Syllabus
"Assembling and Inspection Technologies"

Course topic
Technology of Electronics Products

Number of credits
5 ECTS

Course responsible
Budapest University of Technology and Economics
Department of Electronics Technology
Assoc. Prof. Dr. Oliver Krammer

Course lecturers
Assoc. Prof. Dr. Balázs Illés
Assoc. Prof. Dr. Olivér Krammer
Ass. Prof. Dr. Attila Géczy

Prerequisites
Basic of physics and material science, Electronics, Technology of Electronics Products

Learning outcomes

Knowledge: the students will have deep knowledge in the field assembly and inspection technologies of electronics products based on the course of "Technology of Electronics Products". The course deals with the common steps of automated, mass soldering technologies (reflow- and wave soldering) in details, and gives a brief insight into inspection and test methods applied during the manufacturing of electronic products.

Skills: the students will be capable to fully control the different process steps of automated soldering technologies, to plan testing strategies and to develop inspection algorithms for aiding the defect-free manufacturing of electronic products.

Competences: the acquired competences allow the students to analyse in-manufacturing defects and failures and to provide solutions for eliminating those defects which are closely related to the automated manufacturing of electronic products. Consequently, the students can also use their obtained skills to effectively reduce failure costs in production.

Abstract
The objective of the course "Assembling and Inspection Technologies" is to deepen the knowledge of students in the field assembly and inspection technologies of electronics products based on the course of "Technology of Electronics Products". The course deals with the steps of reflow soldering technology in details. Stencil manufacturing technologies, stencil design guidelines are also be included. In the aspect of automated soldering, heat transportation method for reflow soldering, thermal profiling for reflow- and wave soldering, and troubleshooting for reflow- and wave soldering failures are discussed. Lastly, insight into inspection techniques (AOI – automated optical inspection, X-ray inspection) and into test techniques (ICT – in-circuit test and FP – flying probe test) is given.

Content

1. Introduction
    1.1. Introduction to the course.
    1.2. Repeat of some basic technologies in the course "Technology of Electronics Products".
2. Soldering techniques and solder joint design principles
    2.1. Principles of solder joint design.
    2.2. Brief description of hand soldering.
    2.3. Brief description of automated soldering technologies.
3. Solder paste stencil printing
    3.1. Stencil manufacturing technologies.
    3.2. Properties of solder pastes and stencil life.
    3.3. Troubleshooting of stencil printing failures.
4. Component placement methods and process sequences
    4.1. Type of placement machines.
    4.2. Mechanism of actuation.
    4.3. Feeder types.
5. Reflow soldering ovens and temperature profiling
    5.1. Heat transportation methods and reflow ovens.
    5.2. Thermal profile measurement and reflow failures.
6. Wave soldering and thermal profiles
    6.1. Process steps of wave soldering, wave soldering apparatus.
    6.2. Troubleshooting of wave soldering defects.
    6.3. Selective soldering.
7. Hand soldering and assembly rework
    7.1. Basics of hand soldering.
    7.2. Soldering irons and tips.
    7.3. Soldering guide for electronics components.
    7.4. Lead-free hand soldering.
8. Inspection and test techniques
    8.1. X-ray inspection.
    8.2. Acoustic microscopy, electron microscopy.
    8.3. Optical microscopy, automatic optical inspection.
    8.4. In-circuit and functional test.

Teaching methods

The course is presented in Power Points presentations.

Assessment

The course grade consists of these components:
60% – Knowledge test with a multiple choice questionnaire
40% – Final Project (a literature review about a given assembly technology topic)

Recommended reading

Lee, N.C. (2001). *Reflow Soldering Processes and Troubleshooting*, Elsevier, Newnes

Sauer, W. (2006). *Electronics Process Technology*, Springer-Verlag

Shangguan, D. (2005). *Lead-free Solder Interconnect Reliability*, ASM International

Martin, P. (2004). *Electronic Failure Analysis Handbook*, McGraw-Hill

Syllabus
"Design and realisation of Micro-Nano-BioSensors"

Course topic
Novel technologies for design and realisation of BioSensors at micro and nano level.

Number of credits
5 ECTS

Course responsible
Politecnico di Torino
Department of Electronics and Telecommunications
Prof. Danilo Demarchi

Course lecturers
Prof. Sandro Carrara
Prof. Danilo Demarchi

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

Learning outcomes

Knowledge: basics of quantum mechanics useful for the design and use of nanodevices, in particular nanosensors. Knowledge of the possible device production techniques of nanosystems, in particular of nano-probing solutions.

Skills: design of nanosystems for sensing, choosing the needed interfaces for reading the signals and transferring the information, from the nanolevel to the user interface, passing through microcircuitries.

Competences: the students will reach a sufficient knowledge and skill for being able of choosing novel solutions in terms of nanodevices and nanosensors, with the capability of guiding the strategical choices for system level design.

Abstract
The downscaling of sensing devices is giving several improvements in terms of sensor efficiency, detection limit and is opening the possibility of doing analysis at molecular level. A review of the most important 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. Following these aims, the course will cover the basic concepts of nanoscale sensing and a practical example of nanogap production will be carried out, starting from the fabrication in a cleanroom of the structures where the nanogaps can be created, up to the study of the system useful to produce the nanogaps.

Content

Micro&Nano Technologies Review

0. Introduction/Review of micro&nano technologies
   - 0.1 Structures of crystals and fabrication
   - 0.2 PhotoLithography
   - 0.3 Ion implantation and diffusion
   - 0.4 Thin layers
   - 0.5 Chemical Vapour Deposition
   - 0.6 Metalization and Physical Vapour Deposition

Part 1

1. Modelling molecules for nanosensing
   - 1.1. Introduction to the course
   - 1.2. Modelling of molecules for nanosensors
   - 1.3. Conduction mechanisms in molecules
   - 1.4. *LAB1*: Introduction to the molecular simulation with Gaussian

Part 2

2. Molecules and Devices
   - 2.1. Molecules I
   - 2.2. Molecules II
   - 2.3. *LAB2*: Electronic structure (MO) of molecules with Gaussian
   - 2.4. *LAB3*: I-V simulation of molecular devices with VNL

Part 3

3. Technology and systems
   - 3.1. Interfacing nanometric sensors with I/O CMOS structures
   - 3.2. Read-out architectures for sensor arrays
   - 3.3. Measurements and characterization techniques for molecular systems
   - 3.4. *LAB4*: nanogap fabrication process

Teaching methods

The theoretical part of the course is presented in the Moodle learning environment in the form of videos and supporting material as PDF slides.

The practical work is organised in different laboratories for:

1. fabrication of nanogaps and their functionalization;
2. modelling and simulation of molecular devices using Gaussian and VNL.

Assessment

The evaluation is based on an oral examination of the concepts acquired in the course and this is associated with a practical work on one of the tools presented during the laboratories and the Hands-On sessions. All is finalised with a written report.

The course evaluation consists of these components:

60% – Knowledge test with a multiple choice questionnaire and oral discussion

40% – Final Report

Recommended reading

[1] Carrara S. (2011). *Nano-Bio-Sensing*, Springer Ed.

[2] Carrara S. and Iniewski K. *Handbook of Bioelectronics - Directly Interfacing Electronics and Biological Systems*, Cambridge University Press, August 2015

[3] Rigler, R., & Vogel, H. *Single Molecules and Nanotechnology*. Springer Ed., 2007.

Syllabus
"Modelling and Design of ULSI Circuits and Systems"

Course topic
Modelling Tools and Design Methodology for ULSI circuits and systems.

Number of credits
5 ECTS

Course responsible
Politecnico di Torino
Department of Electronics and Telecommunications
Prof. Danilo Demarchi

Course lecturers
Prof. Gianluca Piccinini
Prof. Mariagrazia Graziano
Prof. Danilo Demarchi

Prerequisites
Knowledge of basic microelectronics, physics of materials and digital circuits design.

Learning outcomes

Knowledge: Highly specialized knowledge on CMOS integrated circuit layout, basic technology, IC design and modelling, considering specific physical effects in short channel transistors.

Skills: Ability to design submicron CMOS ICs using CADENCE and solving problems with modelling of submicron devices behavior.

Competences: Demonstrate innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new modelling and design rules, at the forefront of work or study contexts, including research in nanoelectronics design.

Abstract
The study of ultra-deep-sub-micron effects on Ultra-Large-System-Integration circuits is the focus of the course. The approach is a learning by doing one and is based on the help of a novel and OpenSource tool developed specifically for this purpose and WEB based. The tool (TAMTAMS) is based on up-to-date compact models of ultra-deep submicron effects on devices and interconnections, and includes models of system level performance (power dissipation, frequency, area, skew, noise rejection, sensitivity to process variation,...). TAMTAMS quantitatively predicts the effects on integrated systems due to technology choices and issues. The technologies used are not only the CMOS based ones from 90nm downto 20nm, but also the beyond CMOS ones (e.g. SET, CNFET, MOFET, CNT Wires, …), and a comparison between the two sets in terms of performance is achieved as a final result.

Content

1. Introduction to the course
2. Standard Ultra-deep-submicron CMOS processes
   2.1. Classification of the most used CMOS fabrication processes and assessment of technological scaling issues
   2.2. Advanced CMOS processes: gate, channel and source-drain structures.
   2.3. Use of a WEB based tool (TAMTAMS) for the analysis of the impact at device level of technological choices
3. Standard process to system bottom-up implications
   3.1. How to evaluate the effect of technological choices on the system level performance: frequency, dynamic power, static power, noise, temperature.
   3.2. Interconnects and packaging technologies
   3.3. Use of a WEB based tool for the analysis of the impact at system level of technological and device choices and parameters

Teaching methods

The theoretical part of the course is presented in the Moodle learning environment in the form of Videos and supporting material as PDF slides.
The practical work is organized in different laboratories for the modeling and simulation of some interesting devices, using the WEB based tool developed at Politecnico di Torino and named TAMTAMS.

Assessment

The evaluation is based on an oral examination of the concepts acquired in the course and this is associated with a practical work on one of the tools presented during the laboratories and the Hands-On sessions. All is finalised with a written report.
The course evaluation consists of these components:
60% – Knowledge test with a multiple choice questionnaire and oral discussion
40% – Final Report

Recommended reading

[1] C. Y. Chang, S. M. Sze. ULSI Technology, Mcgraw-Hill College, 1996.

[2] M. Vacca, G. Turvani, F. Riente, M. Graziano, D. Demarchi, and G. Piccinini. TAMTAMS: An open tool to understand nanoelectronics. In 12th IEEE Conference on Nanotechnology (IEEE-NANO), Birmingham, UK, August 2012.

[3] M. Vacca, M. Graziano, D. Demarchi, and G. Piccinini. TAMTAMS: A flexible and open tool for UDSM process-to-system design space exploration. In 13th International Conference on Ultimate Integration on Silicon (ULIS), pages 141–144, Grenoble, France, March 2012.

Syllabus
"Multi-Media Enhancement of Teaching Sensors and MEMS"

Course topic
Multi-Media Enhancement of Teaching Sensors and MEMS

Number of credits
5 ECTS

Course responsible
Budapest University of Technology and Economics
Department of Electronics Technology
Assoc. Prof. Dr. Attila Géczy

Course lecturers
Ass. Prof. Dr. Attila Géczy
Assoc. Prof. Dr. Balázs Illés
Assoc. Prof. Dr. Olivér Krammer

Prerequisites
Basic of physics and material science, Electronics, Microelectronics, Semiconductors

Learning outcomes

Knowledge: the course offers thorough knowledge in the field of sensors and micro electromechanical systems (MEMS). The students will know the basic principles, structures and manufacturing technologies of sensors and MEMS. They will understand additionally the related physical effects, measuring methodologies of given parameters, specific device descriptions, and application possibilities with examples according to the different application fields.

Skills: students will have theoretical and practical skills in the field of sensors and MEMS, with the ability to find, differentiate and apply specific devices for their electronic designs or their research tasks. The course deepens knowledge on working principles, which provides initial skills required for direct sensor/MEMS development.

Competences: the obtained competences can be applied in industrial situations, where sensor/MEMS devices are manufactured or such devices are part of the manufactured product, moreover where these devices are integral part of the manufacturing infrastructure. Also, the competences include the ability to perform and analyse electronic design involving sensor/MEMS devices.

Abstract
The course module provides theoretical and practical information for design, production and application of sensors and Micro Electro-Mechanical System (MEMS) in the practice. After a short introduction with a summary of the basic definitions, the brief overview of the fundamental areas are presented, namely: sensor technologies, transducer structures, and operation principles

of various structures for sensors; technologies, mechanical structures, and operation principles of various structures for MEMS devices. Then various sensor types and applications of various MEMS types are described, where recent developments in structures, application possibilities and applied materials are also discussed.
The course provides the participants with an overview of sensors and MEMS devices, i.e. miniature devices for measuring physical and chemical quantities such as pressure, acceleration, speed chemical concentration, etc. Sensors and MEMS devices fabricated by solid-state and MEMS technology, from ceramics, thin and thick films, polymer films, as well as, by optical fibre technology are described and characterized. The different sensor and MEMS structures, the principles of sensing various parameters, and sensing effects are presented. The overview of application fields includes industrial process control, automotive and household case studies, with a special focus on environmental monitoring and biomedical applications. Advances in sensor packaging, modelling, design and fabrication are also described shortly.

Content

1. Sensor technologies
   1.1. Introduction
   1.2. Sensor Technologies (and Materials): semiconductor technologies, ceramics, thin- and thick-films, polymer films, optical-fiber technologies
   1.3. Sensor Structures: impedance-types, semiconductor devices, sensors based on acoustic-wave propagation, calorimetric sensors, electrochemical cells, sensors with optical waveguides
   1.4. Sensing Effects: thermoresistive, thermoelectric, piezoelectric, pyroelectric, piezoresistive effect, electrets in capacitive transducers, Hall effect, radiation induced effects, adsorption and absorption of, chemical species, selective molecular receptors, permeation through membranes, ion-selective membranes, chemical-optical transduction effects
   1.5. Measuring Various Parameters: thermal, mechanical, acoustic, radiation, magnetic field, chemical and biosensors
   1.6. Application Fields: industrial, automotive, environmental, biomedical, household, comfort and safety
2. MEMS technologies
   2.1. Introduction
   2.2. Technologies: semiconductor technologies, ceramics, thin- and thick-films, polymer film technologies
   2.3. Mechanical Structures: trenches, cavities, micro-channels, membrane, tube, micro-needle, bridge, cantilever and other micro-structures used im MEMS devices
   2.4. MEMS devices: sensors, actuators, optoelectronics and passive electronic components
   2.5. Application Fields: automotive, biomedical, telecommunication and informatics

Teaching methods

The course is presented in multi-media presentations based on Flash and HTML material.

Assessment

The course grade consists of these components:
60% – Knowledge test with a multiple choice questionnaire
40% – Final Project (a literature review about an applied sensor/mems technology)

Recommended reading

Webster, J.G. (2014). *Measurement, Instrumentation, and Sensors Handbook, Second Edition: Two-Volume Set*, CRC Press

Ripka, P. (2007). *Modern Sensors Handbook,* ISTE

Kimberley, W. (2004). *Automotive Electrics, Automotive Electronics - 4th Ed.,* Robert Bosch GmbH

Gad-el-Hak (2002). *The MEMS Handbook*, CRC Press

Soloman, S. (1998). *Sensors Handbook,* McGraw-Hill

Campbell, S.A. (1998). *Semiconductor Micromachining, Vol. 1-2, Techniques and Industrial Applications,* John Wiley & Sons

Syllabus
"Technology of Electronics Products"

Course topic
Technology of Electronics Products

Number of credits
5 ECTS

Course responsible
Budapest University of Technology and Economics
Department of Electronics Technology
Assoc. Prof. Dr. Balázs Illés

Course lecturers
Assoc. Prof. Dr. Balázs Illés
Assoc. Prof. Dr. Olivér Krammer
Ass. Prof. Dr. Attila Géczy

Prerequisites
Basic of physics and material science, Electronics

Learning outcomes

Knowledge: the students will be able to analyse and classify microelectronic components and substrates, as well as, electronics, mechatronics, optoelectronic and other modules. The student will know the construction of electronic appliances including their manufacturing, assembly and maintenance technologies.

Skills: students will be capable to apply the manufacturing methods, procedures and technologies of electronics products.

Competences: with the acquired competences one can successfully apply the design for manufacturing concept for the electronics products and their mass production; they can install production lines and also take quality management and environmental protection requirements into consideration.

Abstract
The course “Technology of Electronics Products” provides knowledge and practical skills for students related to circuit modules and systems. The students will be able to analyse and classify microelectronic components and substrates, as well as, electronics, mechatronics, optoelectronic and other modules. The student will know the construction of electronic appliances including their manufacturing, assembly and maintenance technologies. The course provides a comprehensive overview of microelectronic devices, components, mechatronic, optoelectronic and other modules and about the structure of electronic equipment including their manufacturing, and assembly technologies.

Content

1. Introduction
   1.1. Introduction to the technology of electronic products.
   1.2. Classification of electronic products and technologies.
2. Electronic Assembly Technologies
   2.1. Types forms, and assembling methods of electronic components (surface and trough hole technology); interconnection substrates of circuit modules, materials and technologies.
   2.2. The Trough Hole Technology (THT), sequence of the technology; flux deposition methods; pre-heating techniques; different wave soldering methods; the pin-in-paste technology.
   2.3. The Surface Mounting Technology (SMT), sequence of the technology, stencil printing technology; component placement machines; reflow soldering techniques (infra-red, convention and vapour phase reflow technologies); application of wave soldering in case of surface mounted devices.
3. Technology of Semiconductor-Based Components
   3.1. Mounting and encapsulation technologies of semiconductor devices, chip scale packaging, flip chip mounting, wire bounding technologies; tape automated technology; chip soldering and gluing (conductive adhesives) methods; wafer level packaging.
   3.2. Silicon technologies, basics of semiconductor devices, wafer production, doping with diffusion and ion-implantation, layer deposition and patterning methods.
4. Thin Films and Their Manufacturing
   4.1. Vacuum technology and its application in thin film technology, properties and advantages of thin film circuits.
   4.2. Film deposition and patterning technologies of thin film networks: vacuum evaporation, photolithography and etching; laser processed applied in electronics technology.
5. Thick-Film Technologies
   5.1. Ceramic and polymer thick film technologies; film deposition technologies of thick film circuits: screen-printing and firing; hybrid IC production; trimming of integrated resistors; ceramic thick-film applications.
   5.2. Insulating substrate passive (thin- and thick-film) networks and high density interconnects; design methods and consideration.
   5.3. Mounting and assembling methods of circuit modules and High Density (HDI) substrates
6. Manufacturing Technology and Design of Printed Wiring Boards
   6.1. Manufacturing technologies of single and double sided printed wiring boards (PWBs), mechanical technologies, layer deposition technologies; masking technologies; layer removing technologies (etching).
   6.2. Manufacturing technologies of multi-layer printed wiring boards (PWBs), Co-laminated multilayer printed wiring board technology; microvia processing technology; sequential build up (SBU) multilayer printed wiring board processing; special printed wiring boards.
7. Electronic Appliances
   7.1. Thermal constructions of electronic appliances, basic of thermal management and physics, thermal interface materials; thermal design; cooling solutions (air, liquid and phase change cooling).
   7.2. Basics of appliance design; main development phases; rote of the specification; design for manufacturing; design for reliability; standards of electronics appliances.
   7.3. Quality, reliability, quality assurance in the production lines; quality inspection points and methods; typical soldering failures; environment and other human oriented issues of electronics technology.

Teaching methods
The course is presented by the aid of Power Point presentations.

Assessment
The course grade consists of these components:
60% – Knowledge test with a multiple choice questionnaire
40% – Final Project (a literature review about a given electronics technology topic)

Recommended reading

Tummala, R.R. (2001). *Fundamentals of Microsystems Packaging*, McGraw-Hill

Coombs, C.F. (2008). *Printed Circuits Handbook*, McGraw-Hill

Zarrow, P. (1997). *Surface Mount Technology Terms and Concepts*, Elsevier, Newnes

Landers, T.L. (1994). *Electronics Manufacturing Processes*, Prentice Hall

Datta, M. (2005). *Microelectronic Packaging*, CRC Press

Syllabus
"Virtual Laboratory Support for Microelectronics Packaging Education"

Course topic
Technology of Electronics Products

Number of credits
3 ECTS

Course responsible
Budapest University of Technology and Economics
Department of Electronics Technology
Assoc. Prof. Dr. Oliver Krammer

Course lecturers
Assoc. Prof. Dr. Balázs Illés
Assoc. Prof. Dr. Olivér Krammer
Ass. Prof. Dr. Attila Géczy

Prerequisites
Basic of physics and material science, Electronics

Learning outcomes

Knowledge: the students will be acquainted with the principles of the processes of electronics packaging technologies. The students will know the operating mechanism of machines in the manufacturing line, and will be able to analyse the machines' basic specifications.

Skills: the students will be capable to make a distinction between different packaging technologies (e.g. thick-film, thin-film, PCB based) and to relate the proper equipment and infrastructure for these technologies.

Competences: the acquired competences allow the students to analyse machines operating in the electronics production, and to provide aid for design engineers during the stages of designing, purchasing and building manufacturing lines for electronic products.

Abstract
The objective of the course "Virtual Laboratory Support for Microelectronics Packaging Education" is to provide an overview about the content and usage of a virtual laboratory focusing on microelectronics packaging. The virtual laboratory includes brief descriptions about the basic principles of different packaging technologies, about the equipment and manufacturing machines related to the packaging technologies, and also animations about the principles of manufacturing processes and about the operation of manufacturing machines. The virtual laboratory covers the following areas of microelectronics packaging: manufacturing of printed wiring boards; assembly of electronic circuits – soldering technologies; nanometrology, sensors & microfluidics technology; thin-film and thick-film technologies; laser technologies; failure analysis.

Content

1. Introduction
   1.1. Introduction to the virtual laboratory.
   1.2. Basic usage of the virtual laboratory.
2. Manufacturing of printed wiring boards
   2.1. Mechanical technologies; CNC drilling, peripheral milling, brushing.
   2.2. Photolitography; lamination, exposing, developing, drying.
   2.3. (Electro)chemical technologies; electroplating, tin stripping, immersion silver finishing.
3. Assembly of electronic circuits
   3.1. Manual assembly technologies; manual solder paste deposition, component placement – pick&place and fineplacer principles; reflow soldering.
   3.2. Assembly of through-hole components; selective mini-wave soldering.
   3.3. Assembly of surface mounted components; semi-automatic stencil printing, automatic component placement by pick&place machines, vapour phase soldering.
   3.4. Inspection of assembly; AOI, X-ray inspection.
4. Nanometrology, sensors & microfluidics technology
   4.1. Microfluidics; 3D printing.
   4.2. Sensors; spectrophotometry, Surface Plasmon Resonance Imaging.
   4.3. Nanometrology; Atomic Force Microscopy.
5. Thin-film and thick-film technologies
   5.1. Thin-films; vacuum evaporating; alpha-step profilometry.
   5.2. Thick-films; screen printing, drying-firing, isostatic lamination.
6. Laser technologies
   6.1. Coherent Avia UV Nd:YAG laser.
   6.2. Epilog CO_2 laser.
7. Failure analysis
   7.1. Microscopy techniques; optical microscopy, acoustic microscopy, electron microscopy.
   7.2. Cross-sectional analysis; wet grinding.
   7.3. Life-time tests; shear-test, temperature-humidity-bias test, thermal shock test, highly accelerated stress test.

Teaching methods

The course is presented in Power Points presentations and by the aid animations obtained from the virtual laboratory.

Assessment

The course grade consists of these components:
60% – Knowledge test with a multiple choice questionnaire
40% – Final Project (a literature review about a given laboratory equipment topic)

Recommended reading

http://www.ett.bme.hu/vlab

Syllabus
"Design of Nanoscale MOS ICs"

Course topic
Design of Nanoscale MOS ICs
Number of credits
5 ECTS
Course responsible
TUS Sofia
Department of Micrtoelectronics
Prof. Dr. Marin Hristov
Course lecturer
Assoc. Prof. Dr. Rossen Radonov
Ass. Prof. Dr. Elitsa Gieva

Prerequisites
Microelectronics technology and design rules, solid state physics, computer added design in electronics.

Learning outcomes
Upon successful completion of this course students should be able to:

- Compare the CMOS technologies for nanotransistors as FDSOI and Tri-Gate;
- Explain the steps in IC design and the different design rules;
- Design the schematics of CMOS integrated circuits end perform the simulations;
- Solve the problems with modelling and simulating short channel transistor circuits;
- Design the layout of CMOS ICs;
- Perform the extraction of the schematics from the layout and verification of the design and analyse the cause for the errors.
- Demonstrate innovation, autonomy, and sustained commitment to the development of new modelling and design rules through performing a full design of nanoscale ICs

Abstract
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.

Content
Introduction
The design in the 'More than Moore' era:
The effect 'digital becomes analogue' (subtreshold, gate leakage – pure digital circuits to be simulated with consideration of analogue effects), voltage headroom shrinks and makes analogue and RF design complicated, etc.
1. CAD tools for design of analogue and mixed-signal integrated circuits (CADENCE)
1.1. Schematics.

Getting Started, Understanding Connectivity and Naming Conventions, Creating Schematics, Creating a Multisheet Schematic, Creating Symbols, Automatically Creating Cellviews, Editing Objects, Editing Properties, Traversing the Design Hierarchy and Creating a Design Configuration View, Checking Designs, Plotting Designs, Setting Schematic Composer Options, Customizing the Schematic Composer

1.2. Simulation

1.2.1. Spice

Introduction, Built-In Variables and Arrays, Expressions and Functions, Commands, Circuit Analysis, Components, Command and Model Files, Device Models, Subcircuits, Examples, Analysis, Node Referencing

1.2.2. Spectre

Getting Started with Spectre, SPICE Compatibility, Spectre Netlists, Parameter Specification and Modeling Features, Analyses, Control Statements, Specifying Output Options, Running a Simulation, Time-Saving Techniques, Managing Files, Identifying Problems and Troubleshooting, Example Circuits, Dynamic Loading

1.2.3. Verilog XL

About the Verilog-XL Integration Environment, Setting Up the Simulation Environment, Working with the Stimulus, Running and Controlling a Interactive Simulation, Viewing Simulation Results Interactively, Debugging Your Design, Running Batch Simulations, Comparing Simulation Results, Netlisting

1.3. Layout

1.3.1. Envisia Silicon Ensemble

Introduction, The Basics, Timing-Driven Design Flow, Environment Variables, Error Messages

1.3.2. IC Chip Assembly

Chip Assembly Overview, Preparing, Translating, and Checking Data, Setting Routing Rules, Analyzing and Preparing the Design for Routing, Routing Your Design, Design File Syntax Example, Questions and Answers, Trouble Shooting, Via Naming Conventions

2. CAD tools for design of digital circuits (SYNOPSYS)

2.1. Methodologies

Introduction, The Design Process, Detailed Design, FPGA's and ASIC's, FPGA Design Flow, ASIC Design Flow

2.2. Synopsys Environment

CoCentric, Physical Synthesis, Synthesis Tools, DesignWare, Library Compiler, Simulation Tools, Static Timing and Formal Verification

2.3. VHDL and Verilog

3. Design of deep-submicron devices (subtreshold, gate leakage etc.)

4. 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).

Teaching methods

The theoretical part of the course is presented in the Moodle learning environment in the form of HTML tutorials.

The practical work represents a project for design of submicron integrated circuit with a remote access to SYNOPSIS and CADENCE which run on the server of ECAD laboratory at TU-Sofia. In both cases on-line support by the tutor is provided.

Assessment

The course grade consists of these components:

40% – Knowledge test with a multiple choice questionnaire

60% – Final Project

Recommended reading

Deleonibus S., Intelligent Integrated Systems: Devices, Technologies, and Architectures, Pan Stanford Publishing, 2014, ISBN-13: 978-9814411424.

Collaert N., CMOS Nanoelectronics: Innovative Devices, Architectures, and Applications, CRC Press, 2012, ISBN-13: 978-9814364027.

Deleonibus S., Electronic Device Architectures for the Nano-CMOS Era. From Ultimate CMOS Scaling to Beyond CMOS Devices, Pan Stanford Publishing, 2008, ISBN-13: 978-9814241281.

Lee P., Introduction to Place and Route Design in VLSIs, 2006, ISBN 978-1-4303-0492-0,

Scheffer L., Lavagno L. and Martin G. (ed), Electronic Design Automation for Integrated Circuits Handbook, Volume 1, EDA for IC System Design, Verification and Testing, Taylor & Francis, 2006, ISBN 0-8493-7923-7

Scheffer L., Lavagno L. and Martin G. (ed), Electronic Design Automation for Integrated Circuits Handbook, Volume 2, EDA for IC Implementation, Circuits Design and Process Technology, Taylor & Francis, 2006, ISBN 0-8493-7924-5

Syllabus

"Electronics maintenance in Renewable energies"

Course topic
Fundamentals of maintenance of specific equipment commonly used in Renewable energies industry. Acquisition of knowledge and skills for advanced maintenance and methods of maintenance in Renewable energy plants.

Number of credits
4 ECTS

Course responsible
INOMA Renovables, S.L.
In collaboration with University of Cádiz (UCA). It's planned that this course will be recognized by this University.
Prof. Javier Leal Juárez
Prof. Carlos Hieyte Gambín

Course lecturers
Prof. Javier Leal Juárez
Prof. Carlos Hieyte Gambín
Prof. Rafael Jiménez Castañeda
Prof. Higinio Sánchez Sainz
Prof. Germán Álvarez Tey
Prof. Jose Maria Guerrero Rodríguez

Prerequisites
Fundamentals of Renewable energies (solar thermal, PV, wind energy). Fundamentals of microelectronics.

Learning outcomes

Knowledge: Proffesional knowledge in maintenance of electronic equipment typically used in renewable energies installations and methods for designing a correct maintenance policy.

Skills: Advanced skills in maintenance of Renewable energies power plants, and choosing more suitable method for maintenance of each equipment.

Competences: Able to design a correct maintenance plan, analysis of power electronics devices, selection of adequate measurement devices. Able to evaluate obtained measurement data for identification of operating failures.

Abstract
The importance of maintenance of electronics devices integratated in Renewable energy systems is increasing nowadays. Renewable energy systems use an important variety of electronics devices such as grid-connected and standing alone PV inverters, battery charge controllers, on-grid chargers, rectifiers, solar thermal controllers… In this course, professionals specialized in maintenance will find technical updating of renewable energy systems. They will be able to

define a maintenance plan and its monitoring work. During the course, practical cases based in real breakdowns of Renewable energy electronics devices will be offered. Then, the student will identify the breakdown and will be able to make a correct diagnosis by using both the required competences and measurement devices commonly used in this sector.

Content

1. Working principle of renewable energy systems.
   1.1. Solar thermal systems.
   1.1.Solar photovoltaic systems.
   1.2.Wind electric systems.
2. Fundamentals of maintenance.
   2.1. Corrective maintenance.
   2.2. Preventive maintenance.
   2.3. Predictive maintenance.
3. Components of Renewable energy systems.
   3.1. Low-temperature solar thermal systems.
      3.1.1. System configuration.
      3.1.2. Main devices.
   3.2. Solar photovoltaic systems
      3.2.1. Typology.
      3.2.2. Main devices.
      3.2.3. Electrical diagrams and block diagrams.
   3.3. Wind electric systems
      3.3.1. Classification.
      3.3.2. Typology of windmills.
4. Electronic controllers in low-temperature solar thermal systems.
   4.1. Commercial control devices. Technical data.
   4.2. Description of typical breakdowns.
5. Electronic devices in PV systems.
   5.1. Electronic devices in grid-connected PV installations.
   5.2. Electronic devices in standing-alone PV installations.
   5.3. Description of typical breakdowns.
6. Electronic devices in wind electric systems.
   6.1. Electronic devices in grid-connected wind electric systems.
   6.2. Electronic devices in standing-alone wind electric systems.
   6.3. Description of typical breakdowns.
7. Electronic Maintenance in Renewable energy systems.
   7.1. Instrumentation
   7.2. Measurement methods.
   7.3. Maintenance plans.

Teaching methods

This course will follow a distance-learning model with systems to student independent learning support, according to the rules and structures in which is based the virtualized teaching of UNED.
The student independent learning is very important, so the workload of the course depends on each personal circumstances. The virtual platform, specially discussion forum and personal contact by email, will help students to follow the subject with a regular and consistent work rate.
Students must study and prepare each item chronologically, since each builds on the previous. The following training activities must be developed in each module:

- Reading documentation

- Complete auto-assessments questions and exercises (practical and theoretical)
- Practice with simulators and e-labs

Assessment

The evaluation is a continuous assessment; students must complete the following tasks:

- Distance exercises. The teaching staff will provide exercises with a deadline specified in the platform. Exercises will be focused in short questions related to the subject.
- Forum tasks. Special tasks will be available by forums
- Students participation in the subject (forums, questions, opinions and so on) will be taken into consideration
- Final work. Topics will be proposed by students in a specific forum for such use, and they have to be approved by teaching staff. These proposals must contain a brief description.

The evaluation will be:

- 40% for online exercises
- 40% for the online final work
- 20% for the forum tasks and participation

Recommended reading

- Ferry, D, Bird, J. (2001). *Electronics Materials and Devices.* Academic Press.
- Mohan, N, Undeland, T, Robbins, W. (2003). *Power Electronics: Converters, Applications and Design.* McGraw Hill.
- Duffie, J., Beckman, W (2013). *Solar Engineering of Thermal processes.* John Wiley & Sons.
- Peuser, F., Remmers, K., Schnauss, M. (2010). *Solar Thermal Systems. Successful Planning and Construction.* Solarpraxis.
- Antony, F., Dürschner, C., Remmers, K. (2010). *Photovoltaics for Proffesionals.* Solarpraxis.
- Jain, P. (2013). *Wind energy Engineering.* McGraw-Hill.
- Rivkin, D., Silk, L. (2012). *Wind Turbine Operations, Maintenance, Diagnosis, and Repair.* Jones & Bartlett Learning books.

Syllabus
"Electromagnetic Compatibility of Integrated Circuits"

Course topic
A practical course to take part to a global integrated circuit emission and susceptibility reduction strategy.

Number of credits
3 ECTS

Course responsible
INSA Toulouse
Prof. Etienne Sicard

Course lecturers
Prof. Etienne Sicard
Dr. Alexandre Boyer

Prerequisites
Knowledge of basic electronics design, micro/nano technologies, passive and active component modelling. Basic knowledge in Electromagnetics.

Learning outcomes

Knowledge: Global overview of EMC challenges at IC level. Understanding of basic concepts, units, links between electrical & electromagnetic domain. Review of standard measurement and modelling methods for emission and immunity of ICs. Influence of technology roadmaps to EMC performances. Guidelines for improved EMC. Overview of 3D-IC technologies and impact on EMC.

Skills: Setup standard measurement methods for emission and immunity. Simulation and analysis of EMC performances of fast IOs. Simulation of conducted & radiated noise. Simulation of conducted immunity to radio-frequency interference

Competences: Ability to characterize EMC performances of ICs. Ability to compare measured and simulated EMC performances of ICs. Design for improved EMC using a selection of golden rules.

Abstract
Integrated circuits (ICs) often play an important role in the electromagnetic compatibility (EMC) of embedded systems. Electromagnetic (EM) compliance has traditionally been focused on systems, cables, shielding and protections at printed circuit board level. However, ICs are the ultimate source of noise that produce interference, as well as ultimate victims of electromagnetic interference. Of all the components in a typical electronic system, ICs tend to be the most susceptible to damage caused by over-voltage or over-current conditions. The course aims at presenting the industrial context of EMC, highlighting the importance of EM-friendly integrated circuits which ensure reliable and safe electronic applications. It also aims at providing minimum

skills to students, researchers and engineers to take into account EMC at early stages of electronic product design. This course provides a unique collection of information, both theoretical and practical, focused on the electromagnetic compatibility of integrated circuits. The basic concepts, theory, and an extensive historical review of integrated circuit emission and susceptibility are provided. Standardized measurement methods are detailed through various case studies. EMC models for the core, interface ports, supply network, and packaging are described with applications to conducted switching noise, signal integrity, near-field and radiated noise. Case studies from various cooperative research projects with industry are presented with in-depth descriptions of the ICs, test set-ups, and comparisons between measurements and simulations. Specific guidelines for achieving low emission and susceptibility derived from the experience of EMC experts are also proposed, with prospective vision about the technology scale down and trends towards 3D integration.
A companion tool IC-EMC is used for illustration of the course concepts through a set of simulation trainings covering several aspects of EMC of ICS, including conducted and radiated emission, passive network modelling, noise source and high-speed switch modelling, and susceptibility of devices to conducted interference.

Content

1) Overview
    1.1. Electronic Market Growth
    1.2. Electromagnetic interference
    1.3. What is EMC
    1.4. EMC at IC level
    1.5. Origin of parasitic emission
    1.6. Trends towards higher emission
    1.7. Origin on susceptibility
    1.8. Emission issues
    1.9. Susceptibility issues
    1.10. Standardization issues
    1.11. Conclusion
2) EMC basic concepts
    1.1. Basic Principles
    1.2. Specific Units
    1.3. Radiating element
    1.4. Emission Spectrum
    1.5. Susceptibility Spectrum
    1.6. Notion of margin
    1.7. Impedance
    1.8. Conclusion
3) EMC Measurement Methods
    1.1. Context of EMC certification
    1.2. Illustration of electromagnetic emission produced by electronic devices
    1.3. Illustration of susceptibility to electromagnetic disturbances of electronic devices
    1.4. Some EMC measurement tests
    1.5. Conclusion
4) Design guidelines for EMC of electronic devices
    1.1. Introduction
    1.2. Guidelines for signal integrity
    1.3. Guidelines for power integrity
    1.4. Guidelines for reduced radiated emission
    1.5. Reduction of I/O noise

1.6. Spread-spectrum frequency modulation

5) 3D-IC EMC
   1.1. 3D-IC Benefits
   1.2. 3D-IC Technology
   1.3. 3D-IC EMC Challenges
   1.4. 3D-IC Signal Integrity
   1.5. 3D-IC PDN & Power Integrity
   1.6. 3D-IC Measurement methods
   1.7. 3D-IC EMC Case Study
6) Practical trainings
   1.1. IC-EMC – Reference
   1.2. Basic concepts
   1.3. FFT of typical signals
   1.4. Transient current estimation
   1.5. Emission
   1.6. di/dt noise
   1.7. PDN modeling
   1.8. Signal integrity
   1.9. Impedance mismatch
   1.10. Susceptibility
   1.11. Estimation of susceptibility level

Teaching methods

The theoretical part of the course is presented with PowerPoint slides, live exercises and problem-based learning. Through the Knowledge Alliance project, a Moodle learning environment in the form of HTML tutorials and videos is also considered, in partnership with UNED Madrid, Spain.

The laboratory is based on interactive simulations, using the freeware tool IC-EMC and several problems to solve, addressing both emission and immunity.

Assessment

The evaluation is based on a written report targeting problems similar to the ones solved in practical sessions and discussed in the course.

Recommended reading

- A. Boyer, E. Sicard, "Introduction to Electromagnetic Compatibility of Integrated Circuits", book to appear at South University Press (PUM), 2017

- E. Sicard,A. Boyer, P. Fernandez Lopez, A. Zhou, N. Marier, F. Lafon "EMC performance analysis of a Processor/Memory System using PCB and Package-On-Package", EMC Compo 2015, Nov. 10-13, 2015, Edinburgh

- S. Ben Dhia, M. Ramdani, E. Sicard "EMC of Ics: Techniques for low emission and susceptibility", Springer, USA, 2006, XIV, 474 p. 464 illus., ISBN: 0-387-26600-3

Syllabus

"Integrated circuits and design"

Course topic
Advanced processes in microelectronics technology for the production of integrated circuits and methods for the design of digital integrated circuits. Acquisition of knowledge and skills for creative work in the practice of microelectronics.

Number of credits
4 ECTS

Course responsible
Spanish University for Distance Education (UNED)
Industrial Engineering Technical School (ETSII)
Electrical and Computer Engineering Department (DIEEC)
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego

Course lecturers
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego
Prof. Félix García Loro
Prof. Sergio Martín Gutiérrez
Prof. Gabriel Díaz Orueta

Prerequisites
Fundamentals of microelectronics, main technology processes in microelectronics and fundamental processes in microelectronics technology for the production of integrated circuits.

Learning outcomes

> **Knowledge:** Advanced knowledge in Technologies of integrated circuits and methods for designing digital integrated circuits.
>
> **Skills:** Advanced skills in choosing which is the best technology to use for specific requirements in the production of an integrated circuit and advanced ability of choosing more suitable method for designing a specific integrated circuit
>
> **Competences:** Able to use Lithography technology in the design of integrated circuits. Able to use CMOS technology sequence and BiCMOS integrated circuits. Able to manage and design custom circuits and logical matrices.

Abstract
Microelectronics deals with the miniaturization of electronics components, and its evolution has given rise to many modern benefits. Its progress level directly affects the development of the information technology. Microelectronics involves the design, fabrication and testing of integrated circuits. Integrated circuits are widely used in computers, telecommunication equipment and electronics devices for information acquisition, transmission, storage and processing information.

This course address the technology for production of integrated circuits and methods for the design of digital integrated circuits.

