Internationalized Master Degree Education in Nanoelectronics in Asian Universities

573828-EPP-1-2016-1-BG-EPPKA2-CBHE-JP

CURRICULUM DEVELOPMENT

ACHIEVED RESULTS

PROJECT PARTNERS

BULGARIA

Technical University of Sofia

ITALY

Polytecnico di Torino

NORWAY

University of South-East Norway

CHINA

National Center for Nanoscience and Technology
Chongqing Technology and Business University

INDIA

University of Mumbai
NIIT University

ISRAEL

Bar-Ilan University

Tel Aviv University

MALAYSIA

University of Malaya

Universiti Tunku Abdul Rahman

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For each Partner Country university and course the following information is provided according to the recommendations of EACEA:

- Title of the Degree awarded
- Level of Education
- Academic Programme and Learning Outcomes
- Duration
- ECTS (or equivalent)
- Nr of teaching hours per training course
- Specification if the courses are mandatory or optional / full time or part time
- % of curricula updates compared to the former version (for revised study programmes / courses)
- Nr of students enrolled
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published.

NIIT University

- Title of the Degree awarded: the courses developed are integrated with existing Bachelor, Masters and PhD course work in electronics and communication programme
- Level of Education: Post graduate
- Academic Programme and Learning Outcomes:
  - Courses:

- "Introduction to Nanoelectronics: Science & Technology Basics" - **Learning outcome of the course**:

. After studying these 10 units, the student will be able to relate the nanomaterial properties with phenomena of basic sciences.

1. Demonstrate a working knowledge of nanotechnology principles and industry applications.
2. Explain the nanoscale paradigm in terms of properties at the nanoscale dimension.
3. Apply key concepts in materials science, chemistry, physics, biology and engineering to the field of nanotechnology.
4. Identify current nanotechnology solutions in design, engineering and manufacturing.
5. Search, read and present current nanotechnology literature applied to a particular problem domain.

- " Nanoelectronics Processes, Computation and Design" - **Learning outcome of the course**:

After completion of this course student will able to deals with

1. Nanoelectronics and computational techniques, and will be covering biochemical and quantum-mechanical computers.
2. Parallel architectures, computing and softcomputing systems for nanoelectronics, complex integrated systems and their properties.

- "Nanoelectronics Systems: Future Nanoelectronic Devices and Manufacturing processes" - **Learning outcome of the course:**

This course will be focused on nanoelectronics systems: manufacturing processes and applications. In this course, first 4 units will be covering concepts of microelectronics to

nanoelectronics with VLSI techniques and their limits. Units 5 to 9 will be focused on future nanoelectronic devices in detail. By the end of this course, student will be able to appreciate the importance of paradigm shift of science & technology in case of nanoelectronics vis-à-vis the present day VLSI technology.

- "Nanoelectronics Systems: Applications- Quality living with Smart Future, Present to Future Business Systems" - Learning outcome of the course: After completion, of course student may easily understand following points:

1. Explain the history of nanoelectronics and where the field may evolve over the next 10 to 15 years.
2. Identify societal and technology issues that may impede the adoption of nanotechnology.
3. Identify career paths and requisite knowledge and skills for career change toward nanoelectronics.

- **Knowledge achievements:** The student will get basic knowledge on integrated circuit technology and how this technology is developing and can be applied for designing cost effective and ever increasingly compact systems to be used in future products. Typical features of the systems are their implementation in both analog and digital electronics and their direct interaction with the environments (using sensors and actuators).Dependent on specialization student can get detailed knowledge in radio and radar systems, biologically inspired systems, energy effective sensors, robust digital systems and medical electronics.
- **Skills:** The students should be able to design advanced electronic systems integrated on a miniaturized Silicon chip, thus master methods for designing, analyzing and testing such systems by using professional industry standard software and advanced laboratory instruments. The program will give the necessary skills for understanding and master the complete development phase from an idea to a finished system. During the study student will get a broad experience in designing and testing integrated circuits.
- **General competence**: This program will inspire student to apply and develop skilled curiosity, it will impart respect for scientific values, such as openness, precision, truthfulness, and teach student to distinguish between real knowledge and opinions. After the finished program student should be able to reflect on central ethic and scientific problems related to his/her own work or the work of others. Given by the special focus of the research, student will be qualified to contribute to designing products using minimal energy, which is an important aspect in the consciousness of the people of today. More generally, the candidates will be able to contribute to a challenging, dynamical fields important for the society, and student should be able to exploit and to some degree influence the technological development of the future society.

