time
1	Photolithography (Fabrication of micrometer metal electrodes using Projection lithography)	Dr. S. Angappane	11 Feb 2020	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	14 Apr 2020	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	28 Apr 2020	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	21 Apr 2020	3	2.00 PM-5.00 PM
5	Electrocatalysis (Modifying Glassy carbon electrode with active materials, customized electrode preparation using carbon paper and mounting on electrode holder, three electrode set up for electrocatalysis, HER electrocatalysis using Pt/C and measuring evolved hydrogen using micro GC; OER using RuO ₂ .)	Dr. Neena S John	12 May 2020	3	2.00 PM-5.00 PM