Photovoltaics
Specialisation Syllabus

Contents:

Cell and Module Technology (compulsory / examinable)
Syllabus
Semiconductor Materials
Important semiconductor materials Conduction theory, E-k curves, energy bandgaps, effective mass, direct and indirect transitions. Carrier statistics, intrinsic and extrinsic behaviour, mobility, diffusion, scattering. Equilibrium and non-equilibrium behaviour, recombination Optical and thermal properties.
Semiconductor Devices
Important solar cell devices. P-n junctions, depletion region, derivation of I-V characteristics in the dark. Ideal diode under illumination, optimum bandgap, current and voltage dependence on illumination and temperature. Loss mechanisms for real diodes, recombination, series and shunt resistance, interface states. Heterojunctions, Anderson model, current transport models, window layers. Introduction to multijunction concepts.
Material Fabrication Technologies
Purification of silicon, zone refining and gettering, segregation coefficient. Growth of crystalline silicon, Bridgmann, Czochralski and floating zone methods. Epitaxial growth methods, MBE, MOCVD, LPE, VPE. Thin film deposition methods, evaporation, sputtering, wet chemical, spray pyrolisis, screen printing.
Device Fabrication
Doping, alloying, diffusion and implantation. Device processing methods. Deposition of anti-reflection coatings. Photolithography. Dry and wet etching. Surface texturing and passivation techniques.
Laboratories Semiconductor properties, devices and fabrication
Assessment Coursework and examination
Learning outcomes
The student will ♦ be able to discuss the properties of semiconductors which are important for PV applications. ♦ be able to describe the important PV devices. ♦ have a good understanding of semiconductors in equilibrium and non-equilibrium situations, homojunction and heterojunction solar cell devices and the differences between ideal and real devices. ♦ understand the need for purity and minimisation of crystal imperfections for making high performance devices. ♦ be able to describe and discuss the pros and cons of bulk crystal growth, epitaxial and low cost thin film deposition methods. ♦ at an introductory level outline how to make important solar cell devices.

Advanced Cell Design (compulsory / examinable)
Syllabus
Cell and Module Concepts
Flat plate and concentrator cells and modules. Multijunction concepts. Overview of cell types and technology status.
Advanced Devices
High efficiency crystalline silicon designs. Passivation, light trapping and contact structures. Cost reduction strategies. III-V devices, high concentration, quantum wells devices, multijunction structures, thermophotovoltaic devices. Thin film solar cells, structures and fabrication, novel device designs.
Characterisation Methods
Material characterisation, X-ray diffraction, optical characterisation, minority carrier lifetime and diffusion length measurement. Cell measurement, solar simulation, conversion efficiency and spectral response. I-V-T and C-V-f measurements. Measurement and performance standards.
Laboratories Device operation and characterisation
Assessment Literature review for a chosen cell category and examination.
Learning outcomes
Students will be able to: ♦ discuss the principles of operation and design of PV devices. ♦ discuss the main fabrication methods for advanced PV devices. ♦ describe and use the main characterisation methods used with semiconductor materials and PV devices.

Photovoltaic System Technology (compulsory / examinable)
Syllabus
Basic system design
PV arrays, electrical connections and wiring issues BOS components Overview of stand alone and grid connected systems System sizing
Stand alone systems
Applications Performance assessment Standards and regulations
Grid connected systems
Inverter systems, electrical supply issues Grid connection regulations Harmonic content, reactive power, wiring issues Design of large scale systems
Building integrated systems
System design and sizing Energy in buildings, building components Installation and operation
Concentrator systems
Design of concentrator systems Operation and maintenance
Monitoring and performance
Monitoring specifications Yield and performance ratio, MTBF Operational issues and maintenance Standards for construction and operation Regulations governing system design and operation Health and safety issues
Space systems
Array configurations Quality control and assessment Design of systems
Assessment
Design project and examination
Learning outcomes
The student will: • Be able to complete basic design of both stand alone and grid connected systems • Understand the requirements for construction, electrical connection and operation of systems • Have experience of analysing system performance

Economics, Policy and Environment (compulsory / examinable)
Syllabus
Economic Analysis
Economic theory Production economics Subsidies and tariff issues Financing mechanisms
Policy Issues
Market development Government policies Climate change issues
Environmental Impact Assessment
Module production Energy analysis Life cycle analysis CO_2 emissions
Assessment
Dissertation
Learning outcomes
The students will: • Have an understanding of the economics of photovoltaic systems and their comparison with other electricity sources • Be able to perform an environmental impact assessment or energy analysis for a PV system