- Duration: 2 years
- ECTS (or equivalent): 4 credits per course
- Nr of teaching hours per training course: 45 hrs
- Specification if the courses are mandatory or optional / full time or part time: the courses will be offered as electives and full time
- % of curricula updates compared to the former version (for revised study programmes / courses): 25-30%
- No of students enrolled: 10-15 per course/per semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: https://www.niituniversity.in/programmes

University of Mumbai

- Title of the Degree awarded: the courses developed are integrated with existing Masters programs as well as PhD course work in biological Sciences.
- Level of Education: Post graduate
- Academic Programme and Learning Outcomes:
    - Courses:

- "Raw materials for Nano-biostructures and Bioelectronics" - **Learning outcomes**: Upon successful completion of this course students should be able to understand eukaryotic cell organization, its nano and micro-structure correlated to their functions. Students would be introduced to a selected biopolymers and their potential substitution to synthetic polymers and vaired applications. The Neuronal structure, network and functioning would also be introduced to the learners. The study of special senses like taste, hearing and vision would enable the understanding of the day to day complex biochemical reactions and the role of nanostructures in the relay of this information.
- "Bioelectronics –Nanobiotechnology" - **Learning outcomes**: Upon successful completion of this course students should be able to understand eukaryotic cell organization, its nano and micro-structure correlated to their functions. Students would be introduced to a selected biopolymers and their potential substitution to synthetic
polymers and vaired applications. The Neuronal structure, network and functioning would also be introduced to the learners. The study of special senses like taste, hearing and vision would enable the understanding of the day to day complex biochemical reactions and the role of nanostructures in the relay of this information.
- "Bioelectronics –Socio-ethical and environmental aspects" - **Learning outcomes**: Upon successful completion of this course, students should be able to understand the progress in nano-sciences, the need to develop technologies with due concern and respect to health and environment. Development of regulatory policies in Nano-sciences in the world as well as their country of origin.

- Duration: 2 years
- ECTS (or equivalent): 4 credits per course
- Nr of teaching hours per training course: 60 hrs
- Specification if the courses are mandatory or optional / full time or part time: the courses will be offered as electives, full time
- % of curricula updates compared to the former version (for revised study programmes / courses): 30%
- No of students enrolled: 40 students/semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: www.mu.ac.in

University Tunku Abdul Rahman

- Title of the Degree awarded: B.Eng. Materials and Manufacturing
- Level of Education: Undergraduate
- Academic Programme and Learning Outcomes
    - Courses:

- "Carbon Nanotubes and Applications" - **Learning outcomes**: Upon successful completion of this course students should be able to:

1. Describe Nano diamond particles and diamond like carbon films.
2. Analyze the properties of carbon nanotubes
3. Illustrate the synthesis of carbon nanotubes
4. Explain the applications of carbon Nano tubes

- "Graphene Nanoelectronics: From synthesis to device applications" - **Learning outcomes**: Upon successful completion of this course students should be able to:

1. Develop a broad understanding of graphene and application in devices
2. Evaluate the various chemical and non-chemical approach in production of graphene
3. Examine graphene structures through various characterization tools
4. Compare and contrast the properties of graphene and graphene nanoribbons
5. Relate graphene structure with the performance of devices

- Duration 4 Years
- ECTS (or equivalent) 3
- Nr of teaching hours per training course 36
- Specification if the courses are mandatory or optional / full time or part time Optional
- % of curricula updates compared to the former version (for revised study programmes / courses) 20%
- Nr of students enrolled 50 students/semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: http://www.utar.edu.my & http://study.utar.edu.my

University of Malaya

- Title of the Degree awarded: Bachelor of Science (Materials Science)
- Level of Education: Undergraduate
- Academic Programme and Learning Outcomes:
    - Courses:

- "Materials Characterisation" - **Learning outcomes**: Upon successful completion of this course students should be able to:
1. Explain different methods used to characterize materials.
2. Relate fundamental of physics to the basic operation of the equipment.
3. Interpret the results obtained from different equipment.

- "Nano Materials and Nanotechnology" - **Learning outcomes**: Upon successful completion of this course students should be able to:
1. Explain methods of fabricating nanostructures.
2. Relate the unique properties of nanomaterials to the reduce dimensionality of the material.
3. Describe tools for properties of nanostructures.
4. Discuss applications of nanomaterials and implication of health and safety related to nanomaterials.

- Duration: 3.5 years
- ECTS (or equivalent): 5 per course
- Materials Characterisation (120 learning hours)
- Nano Materials and Nanotechnology (120 learning hours)
- Nr of teaching hours per training course : 42 hours
- Specification if the courses are mandatory or optional / full time or part time:
  Materials Characterisation (Mandatory Course)
  Nano Materials and Nanotechnology (Elective Course)
- % of curricula updates compared to the former version (for revised study programmes / courses): 30%
- Nr of students enrolled: in average 20 students per course semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: https://fs.um.edu.my/bachelor-of-science-materials-science

National Center for Nanoscience and Technology

- Title of the Degree awarded: Master, PhD
- Level of Education: Postgraduate
- Academic Programme and Learning Outcomes
  - Courses:

- "Nanotechnology for Solar Energy Utilization"
- "Functional Nanostructures: Synthesis, Characterizations and Device Applications"
- "Nanoelectronic Materials"

  - Learning outcomes: The major goal of these courses is to provide the students general

concepts and state-of-the-art developments in the field of nanotechnology and materials design. The three

courses were rated as excellent courses by the college for three consecutive years. The students' satisfaction

was 90%.

- Duration: A semester
- ECTS (or equivalent):
  Nanotechnology for Solar Energy Utilization: 4 ECTS
  Nanoelectronic Materials: 4 ECTS
  Functional Nanostructures: Synthesis, Characterizations and Device Applications: 4 ECTS
- Nr of teaching hours per training course:
  Nanotechnology for Solar Energy Utilization: 80
  Nanoelectronic Materials: 80
  Functional Nanostructures: Synthesis, Characterizations and Device Applications: 80
- Specification if the courses are mandatory or optional / full time or part tim:
  Optional courses
- % of curricula updates compared to the former version (for revised study programmes / courses) 30%
- Nr of students enrolled 40 students/semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: http://www.nanoctr.cn/

Chongqing Technology and Business University

- Title of the Degree awarded: Master and Senior Bachelor
- Level of Education: Postgraduate
- Academic Programme and Learning outcomes
    - Courses:

- "Top-down ASIC Design Flow" - **Learning outcomes:** Upon successful completion of this course students should be able to: Explain the design abstraction levels in IC design; Convert the C code specification into a HDL implementation; Perform design optimization techniques (area-latency-power trade-off) at RTL; Simulate RTL designs; Perform FSM optimization techniques; Explain resource sharing and scheduling algorithms in architectural level synthesis; Analytically estimate delay, power and area through the logical effort method; Perform design optimization techniques (area-latency-power trade-off) at logical level; Explain the design steps pertaining the physical layout of CMOS ICs starting from a synthesized HDL netlist; Explain deviant electrical effects (electromigration, heating, skin effect, cross-talk etc.) and relative design compensation techniques at circuit level.
- "Bio-sensing microsystems" - **Learning outcomes:** Upon successful completion of this course students should be able to: Understand the design abstraction levels in bio-sensing microsystems; Use MATLAB/Simulink tool to model and simulate bio-sensing microsystems; Explain the main fabrication techniques for bio-sensing transduces; Explain bio-transducing principles; Estimate analytically errors and uncertainties in electrical measurements; Design a signal acquisition interface for bio-sensing systems;

- Duration: A semester.
- ECTS (or equivalent): 5 ECTS
- Nr of teaching hours per training course: 60
- Specification if the courses are mandatory or optional / full time or part tim: Elective courses
- % of curricula updates compared to the former version (for revised study programmes / courses): 40% of curricula updates
- Nr of students enrolled: 50 students/semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published: https://www.ctbu.edu.cn/

Tel Aviv University

"Fabrication methodologies for micro and nano systems"
The title awarded BSc in electrical engineering
Level of Education: Bachelor degree in science
Academic Program and Learning Outcomes:
Upon successful completion of this course, students should be able to:
This course covers all major microfabrication processes: General overview of the microfabrication technology. The structures of crystals and the silicon crystal, defects in crystals, fabrication processes of silicon crystals (CZ, FZ). Ion implantation. Diffusion. Thin layers: Evaporation, sputtering, CVD, PECVD, oxidation. Etching processes: Wet etching, dry etching (physical, chemical, RIE, DRIE). Photolithography. Conducting coatings. Electrical contacts and packaging: Wire bonding, flip-chip, wafer scale packaging. Overview of the Bipolar and CMOS technology in light of the subjects studied. Overview of MEMS in light of the subjects' studies. Yield and reliability of the VLSI technology. Basic CAD for VLSI.

