Course Outline 10-14 Hours Lectures

Organic Semiconductors for Microelectronics & Displays Applications

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Course Description

This module will offer an introduction to organic semiconductors and their application in thin-film transistors (TFTs), memory devices and organic light-emitting diodes (OLEDs) for lighting and display applications.

In the first part of the module the band theory of solids (inorganic and organics) will guide the way to the energy band diagram of metal-semiconductor (MS) contacts as a fundamental constituent of electronic devices. By means of the metal-oxide-semiconductor (MOS) capacitor concepts such as accumulation and depletion of charge carriers in organic semiconductors will be discussed and contrasted to their inorganic counterparts. This leads over to the structure and operating principle of field-effect transistors, their device architectures, considerations on switching speeds and scaling. As part of their applications, the role of organic TFTs in (unipolar and complementary) logic circuits, displays, and memories will be introduced. The module will then look at general properties and requirements of memories such as writing/reading speeds, retention time, endurance, and scalability/integration. Different memory concepts (e.g. capacitive, resistive, floating-gate) are introduced.

In the second part of the module the field of optical displays will be introduced, covering the technologies currently in use and those expected to feature in the next generation of display technologies with emphasis on OLED-based displays. The module will offer a short introduction the different kinds of optical displays available, and will briefly discuss the current driving forces governing market trends. The lectures will discuss the way in which the human eye operates and how it affects the way in which we perceive optical displays. The course will then move on to cover all of the physical and technical

properties associated with understanding and characterizing optical displays, such as luminous power, luminous efficiencies and understanding the 1931 CIE colour space standard etc. The lectures will cover the various technical approaches applied in the manufacture of different optical displays with emphasis on OLEDs and their application in future display technologies.

PART 1

1: Energy band structure and metal-semiconductor contacts(1hour)

The formation of energy bands in solids will be briefly discussed. On the basis of this discussion the key differences between conductors, insulators and semiconductors will be highlightedtogether with someimportant physical parameters.

2: Metal-insulator-semiconductor capacitor(1 hour)

The structure and operating principles of the metal-insulator-semiconductor capacitor will be discussed with emphasis on the various operating regimes and its use as a test-bed for the study of novel semiconducting material systems.

3: The field effect transistor (2 hours)

The history, physical structure and operating principles of the field-effect transistor will be discussed in detail. Emphasis will be placed on the role of the semiconductor and the device architecture on the overall transistor performance.

4: Organic transistors in microelectronics (2 hours)

The application of transistors for the construction of basic electronic building blocks used in modern digital microelectronics will be discussed. Emphasis will be placed on the circuitry and operating principles of the simplest logic gates such as the NOT gate.

5: Organic memory devices(1 hour)

The science and technology of non-volatile memory technologies such as flash memory devices will be discussed followed by a summaryof various emerging technologies e.g. printed memory cells.

PART 2

Part 1: Introduction to optical displays (0.5 hour)

The driving forces and trends in the optical displays market will first be presented followed by a detailed analysis of the most important properties of optical display technologies currently in use and those being developed.The different approaches for generating colors in an optical display will also be discussed.

Part 2: Colourimetry and colour generation in optical displays (2 hours)

The key difference between radiometric and photometric quantities will be discussed with emphasis on the role of the human eye as the optical detector. Emphasis will be placed on the definition and units of luminous power, illuminance, luminous emittance, luminous intensity and luminance.

Part 3: Non-emissive displays (1 hour)

The physical structure, principle of operation, main benefits and drawbacks and main problems yet to be solved for key non-emissive optical display technologies such as liquid crystal displays (LCDs), electrochromic and electrophoretic displays (EPDs) will be discussed. The difference between passive and active matrix displays will also be briefly presented.

Part 4: Emissive displays (1 hour)

The physical structure, principle of operation, main benefits and drawbacks and main problems yet to be solved for key non-emissive optical display technologies such as inorganic light-emitting diodes (LEDs), plasma displays and thin film electroluminescent displays will be discussed.

Part 5: Organic light emitting diode (OLED) in displays (2.5 hour)

The physical structure, principle of operation, main benefits and drawbacks and main problems yet to be solved for OLED displays technologies, will be discussed. Emphasis will be placed on key technology metrics such as light generation efficiency and the role of organic electroluminescent materials.