Content

1. Technologies of Integrated Circuits
   1.1. Photolithography
   1.2. Photoresists and Non-optical Lithography
   1.3. Vacuum Technology and Plasmas
   1.4. Etching Techniques
2. Design of Digital Integrated Circuits
   2.1. Packaging techniques
   2.2. System packaging: levels of packaging
   2.3. Interconnections in printed circuit boards
   2.4. Modular assembly
   2.5. Environmental and electrical considerations

Teaching methods

This course will follow a distance-learning model with systems to student independent learning support, according to the rules and structures in which is based the virtualized teaching of UNED. The student independent learning is very important, so the workload of the course depends on each personal circumstances. The virtual platform, specially discussion forum and personal contact by email, will help students to follow the subject with a regular and consistent work rate.
Students must study and prepare each item chronologically, since each builds on the previous. The following training activities must be developed in each module:

- Reading documentation
- Complete auto-assessments questions and exercises (practical and theoretical)
- Practice with simulators and e-labs

Assessment

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The evaluation will be:

- 50% for online exercises
- 30% for the online final work
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Recommended reading

- Franssila, S. (2010). *Introduction to Microfabrication.* John Wiley & Sons.
- Kaeslin, H. (2008). *Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication.* Cambridge University Press.
- Widmann, D., Mader, H. and Friedrich, H. (2013). *Technology of Integrated Circuits.* Springer Science & Business Media.
- Hodges, D., Jackson, H. and Saleh, R. (2003). *Analysis and Design of Digital Integrated Circuits.* McGraw-Hill Companies, Incorporated.

- William-Martin, K. (2000). *Digital Integrated Circuits Design.* Oxford University Press.

Syllabus

"Integrated circuits and design"

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Number of credits
4 ECTS

Course responsible
Spanish University for Distance Education (UNED)
Industrial Engineering Technical School (ETSII)
Electrical and Computer Engineering Department (DIEEC)
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego

Course lecturers
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego
Prof. Félix García Loro
Prof. Sergio Martín Gutiérrez
Prof. Gabriel Díaz Orueta

Prerequisites
Fundamentals of microelectronics, main technology processes in microelectronics and fundamental processes in microelectronics technology for the production of integrated circuits.

Learning outcomes

Knowledge: Advanced knowledge in Technologies of integrated circuits and methods for designing digital integrated circuits.

Skills: Advanced skills in choosing which is the best technology to use for specific requirements in the production of an integrated circuit and advanced ability of choosing more suitable method for designing a specific integrated circuit

Competences: Able to use Lithography technology in the design of integrated circuits. Able to use CMOS technology sequence and BiCMOS integrated circuits. Able to manage and design custom circuits and logical matrices.

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Teaching methods

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- Practice with simulators and e-labs

Assessment

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- William-Martin, K. (2000). *Digital Integrated Circuits Design.* Oxford University Press.

Syllabus

"Microelectronics literacy and Technologies"

Course topic
Fundamentals of microelectronics, main technology processes in microelectronics and fundamental processes in microelectronics technology for the production of integrated circuits.

Number of credits
4 ECTS

Course responsible
Spanish University for Distance Education (UNED)
Industrial Engineering Technical School (ETSII)
Electrical and Computer Engineering Department (DIEEC)
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego

Course lecturers
Prof. Manuel Castro Gil
Prof. Rosario Gil Ortego
Prof. Félix García Loro
Prof. Elio San Cristobal Ruiz
Prof. Clara Pérez Molina

Prerequisites
Knowledge of electronics and circuit analysis.

Learning outcomes

> **Knowledge:** Overview of fundamentals of microelectronics. Basic knowledge in the main technology processes in microelectronics.
>
> **Skills:** Skills in classification materials, definition of semiconductor substrates and crystals. Ability of understanding the crystal growth processes, all the main manufacturing processes and thin film processes and choosing which is the best process to use for a specific design.
>
> **Competences:** Able to use different types of large scale integrated circuits. Able to design the oxidation and deposition layers and the diffusion and ion implantation in microelectronics.

Abstract
Microelectronics deals with the miniaturization of electronics components, and its evolution has given rise to many modern benefits. Its progress level directly affects the development of the information technology. Microelectronics involves the design, fabrication and testing of integrated circuits. Integrated circuits are widely used in computers, telecommunication equipment and electronics devices for information acquisition, transmission, storage and

processing information. This course address the fundamentals of microelectronics and fundamental processes in microelectronics technology for the production of integrated circuits.

Content

1. Fundamentals of Microelectronics
   1.1. Historical evolution
   1.2. Introduction to microelectronics
   1.3. Classification of materials
   1.4. Semiconductor substrates
   1.5. Semiconductor crystals
2. Main Technology Processes in Microelectronics
   2.1. Introduction
   2.2. Crystal growth
   2.3. Manufacturing processes: Diffusion
   2.4. Manufacturing processes: Thermal oxidation
   2.5. Manufacturing processes: Ion implantation
   2.6. Manufacturing processes: Rapid Thermal Processing (RTP)
   2.7. Thin film

Teaching methods

This course will follow a distance-learning model with systems to student independent learning support, according to the rules and structures in which is based the virtualized teaching of UNED.

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- Reading documentation
- Complete auto-assessments questions and exercises (practical and theoretical)
- Practice with simulators and e-labs

Assessment

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- Razavi, B. (2012). *Fundamentals of Microelectronics*. Wiley.
- Zhang, G.Q., van Driel, W.D. and Fan, X.J. (2006). *Mechanics of Microelectronics*. Springer Science & Business Media

Syllabus

"Microelectronics literacy and Technologies"

Course topic
Fundamentals of microelectronics, main technology processes in microelectronics and fundamental processes in microelectronics technology for the production of integrated circuits.

Number of credits
4 ECTS

Course responsible
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Prerequisites
Knowledge of electronics and circuit analysis.

Learning outcomes

> **Knowledge:** Overview of fundamentals of microelectronics. Basic knowledge in the main technology processes in microelectronics.
>
> **Skills:** Skills in classification materials, definition of semiconductor substrates and crystals. Ability of understanding the crystal growth processes, all the main manufacturing processes and thin film processes and choosing which is the best process to use for a specific design.
>
> **Competences:** Able to use different types of large scale integrated circuits. Able to design the oxidation and deposition layers and the diffusion and ion implantation in microelectronics.

Abstract
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- Razavi, B. (2012). *Fundamentals of Microelectronics*. Wiley.
- Zhang, G.Q., van Driel, W.D. and Fan, X.J. (2006). *Mechanics of Microelectronics*. Springer Science & Business Media

Syllabus on Nanomaterials for Electronics

Course topic
Nanomaterials for Electronics
Number of credits
5 ECTS
Course responsible
TUS Sofia
Department of Micrtoelectronics
Prof. Dr. Slavka Tzanova
Course lecturer
Ass. Prof. Dr. Elitsa Gieva
Assoc. Prof. Dr. Mariya Alexandrova-Pandieva
Ass. Prof. Maria Angelova
Prerequisites
Microelectronics technology and design rules, solid state physics, computer added design in electronics.

Learning outcomes
Upon successful completion of this course students should be able to:

- Compare the properties of materials for deep-submicron and nanometre CMOS IC, HEMT, single electron transistors and resonant tunnelling devices;
- Discuss the advantages of devices on carbon nanotubes and graphene;
- Explain the physical principles of spintronic devices and choose appropriate materials for them;
- Select a method and plan the procedures for characterisation of molecular systems;
- Plan the fabrication procedure for deep-submicron and nanometre CMOS IC with the proper technological process for the materials of the substrate, implanted areas, isolation, metallisation.

Abstract
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.

Content
1. Current trends in nanoelectronics
The course will cover the materials for:
- Deep-submicron and nanometre CMOS IC (under 50 μm);
- HEMT (high electron mobility transistor);
- Devices on carbon nanotubes and graphene;
- Resonant tunnelling devices and circuits;

- Single electron transistors;
- Spintronics;
- Quantum electronics;
- Bioelectronics and molecular electronic devices.

2. 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.

3. Materials for HEMT:
   - Heterostructures on A3B5 (GaAs/ AlGaAs, InGaAs/InAlAs etc.).

4. Materials for devices on carbon nanotubes and graphene:
   - CNT – Carbon nanotubes – physical characteristics.
   - CNT devices: CNT Transistor, CNT –Based Field Emission Devices, Junctions, Heterojunctions and Quantium Confined Structures Based on Carbon Nanotubes, Microwave Devices Based on Carbon Nanotubes, CNT Based Electrical Sensors;
   - Graphene.

5. Materials for resonant tunnelling devices:
   - Structures of resonant tunnelling devices and circuits: AlAs/GaAs/AlAs, AlSb/InAs/AlSb.

6. Materials for single electron transistors:
   - Single Electron Transistors structure and materials: Si, GaAS.

7. Spintronics:
   - Physical principles and materials for spintronic devices;
   - Spintronic structures: Spin Valves, Spin Pumps, Spin Diodes, Spin Transistors, Spin Based Optoelectronics Devices, Spintronic Computation.

8. Quantum electronics:
   - Quantum electronic devices (QED) – physical principles and materials;
   - Short-Channel MOS Transistor, Split-Gate Transistor, Electron-Wave Transistor, Electron-Spin Transistor, Quantium Cellular Automata (QCA).

9. Materials for bioelectronics and molecular electronic devices:
   - Characterisation of molecular systems: electrical properties of molecules;
   - Molecular electronic devices, polymer electronics, self-assembling circuits, optical molecular memories;
   - Molecular processor, DNA analyzer as biochip.

Teaching methods
The course is presented in the Moodle learning environment in the form of HTML tutorials.
On-line support by the tutor is provided.

There is optional practical work (mandatory of rthe students at TUS) in the laboratory of vacuum layer deposition of the Dep. of Microelectronics at TU-Sofia.

Assessment
Knowledge test with a multiple choice questionnaire

Recommended Readings

Vajtai, R. (Ed.), Springer Handbook of Nanomaterials, Springer, 2013, ISBN 978-3642205958

Bhushan, B. (Ed.), Springer Handbook of Nanotechnology, Springer, 2010, ISBN 978-3642025259

Wiliams A.,Semiconductor Nanomaterials for Flexible Technologies, Sun&Rogers, 2012, ISBN: 978-1437778236

Kumar V., Nanosilicon, 2013, Elsevier Science, ISBN: 9780080445281

Baldo M., Introduction to Nanoelectronics, MIT course materials, http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-701-introduction-to-nanoelectronics-spring-2010/download-course-materials/

COURSE DESCRIPTION

Title	**Design, Prototype Fabrication and Challenging Applications of Silicon Microsystems with Piezoresistive Feedback**
Short name/abbr.	**P_zR Microsystems**
Course objectives	**see in syllabus (Knowledge, Skills and Competences)**
Course description	**see in syllabus**
Targeted students	**bachelor, master, Ph.D. students**
Intro	**see in syllabus**
Developed by	**AMG Technology Ltd (AMGT) and TU-Sofia (TUS)**
Evaluation	**see in syllabus**

Syllabus

Design, Prototype Fabrication and Challenging Applications of Silicon Microsystems with Piezoresistive Feedback

Course topic
The course highlights the synergy between design and processing for the fabrication of microsystems dedicated to advanced applications. Knowledge and skills for creative work in the practice of microsystems will be acquired by the learners.

