ES9ZX-15 Quantum and Novel Concept Devices

24/25

Department
School of Engineering
Level
Taught Postgraduate Level
Module leader
Neophytos Neophytou
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

To present, in context, the fundamental properties of semiconductor materials and devices. Students will study
fundamental aspects and the theory that underpins semiconductor material properties and how these link to device operation. Students will also study electronic structure theory, electronic transport theory, basic principles of low-dimensional nanodevices; basic principles of advanced and novel electronic devices; and the basics of semiconductor material and device simulation. The aim being to provide advanced understanding into semiconductor material and devices, beyond what is taught in undergraduate studies.

Module aims

To provide the students with in depth understanding of the underlying physical principles which underlying semiconductor materials and electronic device operation.

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.

- The Schrodinger's equation in describing electrons on the quantum mechanical level.
- Electronic band theory including energy bands and band diagrams, band velocity, density of states, bandgap, band valleys.
- Carrier statistics, Fermi distribution, occupancy.
- Boltzmann transport equation, scattering rates, mobility, drift-diffusion.
- Generation-recombination effects.
- MOS Capacitance
- Subband quantization
- Thermoelectric transport, Peltier and Seebeck effects
- Ballistic transport
- Introduction to simulation techniques
- Advanced device concepts

Learning outcomes

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

- Critically understand the complex interaction of different physics in providing new properties and device operation concepts. [M2(E)]
- Solve problems (including numerically) in semiconductor materials and devices. M3(E)
- Consolidate advanced knowledge of the electronic properties and behaviour of semiconductor materials. M4(E)
- Evaluate the fundamental parameters controlling the properties of semiconductor materials M3(E)
- Interpret and explain real literature data on the relevant field M4(E)

Indicative reading list

Theory and simulation methods for electronic and phononic transport in thermoelectric materials, N. Neophytou: Springer Briefs in Physics, ISBN 978-3-030-38680-1.

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

Research element

The students will analyse and study research papers from the literature as part of their process of understanding advanced material and device concepts.

Interdisciplinary

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

Subject specific skills

1. Being able to connect device operation to the fundamental underlying physical mechanisms and use those for device optimization and design.
2. Knowledge and understanding of the need for a high level of professional and ethical conduct in engineering
   and the use of technical literature and other information sources.
3. Apply relevant computational 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
Lectures	30 sessions of 1 hour (20%)
Other activity	2 hours (1%)
Private study	118 hours (79%)
Total	150 hours

Private study description

88 hours of guided independent learning

Other activity description

- 1 hour revision lecture
- 1 hour 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 B

	Weighting	Study time	Eligible for self-certification
Online examination	100%		No

Centrally-timetabled online assessment Answerbook will be required.

~Platforms - Submission Through Tabula Assignment Management

- Online examination: No Answerbook required

Feedback on assessment

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

Past exam papers for ES9ZX

Availability

Anti-requisite modules

If you take this module, you cannot also take:

- ES2D6-15 Semiconductor Materials and Devices

Courses

This module is Optional for:

- Year 1 of TESA-H641 Postgraduate Taught Communications and Information Engineering

This module is Option list A for:

- Year 1 of TESA-H643 Postgraduate Taught Electrical Power Engineering

This module is Option list B for:

- Year 1 of TESA-H644 Postgraduate Taught Electrical and Electronic Engineering