Engineering Tripos Part IIB, 4B22: Flexible Electronics, 2017-18

Leader

Dr F Torrisi [1]

Lecturer

Dr F Torrisi

Timing and Structure

Lent term (100% exam, 16 lectures including example classes)

Prerequisites

Recommended (not mandatory): 4B5 Nanotechnology; 3B5 Semiconductor Engineering

Aims

The aims of the course are to:

- Next generation electronic applications will require a higher degree of mechanical flexibility to meet the demand for wearable and conformable electronic devices.
- The purpose of this module is to cover the materials, processes, technology and applications behind the flexible electronics context and highlight the technological developments that have occurred in this rapidly evolving field.
- Due to the vast number of different flexible electronic components that are in production today, the course will be centred on three main subsections which represent the biggest growth areas in the past few years:
- namely, the materials and properties of thin films, the flexible electronic components and the heterogeneous integration, and the large area flexible electronics.
- The module will introduce basic concepts, a theoretical background (e.g. theory of film-on-substrate foil, two and three-layer point bending, theory of electronic bands in organic semiconductors)
- and the materials, before gradually moving into device design, presenting case studies of Thin Film Transistor (TFT) fabrication and characterisation
- (with emphasis on TFT vs MOSFET and effects of downscaling). Case studies of practical applications such as flexible OLED, flexible photovoltaic device and flexible displays will be presented.

Objectives

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

- As specific objectives by the end of the course the student should be able to:
- Describe the various materials and production techniques for flexible thin films in electronics.
- Explain the sheet to sheet and roll to roll processing, coating and encapsulation techniques.
- Apply the theory of Film-on-Foil to calculate the strain in the foil substrate and in the thin film.
- Describe the production processes and the electronic transport in amorphous and polycrystalline silicon films, polymers and nanomaterials: explain advantages/disadvantages.
- Describe the effects of strain on the electrical characteristics (I-V curve, mobility, conductivity) and parasitic elements (overlap capacitances, contact resistance) of a Thin Film Transistor.

- Describe effects of torsion, tension, compression on stretchable devices.
- Explain the basics of effects of downscaling in flexible TFTs and compare TFT vs MOSFET.
- Design a flexible and transparent conducting film in terms of electrical sheet resistance and optical transparency. Describe ITO as flexible transparent conductor and suitable alternative materials.
- Discuss the integration techniques: Chip-on-flex, flex on flex, foil on foil, printed wiring of ultrathin chip. Integration techniques for stretchable devices.
- Discuss and compare advantages and disadvantages of organic vs inorganic flexible thin film transistors. Discuss frequency limitations of OTFTs (testing: ring oscillator).
- Explain the rheological and morphological requirements to design printable inks. Discuss advantages and disadvantages of printed electronic components.
- Explain the basics of the electrical percolation theory in networks of nanomaterials.
- Describe applications of flexible electronic devices in electronics, optoelectronics, energy.

Content

Introduction (2 lectures)

- Overview of Flexible and Stretchable Electronics Technology and beyond.
- Thin-film electronic devices on flexible substrate. Example: from MOSFET to Thin Film Transistor (TFT).

Materials production, processing and properties (3 Lectures)

- Revision of electronic structure of solids and introduction of electronic structure in polymers.
- Metals, amorphous/polycrystalline silicon materials for flexible TFTs, Flexible conducting and semiconducting oxides.
- Polymers and nanomaterials for flexible and stretchable conducting and semiconducting thin films

Mechanics of flexible and stretchable thin-films (2 Lectures)

- Mechanics of a thin-film on flexible substrate. Case study: ITO on flexible Substrates, failure mechanisms.
- Emerging 1D, 2D nanomaterials and polymers for highly flexible and stretchable thin films.

Flexible components and heterogeneous integration (4 Lectures)

- Flexible device case studies: TFTs, Photodetectors and Photovoltaic devices.
- Heterogeneous integration: Chip-on-flex, flex on flex, foil on foil, printed wiring of ultrathin chip. Chemical, mechanical and environmental stability of devices.
- Processes for large-area flexible electronics: Roll-to-roll vs batch-to-batch, printing vs transferring.
- Hybrid integration techniques for stretchable electronics: Stretchable thin film devices and circuits.

Applications (3 Lectures)

- Flexible displays, touch sensors and systems
- Wearable electronic devices
- Printed flexible electronic sensors

Example Class (2 Lectures)

- Study of the Strain in the Substrate and in the flexible Film as function of the induced stress.
- Design and modelling of thin-film transistors.
- Design of flexible transparent and conducting films for display applications.

Booklists

Please see the Booklist for Group B Courses [2] for references for this module.

Examination Guidelines

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

Last modified: 31/05/2017 10:02

Source URL (modified on 31-05-17): https://teaching.eng.cam.ac.uk/content/engineering-tripos-part-iib-4b22-flexible-electronics-2017-18

Links
[1] mailto:ft242@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=50421
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations