EECEVAC04 - SOLAR CELL DESIGN AND FABRICATION

UNIT I : Concepts of Solar energy: the sun, Available solar energy from the sun, insolation vs. world energy demand, Blackbody radiation, Planck's Radiation Law, Wien's displacement Law, Stefan Boltzmann Equation, spectral distribution of extraterrestrial and terrestrial radiations, solar constant, properties of solar radiation Sun-Earth Geometry: Motion of the earth relative to the sun, Apparent motion of the sun relative to a fixed observer on the earth, Air Mass, estimation of available solar radiation on earth, absorption of solar radiation by earth's atmosphere, direct, diffused and albedo components of sunlight, solar radiation table, global radiation data. Mean annual irradiance on horizontal surface across the world, Effects of latitude, declination, slope, surface azimuth angle, hour angle, and the angle of incidence. Radiation on an inclined surface: direct, reflected, and diffused radiations, radiation on inclined surfaces, calculation of angles of incidence, direction of beam radiation, angles for tracking surfaces, ratio of beam radiation on tilted surface to that of horizontal surface

UNIT II: Photovoltaic technology: Introduction to PV, conversion of solar radiation to electrical energy, PV sizing for meeting the world's energy need, how much land area is needed, advantages and disadvantages of PV systems. Reliability and sizing of the PV/PT systems, uncertainty and risk factors in PV/PT design, Cost analysis, Terawatt challenge, Energy payback, different options of PV modules, thin film solar cells. Light absorption, Direct-bandgap and indirect bandgap semiconductors, light absorption coefficient, Reflection and reflection losses, Absorption as a function of photon energy, Carrier transport.

UNIT III : Performance parameters of PV cells: Fundamental principles of solar cell operation, Solar cell device physics, Basic structure of solar cells, Quasi Fermi energy levels, Law of junctions, Carrier generation rate, Recombination rate, Dark current, Light generated current, Current-voltage (I-V) relationship. Solar cell output parameter, Fill factor, solar cell efficiency, Short circuit current, Open circuit voltage, Maximum power point operation, Effect of finite width of the solar cell, Solar cell equivalent circuit, Effect of bandgap, maximum thermodynamic efficiency. Practical efficiency limit, Losses in short circuit current, open circuit voltage, efficiency, Temperature effects, Fill factor losses, I-V characteristic measurement, Efficiency measurement, Parasitic resistances, Effects of series and shunt resistances

UNIT IV: Solar cell module design and fabrication: Silicon solar cells to Photovoltaic Module (PV) production, Cell fabrication and interconnections, Top and Bottom connections, Manufacturing process, Cell matrix, encapsulation, vacuum lamination, Post-lamination steps, Bifacial modules, Electrical and optical performance of modules, Local shading and hot spot formation, Field performance. Introduction to concentrated Solar Power (CSP) systems, Energy generation and capacity factor, Tracking requirements,

Photovoltaic and solar thermal concentrators, concentrator optics, solar collectors for CSP systems. concentrated Photovoltaic (CPV) systems: Principles and Practices, Fresnel lens, tracking systems. CPV modules, and engineering practices for CPV solar plants.

UNIT V: Performance evaluation of solar modules: Measurements and characterization of solar cells and PV modules, V – I characteristics, spectral response measurements, measurements and characterization of thin film solar cells Domestic, industrial and commercial applications, Lifetime of the PV modules, Degradation caused by UV radiation, Moisture penetration, Corrosion, Dust deposition/soiling losses, Reflection losses, Thermal effects, Delamination of the module, prevention of energy yield losses.

REFERENCES:

1]. BU Barnes and Noble book store "Solar Cells: Operating Principles, Technology and System Applications", Martin Green published by the University of New South Wales, 1980 (Required)
2]. John A. Duffie and William A.Beckman "Solar Engineering of Thermal Processes", Fourth Edition, John Wiley and Sons. Inc. 2005 (Chapters 1, 2, 3, and 7) Recommended
3]. Antonio Luque and Steven Hegedus "Photovoltaic Science and Engineering Handbook", Second Edition, John Wiley and Sons, 2012 An excellent Resource
4]. Jeff Poortmans and Vladimir Arkhipov "Thin film Solar Cells", (Ed) John Wiley and Sons Ltd. 2006
5]. Stephen J. Fonash "Solar Cell Device Physics", Second Edition, Elsevier, Inc., 2010
6]. Thomas Markvart (Editor) "Solar Electricity", Second Edition,John Wiley and Sons, Ltd., 2000.
7]. Keith Lovegrove and Wes Stein, Woodhead "Concentrating Solar Power Technology, principles, developments and applications", Publishing series in Energy, Woodhead Publishing, 1518 Walnut Street, Suite 1100, Philadelphia, PA 19102-3406, USA 2012
8]. www.pveducation.org