UNIVERSITÀ DI PISA

Materials and Devices for Nanoscale Electronics

MASSIMO MACUCCI

Anno accademico	2019/20
CdS	MATERIALS AND NANOTECHNOLOGY
Codice	827II
CFU	6

Moduli	Settore/i	Tipo	Ore	Docente/i
MATERIALS AND DEVICES FOR NANOSCALE ELECTRONICS	ING-INF/01	LEZIONI	48	MASSIMO MACUCCI

Learning outcomes

Knowledge
The student who successfully completes the course will have a general understanding of the role played by materials in nanoscale electronics and of the scaling process of CMOS devices, as well as of some of the main "beyond CMOS" technologies that have been proposed (including devices based on Coulomb Blockade, graphene, etc.). He/she will acquire the ability to evaluate the electrical behavior of nanostructures within the Landauer-Buettiker formalism and to make a first assessment of a proposed technology or of the validity of a new material system.

Assessment criteria of knowledge
During the oral exam the student must be able to demonstrate his/her knowledge of the course material and his/her capability to apply it to the evaluation and selection of materials for nanoscale electronics applications.
Methods:
Final oral exam

Skills
Knowledge of the properties of the main materials used for nanoelectronic devices, understanding of the scaling process of CMOS devices, capability to set up the main components for the simulation of transport in a nanodevice.

Assessment criteria of skills
Through the questions during the oral exam.

Behaviors
The student will develop an ability to establish how material properties can be exploited to implement a new device or to improve the performance of an existing device.

Assessment criteria of behaviors
An assessment will be performed during the exam.

Prerequisites
Knowledge of the operation of basic electron devices, elementary quantum mechanics, basic chemistry.

Teaching methods
All lectures are in English
Delivery: face to face
Learning activities:

- attending lectures
- participation in discussions
- individual study

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Attendance: Advised
Teaching methods:

- Lectures
- Task-based learning/problem-based learning/inquiry-based learning

Syllabus

The course includes an in-depth discussion of the scaling of CMOS devices (both constant-field and generalized scaling); an analysis of the main nonidealities, such as hot-electron effects, drain induced barrier lowering (DIBL), random distribution of dopants, limitations in the subthreshold slope and in the speed of propagation of signals, role of new materials and geometries in the new generations of devices; computation of conductance through a ballistic device; the concept of Coulomb blockade and its application to single-electron transistors; heterostructures based on compound semiconductors and their usage for HEMTs (high electron mobility transistors), quantum devices, and non-invasive charge detectors. A further set of topics is chosen according to the preferences expressed by the students, and typical selections are carbon electronics, quantum computing, molecular electronics, technological processes for the fabrication of nanodevices.

Bibliography

There is no official textbook. Audio recordings of the lectures and the photos of all blackboard writings are available on the course web site. Suggested reading includes the following books: Yuan Taur, Tak H. Ning, "Fundamentals of Modern VLSI Devices" (Cambridge University Press, 2009). Willam H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, "Numerical Recipes: The Art of Scientific Computing" (Cambridge University Press, 1992).

Non-attending students info

All lectures (audio recordings and photos of the blackboards) are available on the web site, meetings with the instructor can be arranged by e-mail or by phone.

Assessment methods

There is an oral exam consisting of three questions on the topics covered in the class. The final grade is the average of the grades obtained for the three questions. The average duration of the exam is 30 minutes.

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