Engineering Tripos Part IB, 2P8: Electrical Engineering, 2020-21

Course Leader

Prof A J Flewitt [1]

Lecturers

Professor A J Flewitt and Professor C Durkan [2]

Timing and Structure

Weeks 1-4 Easter term. 16 lectures including worked examples, 4 lectures/week.

Aims

The aims of the course are to:

- Give the student an appreciation of the scientific understanding, electronic materials, processing technology, and the design of the transistors, displays and storage devices inside a modern personal computer.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the concepts of electronic motion in metals and semiconductors and doping in semiconductors.
- Understand the concepts in the design of a field effect transistor.
- Understand the relationship between switching speed and dimensions in transistor design.
- Give an overview of the technology of processing materials and the impact on transistor design.
- Give an overview of lithography techniques and the impact on transistor design.
- Understand the technological implications of increased speed and reduced dimensions of transistors
- Give a vision of potential future developments where transistors have atomic scales.
- Have an appreciation of the different technologies which can be used for flat panel displays.
- Have a basic understanding of liquid crystal displays and active matrix liquid crystal displays.
- Have a basic understanding of how a magnetic storage hard disk drive works, and materials used.

Content

Ubiquity of Semiconductor Devices (1L)

Semiconductor devices are hugely common in modern life,in cell-phones,computers,TVs,solar cells, lighting (light emitting diodes). How do they work inside?

Electronic devices in computers - Switches, logic, storage, DRAM, SRAM, idea of Moore's law

What is a Semiconductor (1L)

- Bonding in metals and semiconductors. Band gaps. Perodic table, Doping.
- The electron as a particle, a pin-ball model for conduction. Mobility, saturated velocity. Worked examples.

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) (4L)

- Operating concepts of MOSFETs. Transit time. Switching speed. Gate control.
- MESFETs vs MOSFETs. Why Si not GaAs.
- Elementary discussion of Scaling and Moore's law.

Technological Challenges (5L)

- Material preparation, lithography - comparison of U.V., electron beam, X-ray.
- Oxidation of silicon
- Etching - wet and dry processes.
- Doping - diffusion, ion implantation, reduction/process limits, metallisation.
- Worked examples.

Magnetic storage technology (1L)

- Elementary principles of magnetic storage - BH loops, bits, writing, reading.
- The mechanical design of a modern hard disk drive.
- The material in a disk and read head.

Displays (3L)

- Display technologies - electricity into light.
- What are Liquid crystals.
- Active matrix liquid crystal displays.

Towards the Future (1L)

- How device dimensions and voltages reduce to give even smaller and faster transistors, towards and atomic scale.

Booklists

Please refer to the Booklist for Part IB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D2

Understand customer and user needs and the importance of considerations such as aesthetics.

D3

Identify and manage cost drivers.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P5

Awareness of nature of intellectual property and contractual issues.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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