

Syllabus on Nanoscale Elements for Electronics and Sensing: Design and Device Production

Abstract

A review of the most important nano-sensing solutions at the state of the art will be done then a specific research area will be put under analysis. With this goal one of the most promising structures, the nanogaps, will be studied. With nanogaps it is possible to analyse molecules at nanometric scale, but they can be also used as base of novel nanoelectronic devices. In fact the fabrication of electrodes with a controlled nanometric separation is strategic for many application fields as molecular electronics and biosensors. Following these aims, the course will cover the basic concepts of nanoscale sensing and a practical example of nanogap production will be analysed in details, starting from the fabrication in a cleanroom of the structures where the nanogaps can be created, up to the study of the system useful for the production of the nanogaps themselves.

Pre-requisites

Knowledge of basic microelectronic technologies and of electronic devices. Basic principles of organic chemistry and sensing techniques.

Learning Outcomes

The student will acquire the basic knowledge about Quantum Mechanics for nanoelectronics. Using these new concepts, the student will be able to understand the principles of the design, the simulation and the fabrication of nanostructures for electronic devices and sensors.

Instructional methods: e-learning with distant support, individual work, practical work at clean rooms

The course is based on e-learning material, and in particular videos on theoretical lectures.

Materials and textbooks

- Slides and videos from the e-learning website
- Reference Books
 - Petty, M. C. (2007). Molecular Electronics, John Wiley & Sons Ltd
 - Carrara, S. (2011). Nano-Bio-Sensing, Springer. doi:10.1007/978-1-4419-6169-3
 - Deleonibus, S. (2008). Electronic Device Architectures for the Nano-Cmos Era: From Ultimate CMOS Scaling to Beyond CMOS Devices, Pan Stanford Publishing Pte. Ltd.

Content

Part 1

1. Modelling molecules for electronics
 - 1.1. Introduction to the course
 - 1.2. Molecular electronic structure
 - 1.3. Modelling of molecules for nanoelectronic and sensors
 - 1.4. Conduction mechanisms in molecules

Part 2

2. Molecules and Devices
 - 2.1. Molecules I
 - 2.2. Molecules II
 - 2.3. Molecular devices I: wires, diodes, switches
 - 2.4. Molecular devices II: transistors, memories
 - 2.5. Molecular devices III: molecular QCA

Part 3

3. Technology and systems
 - 3.1. Interfacing molecular devices with I/O CMOS structures
 - 3.2. Read-out architectures for molecular systems and sensor arrays
 - 3.3. Measurement and characterization techniques for molecular systems

Evaluation: knowledge test practical test

The evaluation is based on an oral examination of the concepts acquired in the course.

Credits (ECTS): 6