

## Engineering Tripos Part IIB, 4B6: Solid State Devices & Chemical & Biological Sensors, 2017-18

### Module Leader

[Prof D Chu](#) [1]

### Lecturer

Prof D Chu

### Timing and Structure

Lent term. 12 lectures (including examples classes). Assessment: 100% exam

### Prerequisites

3B5 and 3B6 useful

### Aims

The aims of the course are to:

- introduce the student to the theory, and design of MOS Field-Effect Transistors (MOSFETs) and thin film transistors (TFTs), based on both single crystal and thin-film materials.
- introduce examples of applications of MOSFETs and thin film transistors (TFTs) as well as in combination with different functional materials.

### Objectives

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

- understand MOSFET theory and standard approximations.
- correlate material properties and conduction mechanisms with the MOSFET electrical characteristics, for single crystal, amorphous and polycrystalline thin film devices (TFTs).
- understand the basic properties of ferroelectric materials and its application for non-volatile memory devices (FRAMs).
- understand the concept of giant magneto-resistance and related materials structures and its applications including non-volatile memory devices (MRAMs).
- understand the basic operation of chemical and biological sensors based on FETs.

### Content

The aim of this module is to introduce the student to the theory, and design of MOS Field-Effect Transistors (MOSFETs) and thin film transistors (TFTs), based on both single crystal and thin-film materials. This will be followed by application examples, including ferroelectric and magnetic random access memories (FRAM and MRAM) in non-volatile memory technologies as well as chemical/biological sensors in sensor technologies. Emphasis will be on both device physics and application technology.

### **MOS Devices Introduction (3L)**

Properties of MOS Capacitors, Capacitance - voltage characteristics; MOSFET structures and operation.

### **MOS Devices & Thin Film Transistors (3L)**

Short channel and hot electron effects; Applications and future trends in miniaturising single crystal devices; Amorphous and polycrystalline silicon.

### **Non-Volatile Memory Devices (4L)**

Ferroelectrics and ferroelectric random access memories; Giant magneto-resistance (GMR) and magnetic random access memories.

### **Chemical & Biological Sensors (1L)**

Solution based chemical sensor and biosensors based on FETs.

### **References**

- Lecture Notes. [4B6 Lecture Notes](#) [2]
- S M Sze, "Physics of Semiconductor", John Wiley, 1981, Chapters 7 and 8 (note that there is rather more than covered in the lectures).
- J Singh : "Semiconductor Devices", John Wiley 2001
- Article "Thin -Film Transistors", by P Migliorato, in Encyclopedia of Physical Science and Technology, (Excluding the mathematical derivations), distributed at the lectures.
- J F Scott: "Ferroelectric Memories", Springer, 2000.

### **Booklists**

Please see the [Booklist for Group B Courses](#) [3] for references for this module.

### **Examination Guidelines**

Please refer to [Form & conduct of the examinations](#) [4].

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### **Links**

[1] <mailto:dpc31@cam.ac.uk>

[2] [http://www-g.eng.cam.ac.uk/photronics\\_sensors/lecturenotes/](http://www-g.eng.cam.ac.uk/photronics_sensors/lecturenotes/)

[3] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=49821>

[4] <https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations>