ES2D6-15 Semiconductor Materials and Devices

22/23

Department
School of Engineering
Level
Undergraduate Level 2
Module leader
Tim Ashley
Credit value
15
Module duration
10 weeks
Assessment
40% coursework, 60% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES2D6-15 Semiconductor Materials and Devices

Module web page

Module aims

To present, in context, the fundamental properties of semiconductor materials and devices. Students will study fundamental aspects of semiconductor material properties and how these link to device operation, including pn-junction diodes, bipolar transistors, field effect transistors, solar cells, light-emitting diodes and diode lasers, and thermoelectric and piezoelectric devices. Students will study the basic theory that underpins material properties and the device operation. Students will also study basic fabrication methods; basic electronic structure theory and electronic transport theory;basic principles of low-dimensional nanodevices; and the basics of semiconductor material and device simulation. The aim being to encourage development of problem solving and modelling skills in order that more advanced concepts related to devices can be tackled in later years.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Physics of doped semiconductor materials extending beyond silicon
- Energy bands, density of states, Fermi distributions, occupancy
- Description of mobility and generation-recombination effects
- Behaviour of diodes, including optoelectronic devices
- Behaviour of bipolar and field effect transistors
- Growth and fabrication technology for electronic devices
- Drift-diffusion transport including continuity equation
- Ballistic transport
- Introduction to simulation techniques
- Thermoelectric transport, Peltier and Seebeck effects
- Advanced device concepts

Learning outcomes

By the end of the module, students should be able to:

- Critically understand the interaction of different physics in providing new properties and device operation concepts.
- Solve problems (including numerically) in semiconductor materials and devices.
- Understand the operation of realistic devices and the effect of non-idealities.
- Consolidate knowledge of the electronic properties and behaviour of semiconductor materials.
- Analyse the operation of electronic devices (diodes, FETs, BJTs, solar cells, thermoelectrics etc.) from the bottom up
- Evaluate the fundamental parameters controlling the properties of semiconductor materials.

Indicative reading list

S. O. Kasap, Principles of Electronic Materials and Devices, 4th edition McGraw Hill, published 25/04/2017, ISBN 9780078028182, essential

Guide to state-of-the-art electron devices
Ed: Joachim N. Burghartz; IEEE Electron Devices Society John Wiley & Sons Inc., published 2013, ISBN
9781118347263, further reading

Physics of semiconductor devices
S.M. Sze and Kwok K. Ng; 3rd ed., Hoboken, N.J. : Wiley-Interscience, published 2007, ISBN Print 9780470068328, ISBN Ebook 9780470068304, further reading

Semiconductor device fundamentals
Robert F. Pierret, Addison-Wesley c1996, ISBN 0201543931, 0131784595, 9780201543933, 9780131784598, further reading

Lessons from nanoelectronics: a new perspective on transport, Part A: basic concepts
Supriyo Datta' 2nd ed., World Scientific Publishing, published 2017, ISBN 9813209747, 9789813209749, further reading

The Oxford solid state basics
Steven H. Simon, Oxford University Press, Incorporated, published 16-08-2013, Print ISBN 9780199680764, Ebook ISBN 9780191502101 further reading

Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, 7th edition, Pearson Education, 2015, further reading

The Feynman lectures on physics
Richard P. Feynman; Robert B. Leighton; Matthew L. Sands; Michael A. Gottlieb, Pearson/Addison-Wesley, published c2006, ISBN 0805390456, 0805390464, 0805390472, 0805390499, 0805390634, further reading

Interdisciplinary

Spans the boundaries of Physics and Electronic Engineering, integrating fundamental physics concepts into design, analysis and use of practical electronic components.

Subject specific skills

1. Plan the semiconductor device design process, evaluating outcomes, and working with technical uncertainty.
2. Knowledge and understanding of the need for a high level of professional and ethical conduct in engineering and the use of technical literature, other information sources and industry standards.
3. Ability to apply relevant practical and laboratory skills.

Transferable skills

1. Numeracy: apply mathematical and computational methods to communicate parameters, model and optimize solutions.
2. Apply problem solving skills, information retrieval, and the effective use of general IT facilities.
3. Communicate (written and oral; to technical and non-technical audiences) and work with others.
4. Plan self-learning and improve performance, as the foundation for lifelong learning/CPD.
5. Overcome difficulties by employing skills, knowledge and understanding in a flexible manner.

Study

Study time

Type	Required	Optional
Lectures	30 sessions of 1 hour (20%)	
Tutorials	(0%)	10 sessions of 1 hour
Practical classes	2 sessions of 4 hours (5%)	
Other activity	4 hours (3%)	
Private study	108 hours (72%)	
Total	150 hours	

Private study description

78 hours of guided independent learning

Other activity description

- 2 x 1 hr = 2 hours revision lectures
- 2 x 1hr = 2 hours computer-based formative test

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group D4

	Weighting	Study time
Laboratory Report Written Report	40%	
Online Examination 2 x 1 hour QMP online examination ~Platforms - QMP	60%	

- Online examination: No Answerbook required
- Students may use a calculator
- Engineering Data Book 8th Edition
- Graph paper

Feedback on assessment

- Support through advice and feedback hours.
- Written feedback on marked laboratory reports.
- Cohort-level feedback on computer-based formative test.
- Cohort-level feedback on final exam.

Past exam papers for ES2D6

Availability

Courses

This module is Core for:

- Year 2 of UESA-H63W BEng Electronic Engineering
- Year 2 of UESA-H63X MEng Electronic Engineering
- Year 2 of UESA-H605 Undergraduate Electrical and Electronic Engineering
- Year 2 of UESA-H606 Undergraduate Electrical and Electronic Engineering MEng

This module is Optional for:

- Year 2 of UCSA-G406 Undergraduate Computer Systems Engineering
- Year 2 of UCSA-G408 Undergraduate Computer Systems Engineering

This module is Option list A for:

- Year 2 of UESA-H113 BEng Engineering
- UESA-H112 BSc Engineering
    - Year 2 of H112 Engineering
    - Year 2 of H112 Engineering
- Year 2 of UESA-HN11 BSc Engineering and Business Studies
- Year 2 of UESA-H114 MEng Engineering