Nanoelectronics for ICT

This course is aimed at providing knowledge and skills in the fundamental nanoelectronics applications for information and communication technologies (ICT). By the end of the course the students will know the functioning principles, main characteristics and parameters, classification and peculiarities of processors, memories, interfaces used in ICT, and they will be able to design parts of ICT systems, applying their knowledge on the fundamentals of submicron technology.

The main topics in the course are:

- Latest developments and trends in the field of digital ICs fabricated in sub-micron technologies, e.g. 3-gate transistors on 22 nm и 14 nm technology.
- Processors, characteristics and parameters, structure and topology, core microprocessor architectures CISC, RISC, VLIW and EPIC and their hardware implementation, the six traditional platforms: desktops, laptops, workstations, servers, mainframes and supercomputers and their characteristics;
- Memories: RAM (DRAM, SRAM), Ferroelectric RAM, ROM, PROM, EPROM, EEPROM, NVRAM, Battery RAM, Flash memory; hard and optical drives principle of memorizing data, characteristics and parameters technology;
- Microelectronic Circuits and Systems in wireless communications for computers, mobile phones, PDA, car navigation systems, standards for wireless communications, integrated circuits and systems with mixed signals;
- Screens, key features, LCD, plasma displays, LED, OLED, AMOLED, touch screen technology.

Design of Nanoscale MOS ICs

Problems related to the design and investigation of submicron and nanoscale MOS integrated circuits are covered by this course. Currently there are some nanotechnologies in the means of 14 nm design kits, which are available via the EUROPRACTICE organization. The main attention is drawn to the theoretical and practical usage of state-of-the-art industrial CAD systems, e.g. CADENCE, SYNOPSYS and others. The designers who use those systems can implement nanoscale elements from the relevant standard cell libraries. The specific parameters, related to the nanoscale effects are represented in the embedded system models of the elements..

The main topics in the course are:

- CAD tools for design of analogue and mixed-signal integrated circuits (CADENCE): schematics, simulation (with SPICE, Spectre, Verilog XL), Layout (Envisia Silicon Ensemble, IC Chip Assembly)
- CAD tools for design of digital circuits (SYNOPSYS): Methodologies (detailed design, FPGA's and ASIC's, FPGA design flow, ASIC design flow); Synopsys Environment (CoCentric, Physical Synthesis, Synthesis Tools, DesignWare, Library Compiler, Simulation Tools, Static Timing and Formal Verification); VHDL and Verilog
- Design of deep-submicron devices (subtreshold, gate leakage etc.)

- System design, future trends (multiphysics simulation, error propagation, multi-technology, multi-scale: device (nm) to board (dm), analogue and digital design for deep-submicron technologies).

Nanomaterials for Electronics

This course will take an in-depth look at nanomaterials used in nanoelectronics. Theory and concepts of nanomaterials will be covered, including the chemistry and physics of nanomaterials. The course will also focus on major classes of nanomaterials, including carbon nanotubes, nanostructured materials, nanowires, nanoparticles, nanoclays, and other nanomaterials. Applications of nanomaterials to technology areas in nanoelectronics will also be discussed.

Main topics:

- Materials for deep-submicron and nanometer CMOS IC: Materials for the substrate – tight Si; Alternative materials for the gate insulator: high K gate insulators; Gate electrode materials (n+ polysilicon, mid-gap, metals); SOI; Double-Gate Transistor Structures and Multi-Gate Transistor Structures.
- Materials for HEMT: Heterostructures on A3B5 (GaAs/ AlGaAs, InGaAs/InAlAs etc.).
- Materials for devices on carbon nanotubes and graphene:
- Materials for resonant tunnelling devices: Structures of resonant tunnelling devices and circuits: AlAs/GaAs/AlAs, AlSb/InAs/AlSb.
- Materials for single electron transistors: Single Electron Transistors structure and materials: Si, GaAS.
- Spintronics: Physical principles and materials for spintronic devices.
- Quantum electronic devices – physical principles and materials;
- Short-Channel MOS Transistor, Split-Gate Transistor, Electron-Wave Transistor, Electron-Spin Transistor, Quantium Cellular Automata.
- Materials for bioelectronics and molecular electronic devices.