Number of credits
3ECTS

Course responsible
Vladimir Stavrov
AMG Technology Ltd. (AMGT)
Prof. Slavka Tsanova
Technical University Sofia (TUS)

Course lecturers
Vladimir Stavrov
Prof. Slavka Tsanova
Galina Stavreva

Prerequisites
Microsystems' related fundamentals of: material science, micro technologies, methods for control and analyses of fabrication processes, and basic knowledge for compliant mechanisms.

Learning outcomes

Knowledge: Knowledge of most important part of the theory, facts, and principles of embodiment of application specific microsystems with piezoresistive feedback - emphasize on synergy between electronic and mechanical properties of materials, exploited technologies, microsystems' design rules, and devices' performance

Skills: Ability to transduce the targeted specification of the microsystem into a relevant selection of base material, exploited technology and microsystems' layout in application specific prototyping, emphasizing on the differences between microelectronics and microsystems

Competences: Ability to provide autonomously exploitable outcomes of all main intermediate stages of design, computer simulation, mask layers' extraction, selection of the best processing option for microsystems' fabrication, and implementation of devices' validation in accordance to the specific application

Abstract

Microsystems deal with the miniature mechanical mechanisms with embedded electronic elements fabricated by technologies similar to microelectronics. The synergy between fabrication technology and design will be demonstrated on various devices with piezoresistive feedback. Based on device specifications this course addresses the whole development cycle, incl. selection of materials and exploitable technology, as well as the design of different functional elements. The impact of different process steps and design parameters on microsystems' performance is illustrated, emphasising the options for technology or layout modifications. Examples of specific applications of cantilevers and in-plane moveable flexure mechanisms are in-depth analyzed.

Content

1. **Introduction**:
   - 1.1. Why microsystems with piezoresistive feedback? Motivation, definitions, challenges and perspectives; definition of the specific area of the course
   - 1.2. Principle of operation of different silicon microsystems – detection of flexure bending; explanation of the examination method

2. **Fabrication of microsystems**
   - 2.1. Review of materials for silicon microsystems: Why still silicon is the raw material? Short review of the materials used in fabrication of silicon microsystems?
   - 2.2. Facilities for prototyping of microsystems: issues from the practice
   - 2.3. Technology background: review, critical assessment and constrains due to the available processes in microsystems' development and prototyping
   - 2.4. Technology integration issues: process/materials' compatibility, selectivity, anisotropy, economical, etc. aspects
   - 2.5. Examples for process integration - 1: self-sensing and self-actuated cantilevers for chemical recognition and AFM
   - 2.6. Examples for process integration - 2: microsystems with sidewall piezoresistors

3. **Design aspects of microsystems' prototyping**

    3.1. Test procedures at development and fabrication of microstructures

    3.2. Design of Microdevices with Piezoresistive Feedback: examples for microsystems with planar and sidewall piezoresistors

    3.3. Design options for microdevices with sidewall piezoresistors. Multi-Project Wafer process – a roadmap to a one-day prototyping of microsystems

4. **Advanced applications of microsystems with piezoresistive feedback**

    4.1. Cantilever sensors with embedded strain sensing for advanced applications; self-sensing cantilever sensors for AFM

    4.2. Position sensors with piezoresistive feedback: 1D, 2D and 3D cases

    4.3. Applications of 1D and 2D piezoresistive position sensors: scan stages for SPM and structural health monitoring (SHM)

    4.4. Force measurement with sidewall piezoresistive sensors – mechanical transducers, examples and critical analysis. Weight based traceability and monitoring

Teaching methods

The theoretical part of the course, related to theory of the fabrication processes, principles of operation of microsystems and design related constrains, is presented in PowerPoint slides. The correlation between available technologies, microsystems' specifications and design rules of electrical and mechanical elements, is highlighted. Also, practical examples and results obtained at microsystems' exploitation are analyzed in details. Based on the MECA Knowledge Alliance project in partnership with TU Sofia, Bulgaria, learning environment in the form of HTML tutorials is also considered. The practical laboratory is based on interactive design and simulation activities implementing step-by step optimization using various CAD-CAM tools. Additionally, students solve practical problems found in design of application specific cases, during the lab exercises. Simultaneous meeting the microsystems' specifications and constrains of the available manufacturing technologies by means of different design approaches, is addressed in the course.

Evaluation/Assessment

The evaluation is based on the examination of concepts acquired in the course and consists of the following components:

40% - Final report targeting various problems and issues, according to those solved during the lectures and the labs;

60% - Final design project of a small complexity microsystem.

Recommended reading

- Senturia, S. D., Microsystem Design. Dordrecht: Kluwer Academic Publishers, 2001.
- Mahalik N. P., Micromanufacturing and Nanotechnology, Springer – Verlag, Berlin, 2006.
- Hsu, T.R., MEMS and Microsystems Design and Manufacture, McGraw Hill, 2002.
- Smith C. S., Piezoresistance Effect in Germanium and Silicon, Phys. Rev., vol. 94, no. 1 pp 42-49, 1954Kanda Y., A graphical representation of on piezoresistance coefficient in Silicon, IEEE Trans. Electron Devices ED29, 1982, pp 64-70.
- Schomburg W. K., Introduction to Microsystem Design, Springer-Verlag Berlin, 2011

Syllabus
" Silicon Homojunction Solar Cells "

Course topic
Fundamentals of homojunction solar cells: principle, industrial fabrication process, limitations and market perspectives

Number of credits
0.5 ECTS

Course responsible
INES-LITEN CEA Tech
Yannick Veschetti

Prerequisites
Basic knowledge on radiation/ matter interaction, basic knowledge on the physics of semi-conductors.

Learning outcomes

> **Knowledge:** Fundamentals and principle of photovoltaic cells, example of industrial process, limitations in efficiency of solar cells and market perspectives
>
> **Skills:** Understanding the principle of solar cells; Being able to recognize the different steps of production; Being able to identify the main parameters limiting the efficiency; Comparing the advanced technologies
>
> **Competences:** Being able to participate to or to manage solar cells project developments: requirements, design and quality.

Abstract
Silicon Homojunction is the main available technology for the production of solar cells. To understand how it is possible to obtain the best quality / price ratio, it is first necessary to explain the principle and the fundamentals of the electric current generation. The industrial fabrication process is then detailed, covering each step and each component of the solar cell. The limitations in the efficiency are then presented, and several advanced technologies aiming at improving the efficiency are also compared. The market perspective is finally discussed to insist on the prominence of the silicon homojunction technology.

Content
1. Fundamentals and principle of photovoltaic cell
   1.1. Principle of semiconductors
   1.2. P/N junction structure
   1.3. P/N junction under illumination
   1.4. Solar cell structure and main limitations
   1.5. Electrical parameters
2. Presentation of industrial fabrication process (Al-BSF cell)

2.1. Why crystalline silicon for PV?
2.2. mc-silicone and mono-crystalline wafer
2.3. Standard industrial process
2.4. Surface texturing
2.5. Junction formation
2.6. Process flow
2.7. Metal formation by scree-printing
3. Limitations in efficiency of Al-BSF cell
3.1. Advantages and limitations of processing steps
3.2. Parameters for simulation
3.3. Technological progress over 50 years
4. Advanced technologies
4.1. Continuous improvements
4.2. Selective emitter
4.3. PERC cell rear passivation
4.4. Process flow evolution
4.5. MWT cells
4.6. N type cells
4.7. PERT technology
4.8. Diffused bi-facial N-type solar cells
4.9. IBC solar cells
5. Market perspective
5.1. Cell structure evolution
5.2. PV market

Teaching methods

The course is presented in the Moodle learning environment in the form of HTML tutorials.

Assessment

Recommended reading

- Handbook of Photovoltaic Science and Engineering, Edited by Antonio Luque Instituto de Energ´ıa Solar, Universidad Polit´ecnica de Madrid, Spain And Steven Hegedus Institute of Energy Conversion, University of Delaware, USA
  John Wiley & Sons Ltd
- Silicon Processing for Photovoltaics II, Chandra P. Khattak et C.P. Khattak
- Solar Cells : Operating Principles, Technology and System Applications1986 by Martin A. Greent

Syllabus
"MEMS Sensors and Actuators"

Course topic
Concepts of MEMS sensing and actuating, as well as control techniques for MEMS, supported by real case studies and application examples.

Number of credits
6 ECTS

Course responsible
Ss. Cyril and Methodius University, Skopje
Faculty of Electrical Engineering and Information Technologies
Department of Automation and System Engineering
Prof. Mile Stankovski

Course lecturers
Prof. Mile Stankovski

Prerequisites
Knowledge of basic physical principles of sensors and actuators, and knowledge of basics of MEMS.

Learning outcomes

Knowledge: basics of MEMS sensors and MEMS actuators, and of the physical concepts and principles involved in their functioning. Knowledge of the control laws and techniques implemented in MEMS.

Skills: The students will reach a sufficient level of knowledge and skill to be able to work with MEMS sensors and actuators, and to be able to choose a suitable control methodology for a given MEMS control problem.

Competences: The students will gain capabilities of working with MEMS systems and of designing of control loops for MEMS systems.

Abstract
The ever expanding field of MEMS is an interdisciplinary one. Working with different types of MEMS sensors and actuators and understanding the physical concepts and characteristics that their functioning is based on, is of utmost importance. Furthermore, like macro systems, MEMS also operate in closed loop control systems, where the need for precise control and guidance is essential. Based on this notion, this course aims at educating the students about the basics of MEMS sensor and actuator functioning, and of the methods and techniques of designing suitable control laws for MEMS. All this will be supported by practical laboratory examples and case studies in order to provide students with hands-on experience and practice.

