The University Of Sheffield.

Electronic & Electrical Engineering.

EEE337 SEMICONDUCTOR ELECTRONICS

Credits: 10

Course Description including Aims

1. Review semiconductor band structure, doping, conduction, junctions
2. Introduce the various electronic material systems (Si, Ge, III-V, GaN) and outline their electronic properties and principal applications
3. Introduce different semiconductor alloys and heterojunctions used in electronic devices.
4. Demonstrate performance and functional improvements possible using alloys and heterojunctions.
5. Review Solar Cell developments encompassing single and multijunction, as well as thin film solar cells.
6. Introduce optical detector technologies and applications for different wavelength ranges
7. Explore heterostructure optoelectronic devices such as Lasers, LEDs
8. Introduce high speed electronic devices for microwave applications

Outline Syllabus

Fundamental Properties: Band structure, doping, carrier concentrations, generation and recombination processes, transport properties, p-n homojunctions, heterojunctions. **Semiconductor Materials:** review of whole family of semiconductors, specific electronic properties, chemical properties, main applications. **Solar Cells:** materials, device structure types, efficiencies, projections. **Optoelectronic devices:** LEDs, Lasers, detectors, figures of merit, applications and wavelengths. **High Speed Devices:** IMPATT, tunnel diodes, Gunn diodes, negative differential resistance, comparison of performance.

Time Allocation

24 lectures, 73 hours guided independent study.

Recommended Previous Courses

Knowledge equivalent to EEE118, EEE225.

Assessment

3 out of 4 questions, 2 hour examination.

Recommended Books

AUTHOR	BOOK TITLE	PUBLISHER
Simon Sze and Ming-Kwei Lee	Semiconductor Devices Physics and Technology	Wiley
S.M.Sze and Kwok K. Ng	Physics of Semiconductor Devices	Wiley
Streetman and Banerjee	Solid State Electronic Devices	Prentice Hall
David Pulfrey	Understanding Modern Transistors and Diodes	Cambridge

Objectives

By the end of this module students will be able to

1. Demonstrate an understanding of how semiconductors are used to make functional electronic and optoelectronic devices in common use today
2. Articulate the differences between the various semiconductors and why they are used in specific applications
3. Discuss the role of heterojunctions in optoelectronic devices, the range of materials available and the wavelengths covered
4. Demonstrate awareness of the various solar cell materials and designs to achieve cost effectiveness and efficiency
5. Identify and justify detector technologies according to applications
6. Demonstrate understanding of how LEDs and Lasers operate.
7. Demonstrate an understanding of speed-related issues of microwave devices
8. Show an awareness of current and potential future technologies for microwave devices

Detailed Syllabus

lecture	topic
1-3	Crystals, band structure, transport, semiconductor materials and their properties,
4-5	Carrier generation and recombination processes
6-7	Solar Cells operating principles, materials and technologies
8-10	Photodetector technologies for high speed applications, APDs and Infrared detection
11-12	Discussion and revision of previous topics
12-13	LEDs operating principles, use of quantum wells, blue and white LEDs
14-17	Lasers operating principles, DFB, quantum wells, quantum dots
18-20	Microwave devices, negative differential resistance, IMPATT diodes
21-22	Tunnel diodes and Gunn Diodes
23-24	Revision

EEE337 UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p/SM1m	Underlying materials, bandstructure and control of carriers in electronic devices made using different semiconductors ranging from single element Silicon to III-V and II-VI compound semiconductors.
EA1p/EA1m	Analysis, evaluation and design of electronic devices. Key design features to optimise absorption of light in solar cells, emission of light and high speed transport, are analysed.

EA2p/EA2m	Analytical modelling of semiconductor devices, such as quantum efficiency in solar cells and photodiodes, as well as emission efficiency in LEDs and Lasers.
EA4p/EA4m	Appreciation of systems application of devices such as use of negative differential resistance to tune circuit response.
D5p/D5m	Cost/efficiency evaluation of solar cells and photodetectors. Factors including material and manufacturing cost and fundamental limitation of semiconductor materials are analysed.
ET4p/ET4m	Sustainable energy consideration in solar cells and efficient LEDs and Lasers. Consideration of cost of manufacturing versus performance of solar cells are included. Techniques to minimise the threshold currents in LEDs and Lasers to reduce energy consumption are also discussed.
EP2p/EP2m	Materials studies for various semiconductor devices, detailed characteristics of solar cells such as detailed analysis of PERL solar cell.
EP1p/EP1m	Semiconductor materials and device manufacturing for Silicon and compound semiconductors.
EP4p/EP4m	Reference to technical publications to highlight current state of the art performance in semiconductor devices.
EP8p/EP8m	Comparison with predicted and real published data, related to EA2p.
EA2m/EA2p	Selection of semiconductor materials for different applications and prediction of their performance using analytical methods
D5i	Understanding of trade-off between performance and manufacturing cost of components such as solar cells and photodetectors

These learning outcomes are assessed in a written examination.