Content

1. Brief Introduction to MEMS
   1.1. What are MEMS?
   1.2. Materials for MEMS
   1.3. Micromachining and Microfabrication Processes
2. MEMS Sensors - Principles and Application
   2.1. Introduction
   2.2. MEMS Position and Displacement Sensors
   2.3. MEMS Inertial Sensors
   2.4. MEMS Pressure Sensors
   2.5. Application: MEMS Sensing in Microgrippers
   2.6. Application: MEMS Sensing in Flowmeters
3. MEMS Actuators - Principles and Application
   3.1. Introduction
   3.2. Principles of MEMS Actuation
   3.3. Piezoelectric Actuators
   3.4. Electrostatic Actuators
   3.5. Thermal Actuators
   3.6. Application: MEMS Actuators in Flow Control
4. Control Techniques for MEMS
   4.1. Introduction
   4.2. Basic Aspects of Control Theory
   4.3. Control Systems in MEMS
   4.4. Examples of Using Closed Loop Control in MEMS
5. Examples of MEMS Applications
   5.1. MEMS Sensors, Actuators, and Control in Automotive Systems
   5.2. MEMS Sensors, Actuators, and Control in Industrial Applications
   5.3. MEMS Sensors, Actuators, and Control in Life Sciences
   5.4. MEMS Applications in Navigation
6. Laboratory:
   6.1. Control System for MEMS Inertial Sensors
   6.2. Application of MEMS Flow Sensors for Flow Control Implementation
   6.3. Control of Microgripper Units

Teaching methods

The theoretical section of the course will be found in the Moodle learning environment in the form of HTML tutorials and presentations.
The laboratory experiments will be recorded and the most important steps of the experiment will be shown and explained to the student.

Assessment

The evaluation is based on a written report, a multiple choice quiz, and an oral examination of the knowledge acquired in the course, by the following formula:

60% – Knowledge test with a multiple choice questionnaire and oral discussion
40% – Final Report

Recommended reading

- Maluf, N., Williams, K. (2004). *An Introduction to MEMS Engineering.* Artech House
- Gaura, E., Newman, R. (2006). *Smart MEMS and Sensor Systems*. Imperial College Press
- Choudhary, V, Iniewski, K. (2013). *MEMS Fundamental Technology and Applications.* CRC Press.

- нашата книга

Syllabus
"Semiconductor Device Modeling"

Course topic
Basic techniques used in the field of computational electronics related to device simulation. Theory of semi-classical methods for semiconductor device modeling and numerical solution approach used for these methods.

Number of credits
6 ECTS

Course responsible
Ss. Cyril and Methodius University, Skopje
Faculty of Electrical Engineering and Information Technologies
Institute of Electronics
Prof. Katerina Raleva

Course lecturers
Prof. Katerina Raleva

Prerequisites
Knowledge of physics of semiconductor devices and knowledge of electronic devices.

Learning outcomes

> **Knowledge:** Knowledge on the field of semiconductor device modeling on a physical level. The course will outline different semi-classical simulation methods needed for modeling micro and nanoscale semiconductor devices, such as, drift-diffusion, hydrodynamic and particle-based simulation methods.
>
> **Skills:** The students will be able to understand multiple scale transport in semiconductors and skill to design drift-diffusion and particle based device simulator.
>
> **Competences:** The students will gain ability to design novel simulation methods needed for modeling state-of-the-art nanoscale devices.

Abstract
As semiconductor feature sizes shrink into the nanometer scale regime, even conventional device behaviour becomes increasingly complicated as new physical phenomena at short dimensions occur, and limitations in material properties are reached. In addition to the problems related to the understanding of actual operation of ultra-small devices, the reduced feature sizes require more complicated and time-consuming manufacturing processes. This fact signifies that a pure trial-and-error approach to device optimization will become impossible since it is both too time consuming and too expensive. Since computers are considerably cheaper resources, simulation is becoming an indispensable tool for the device engineer. Besides offering the possibility to test hypothetical devices which have not (or could not) yet been manufactured, simulation offers unique insight into device behavior by allowing the observation of phenomena that cannot be measured on real devices. Device simulation can be thought of as one component of technology

for computer-aided design (TCAD), which provides a basis for device modeling, which deals with compact behavioral models for devices and sub-circuits relevant for circuit simulation in commercial packages.

This course aims to learn students about physically based device modeling with the emphasis on different semi-classical simulation methods needed for modeling micro and nanoscale semiconductor devices. All this will be supported by practical examples in order to provide students with hands-on experience and practice.

Content

1. Introduction to Semiconductor Device Modeling
   1.1. What is Computational Electronics?
   1.2. The Hierarchy of Transport Models
   1.3. The need for Semiconductor Device Modeling
2. Semiconductor Fundamentals
   2.1. Semiconductor Bandstructure
   2.2. Carrier Dynamics
   2.3. Effective Mass in Semiconductors
   2.4. Semiclassical Transport Theory
   2.5. Boltzmann Transport Equation (BTE)
   2.6. Scattering Processes
   2.7. Relaxation-Time Approximation
   2.8. Solving BTE in the Relaxation-Time Approximation
3. The Drift-Diffusion Equations
   3.1. Steady-State Solution of Bipolar Semiconductor Equations
   3.2. Gummel's Iteration Method
   3.3. Newton's Method
   3.4. Generation and Recombination
   3.5. Time-Dependent Simulation
   3.6. Scharfetter-Gummel Approximation
   3.7. Extension of the Validity of the Drift-Diffusion Model
4. Hydrodynamic Model
   4.1. Extensions of the Drift-Diffusion Model
   4.2. Stratton's Approach
   4.3. Balance Equation Model
5. Particle-Based Device Simulation Methods
   5.1. Free-flight Generation
   5.2. Final State After Scattering
   5.3. Ensemble Monte-Carlo Simulation
   5.4. Device Simulation Using Particles – Monte Carlo Device Simulation

Teaching methods

The theoretical section of the course will be found in the Moodle learning environment in the form of HTML tutorials and presentations.

Assessment

The evaluation is based on homework assignments, a knowledge test and an oral examination of the knowledge acquired in the course, by the following formula:

30% - Homework assignments
40% – Knowledge test and oral discussion
30% – Final Report

Recommended reading

- Vasileska D., Goodnick S., Klimeck G. (2010). *Computational Electronics – Seimclassical and Quantum Device Modeling and Simulation.* CRC Press Taylor&Francis Group.
- Tomizawa K. (1993). *Numerical Simulation of Submicron Semiconductor Devices*. Artech House.
- Lundstrom M. (2009). *Fundamentals of Carrier Transport.* Cambridge University Press.

COURSE DESCRIPTION

name	**Design for manufacturing of microsystems**
shortname/abbr.	**DFM**
course objectives	**see in syllabus (Knowledge, Skills, Competences)**
description	**see in syllabus**
target students	**bachelor, master, Ph.D. students**
intro	**see in syllabus**
developed by	**POLITEHNICA University of Bucharest, Center for Technological Electronics and Interconnection Techniques (UPB-CETTI)**
evaluation	**see in syllabus**

Syllabus
"Design for manufacturing of microsystems"

Course topic

A practice oriented course for understanding Electronic Design Automation (EDA) and manufacturing principles oriented to design for manufacturing of microsystems and electronic modules.

Number of credits

3 ECTS

Course responsible

POLITEHNICA University of Bucharest
Prof. Norocel Codreanu

Course lecturers

Prof. Norocel Codreanu
Prof. Ciprian Ionescu
Assoc. Prof. Ioan Plotog

Prerequisites

Knowledge of basic electronics design, passive and active electronic components and circuits, modelling, simulation, and materials for electronics; basic knowledge of microelectronics, technologies and electronic packaging.

Learning outcomes

Knowledge: Advanced knowledge in the field of Design For Manufacturing (DFM) of microsystems and modules, involving deep understanding Electronic Design Automation (EDA) theories and manufacturing principles based on optimum design solutions.

Skills: Ability to design specific electronic modules which contain microsystems using the Cadence design environment and ability to solve Design For Manufacturing (DFM) problems based on pre-layout and post-layout simulation.

Competences: Demonstration of advanced ability to use engineering knowledge, skills, innovation, autonomy and methodological abilities in the design for manufacturing of specific electronic modules, including research and development in this field; ability to manage and design custom modules with microsystems.

Abstract

The course introduces students to modern manufacturing, with the main focus to design for manufacturing. Design plays a critical role in the success or failure of manufacturing and assembling. The course exposes students to integration of engineering design activities oriented to manufacturing and volume production. Labs are integral parts of the course, and expose students to various practical design and manufacturing issues and problems. This course provides students with the opportunity to develop and demonstrate an understanding of product design and manufacturing processes fundamentals, offering design for manufacturing and assembling techniques, which are used to minimize product cost through design and process improvements. Computer aided design (CAD) and computer aided manufacturing (CAM) principles are introduced in the development of microsystems and modules. This part will introduce students to the use of modern production methods, including printed circuit board (PCB) layout and computer numerical control (CNC) drilling and milling. It will also enable students to experience the full cycle of design, manufacture and testing of microsystems and modules. Additionally, students will execute a practical project, while obtaining feedback from industry concerning the introduction in production. Finally, attendees will have a unique opportunity to obtain first-hand information on design issues that impact both manufacturability and testability.

Content

1) Basics of Electronic Design Automation (EDA), manufacturing and Design for Manufacturing (DFM)
   - 1.1 Intro to EDA and DFM
   - 1.2 International standards used in industry
   - 1.3 Overview of DFM issues and problems
2) Modelling, simulation and design of interconnection structures for microsystems and modules
   - 2.1 Introduction
   - 2.2 Meshing and cells
   - 2.3 Layer stack-up and thickness
   - 2.4 Practical modelling and simulation of microsystems interconnection structures/elements
3) Computer Aided Design of microsystems structures and elements
   - 3.1 Introduction
   - 3.2 Software tools for CAD and DFM
   - 3.3 Beam design
   - 3.4 Mirror design
     - 3.4.1 Simple mirror design
     - 3.4.2 Four-layer optical mirror
     - 3.4.3 Thermally-actuated pop-up mirror
4) Design rules and guidelines for DFM
   - 4.1 DFM rules and guidelines
   - 4.2 DFM examples from industry
5) New trends in microsystems design for manufacturing
   - 5.1 The present and the future of DFM
   - 5.2 New trends in microsystems design

Teaching methods

The theoretical part of the course is presented with PowerPoint slides, practical examples/projects and problem-based learning. Based on the MECA Knowledge Alliance project, a Moodle learning environment in the form of HTML tutorials is also considered, in partnership with Giga Electronic International, Romania. The laboratory is based on interactive design and simulation activities using the Lite version of the Cadence/OrCAD 16.6-2015 design environment and other various CAD-CAM tools. Additionally, during the lab students solve practical problems found in various electronic projects, addressing the design for manufacturing of microsystems and modules.

Evaluation/Assessment

The evaluation is based on the examination of concepts acquired in the course and consists of the following components:
40% - Final report targeting various problems and issues, according to those solved during the lectures and the labs;
60% - Final design project of a small complexity electronic circuit.

Recommended reading

- Deiter G. E., McGraw Hill - *Engineering Design - Material & Processing Approach*, 2nd ed., 2000;
- Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight - *Product Design for Manufacturing and Assembly*, CRC Press, 2010;
- Kalpakjian, S. and Schmid, S. R. - *Manufacturing Engineering and Technology*, 4th ed., Prendice-Hall, N.J., 2001;
- Linbeck, J. R. - *Product Design and Manufacture*, Prendice-Hall, N.J., 1995;
- Singh, N. - *Systems Approach to Computer-integrated Design and Manufacturing*, John-Wiley, 1996;
- Jin Y., Wang Z., Chen J., *Introduction to Microsystem Packaging Technology*, CRC Press, Boca Raton, 2011, ISBN 978-143981910-4;
- Harper C. A., *Electronic packaging and interconnection handbook*, McGraw-Hill, 2000;
- Coombs C. F., Jr., *Printed circuits handbook*, 6th ed., McGraw Hill Professional, 2007, ISBN 978-0071510790;
- J. Lau, C. P. Wong, J. L. Prince, W. Nakayama, *Electronic Packaging – Design, Materials, Process and Reliability*, McGraw-Hill, 1998;
- Fitzpatrick D., *Analog Design and Simulation using OrCAD Capture and PSpice*, Newnes/Elsevier, Oxford, 2012, ISBN 978-0-08-097095-0.

COURSE DESCRIPTION

name	**Electronic packaging and assembling technologies of microsystems**
shortname/abbr.	**EPAT**
course objectives	**see in syllabus (Knowledge, Skills, Competences)**
description	**see in syllabus**
target students	**bachelor, master, Ph.D. students**
intro	**see in syllabus**
developed by	**POLITEHNICA University of Bucharest, Center for Technological Electronics and Interconnection Techniques (UPB-CETTI)**
evaluation	**see in syllabus**

Syllabus
"Electronic packaging and assembling technologies of microsystems"

Course topic

A practice oriented course for understanding the electronic packaging and the related assembling technologies of microsystems and electronic modules.

Number of credits

3 ECTS

Course responsible

POLITEHNICA University of Bucharest
Prof. Norocel Codreanu

Course lecturers

Prof. Norocel Codreanu
Prof. Ciprian Ionescu
Assoc. Prof. Ioan Plotog

Prerequisites

Basic knowledge of electronics, passive and active electronic components and circuits, materials for electronics, microelectronics and modern technologies used in electronics industry.

Learning outcomes

Knowledge: Advanced knowledge in the field of electronic packaging and assembling technologies of modules and microsystems, involving solid understanding of manufacturing theories based on world recognized standards.

Skills: Ability in selecting the proper the packaging technology, based on specific requirements, in the manufacturing of electronic modules and advanced ability of selecting the suitable assembling technology for realizing specific microsystems.

Competences: Demonstration of advanced ability to use engineering knowledge, skills, innovation, autonomy and methodological abilities in electronic packaging and assembling technologies of microsystems, including research and development in this field; ability to manage and perform engineering packaging tasks.

Abstract

The course introduces students to modern electronic packaging and assembling technologies of microsystems and modules. It exposes students the fundamentals of microsystems packaging and assembling technologies, packaging materials, current assembling technologies, basics of nanopackaging and packaging technologies trends. Labs are integral parts of the course, and expose students to various practical manufacturing and assembling issues/problems found in industry. This course provides students with the opportunity to develop and demonstrate an understanding of manufacturing processes, techniques and technologies which are used to optimise the development of microsystems/modules. It will also enable students to experience the full cycle of manufacturing and testing of electronic products. Additionally, each student will manufacture a small complexity electronic module, receiving permanently real feedback from various industrial partners.

Content

1) Fundamentals of microsystems packaging and assembling technologies
   1.1 Introduction
   1.2 The packaging hierarchy
   1.3 Milestones in packaging
   1.4 Packages and technologies
2) Packaging materials
   2.1 Materials for packaging technology
   2.2 Plastic materials and processes
   2.3 Dielectric materials used in the manufacture of printed circuit boards
   2.4 Materials for lead-free products
3) Assembling technologies
   3.1 Chip packaging technologies
   3.2 Package/Board assembling technologies
4) Basics of nanopackaging
   4.1 Introduction
   4.2 Nanomaterials
   4.3 Carbon nanotubes
   4.4 Applications of nanomaterials
   4.5 Nanotechnology images
5) Packaging technologies trends

Teaching methods

The theoretical part of the course is presented with PowerPoint slides, technological examples, case studies and problem-based learning. Based on the MECA Knowledge Alliance project, a Moodle learning environment in the form of HTML tutorials is also considered, in partnership with Giga Electronic International, Romania. The laboratory is based on interactive activities using the Lite version of the Cadence/OrCAD 16.6-2015 design environment, other various CAD-CAM tools and the technological facility of UPB-CETTI for microsystems/modules manufacturing. Additionally, during the lab, students are involved in practical technological tasks, addressing various electronic packaging issues and related assembling technologies for the development of microsystems and electronic modules.

Evaluation/Assessment

The evaluation is based on the examination of concepts acquired in the course and consists of the following components:
40% - Final report targeting various problems and issues, according to those solved during the lectures and the labs;
60% - Knowledge test with a multiple choice questionnaire and oral discussion.

Recommended reading

- Tummala, R. - *Fundamentals of Microsystems Packaging*, McGraw-Hill, 2001, ISBN: 0071371699
- Kalpakjian, S. and Schmid, S. R. - *Manufacturing Engineering and Technology*, 4th ed., Prendice-Hall, N.J., 2001;
- Linbeck, J. R. - *Product Design and Manufacture*, Prendice-Hall, N.J., 1995;
- Harper C. A., *Electronic packaging and interconnection handbook*, McGraw-Hill, 2000;
- Coombs C. F., Jr., *Printed circuits handbook*, 6th ed., McGraw Hill Professional, 2007, ISBN 978-0071510790;
- J. Lau, C. P. Wong, J. L. Prince, W. Nakayama, *Electronic Packaging – Design, Materials, Process and Reliability*, McGraw-Hill, 1998;
- Jin Y., Wang Z., Chen J., *Introduction to Microsystem Packaging Technology*, CRC Press, Boca Raton, 2011, ISBN 978-143981910-4.

COURSE DESCRIPTION

name	**Survival in labour market**
shortname/abbr.	**SLM**
course objectives	**see in syllabus (Knowledge, Skills, Competences)**
description	**see in syllabus**
target students	**bachelor, master, Ph.D. students**
intro	**see in syllabus**
developed by	**Technical University Berlin, Chair of Space Technologies**
evaluation	**see in syllabus**

Syllabus
"Survival in labour market"

Course topic

A practice oriented course for understanding all important facts in relation to survival in labour market including inter alia the management methodology Six Sigma.

Number of credits

3 ECTS

Course responsible

Technical University Berlin
Elena Eyngorn

Course lecturers

Elena Eyngorn

Prerequisites

no prerequities required

Learning outcomes

Knowledge: Advanced knowledge in the field of survival in labour market involving solid understanding of the benefits of Six Sigma, such as improved processes, greater productivity, reduced operating costs, greater throughput and improved quality.

Skills: Ability in understanding the importance of interpersonal skills, such as communication, in the business world and how to make the right decision for an organization (of any size). Additionally, the ability to define success in labour market and identify the importance of the Six Sigma methodology.

Competences: Advanced ability of selecting the suitable strategies for survival in labour market. Demonstration of advanced ability in performing management tasks such as the writing of required documents and use project management techniques presented in the course.

Abstract

The last couple of decades small, mid-sized and Fortune 500 companies have embraced Six Sigma to generate more profit and greater savings. So what is Six Sigma? Six Sigma is a data-driven approach for eliminating defects and waste in any business process. You can compare Six Sigma with turning your water faucet and experiencing the flow of clean, clear water. Reliable systems are in place to purify, treat and pressure the water through the faucet. That is what Six Sigma does to business: treats the processes in business so that they deliver their intended result. What is "Sigma"? The word is a statistical term that measures how far a given process deviates from perfection. Sigma is a way to measure quality and performance. The central idea behind Six Sigma is that if you can measure how many "defects" you have in a process, you can systematically figure out how to eliminate them and get as close to "zero defects" as possible.' This course introduces students to the management methodology Six Sigma.
Additionally, students will get an insight in diverse related subjects including inter alia management skills, such as meeting management, time management and stress management and interpersonal skills in the context of survival in labour market.

Content

1) Fundamentals of survival in labour market
    1.1 Introduction
    1.2 Definition labour markets
    1.3 Survival strategies
2) Methodology Six Sigma
    2.1 Introduction to Six Sigma
    2.2 Benefits of the management methodology Six Sigma
3) Management skills
    3.1 Meeting management
    3.2 Time management
    3.3 Stress management
4) Leadership and influence
    4.1 Leadership techniques
    4.2 Teamwork and team building
    4.3 Supervising others
    4.4 Motivating employees
5) Project management (PM)
    5.1 Definition and introduction to PM
    5.2 Project management techniques
    5.3 "Triple constraint"
6) Interpersonal skills
    5.1 Communication as the most important soft skill
    5.2 Business writing as key method of communication
    5.3 Preparation of most important documents

Teaching methods

The theoretical part of the course is presented with PowerPoint slides, practical examples/projects and problem-based learning. A course on the e-learning platform moodle of the Technical University Berlin is also considered. The contents will be presented in lectures but also group and project work will be offered to put the theory into practice but also "serious games" will be applied.

Evaluation/Assessment

The evaluation is based on the examination of concepts acquired in the course and consists of the following components:

40% - Final report targeting various problems and issues, according to those solved during the lectures and the labs;
60% - Knowledge test with a multiple choice questionnaire and oral discussion.

Recommended reading

- Adair, John (2009): *Effective Communication (Revised Edition): The Most Important Management Skill of All*, London: Pan Books.
- Chambers, Harry E. (2001): *Effective Communication Skills for Scientific and Technical Professionals,* New York: Basic Books.
- Day, Dave (2013): *Effective Management: Interpersonal Skills That Will Help You Earn the Respet and Commitment of Employees*, Toronto: Productive Publicatios.
- Dr. Gordon, Thomas (2001*): Leader Effectiveness Training: L.E.T. Proven Skills for Leading Today´s Business into Tomorrow*, New York: The Berkley Publishing Group.
- Lester, Albert (2014): *Project Management, Planning and Control: Managing Engineering, Construction and manufacting Projects to PMI, APM and BSI Standards*, Waltham: Butterworth-Heinemann (for Elsevier).
- Mosley, Donald C.Sr.; Mosley, Donald C.Jr.; Pietri, Paul H. (2011): *Supervisory Management: The Art of Inspiring, Enpowering and Developing People*, Mason: South-Western Cengage Learning.
- OECD (2011): *OECD Reviews of Labour Market and Social Policies: Russian Federation 2011*, OECD Publishing.