1. Analyze any Micro and Nano fabrication process flow;
2. Design common Micro and Nano fabrication process modulus,
3. Modeling process modules using basic physics and chemistry principles,
4. Integration of CMOS Process modulus,
5. Utilization of micro and nano process tools and methods

Course duration: 1 semester
ECTS (or equivalent): 4 ECTS
Teaching hours per training course
The course is mandatory; the curricula adopted comparing to former version by 50 percent including the transformation of content for online or hybrid teaching/learning
94 students/semester
grades average: 88
Universities' website where the Study Programs are listed as part of the academic offer and the modalities on how to apply are published.
https://en-engineering.tau.ac.il/School-of-Electrical-Engineering/main

"Introduction to VLSI Design"
Title of the degree awarded: B.Sc. in Electrical Engineering
Level of education: Undergraduate
Academic Program and Learning Outcomes:
Prerequisites:Digital Logic systems; Electronic Devices.
Learning outcomes
Upon successful completion of this course students should be able to:
1. Design building blocks of digital integrated VLSI circuits.
2. Simulate small to medium level VLSI circuits and systems.
3. Verify small to medium digital circuits including data path and memories.
4. Estimate the performance of large VLSI circuits, using manual calculations
5. Work in team designing very large-scale integrated circuits.

Duration: 1 semester (13 weeks)
ECTS (or equivalent): 4 ECTS
52 hours (lectures + recitations)
Specification if the courses are mandatory or optional / full time or part time: Mandatory

Number of enrolled students 166
Grades average: 86
50% of curricula updates compared to the former version (for revised study programs/courses):
Universities' website where the Study Programs are listed as part of the academic offer and the modalities on how to apply are published:
https://en-engineering.tau.ac.il/School-of-Electrical-Engineering/main

"Advanced Electronic Devices"
Status: Mandatory for the Microelectrons specialization
Learning outcomes
Prerequisites: Electronic Devices
Upon successful completion of this course students should be able to:
1. Calculate basic electrical parameters of passive components for advanced micro and nano scale circuits.
2. Analyze metal oxide silicon capacitors.
3. Design and analyze diodes.
4. Extract MOS transistor capacitor and calculate SPIC parameters.
5. Approach any new semiconductor device
Duration: 1 semester (13 weeks)
ECTS (or equivalent): 4 ECTS
52 hours (lectures + recitations)
Mandatory course
50% of curricula updates compared to the former version (for revised study programs/courses):
102 enrolled TAU students
grades average: 86

"Integrated Analog Circuits Design"
Credits: 4 ECTS
Prerequisites: Digital Logic systems; Electronic Devices.
Learning outcomes
Upon successful completion of this course students should be able to:

- Design building blocks of digital integrated VLSI circuits.
- Simulate small to medium level VLSI circuits and systems.
- Verify small to medium digital circuits including data path and memories.
- Estimate the performance of large VLSI circuits, using manual calculations
- Design circuits as part of a team for making integrated circuits and systems.

Duration: 1 semester (13 weeks)
ECTS (or equivalent): 4 ECTS
52 hours (lectures + recitations)
Mandatory course
42 enrolled TAU students
grades average: 92
https://en-engineering.tau.ac.il/School-of-Electrical-Engineering/main

Bar Ilan University

- Title of the Degree awarded BSc
- Level of Education: B.Sc
- Academic Programme and Learning Outcomes
  - Courses

- "Electronic device at the nanoscale" - **Learning outcomes**: This course introduces the student to the principles of operation of nano-scale electron device.
Skills and Competences: Introduction to semiconductor device, Physics of semiconductors.
- "Sensing at the nanoscale " - **Learning outcomes:** On successful completion of this module, students should be acquainted with the up to date sensing techniques. They should be able to select the appropriate probe to their
research. They will also be familiar with important applications in wide range of topics, from bio-sensors to nono-electronics.
Knowledge: Fundamentals of sensing techniques at the nanoscale, and their current applications in nano-electronics and nano-medicine.
Skills and Competences: Students will be able to better plan their research and include the use of proper sensors.
- Duration 1 semester
- ECTS (or equivalent) 3
- Nr of teaching hours per training course 60
- Specification if the courses are mandatory or optional / full time or part time: Optional
- % of curricula updates compared to the former version (for revised study programmes / courses) 30%
- Nr of students enrolled: 40 per course per semester
- Universities' website where the Study Programmes are listed as part of the academic offer and the modalities on how to apply are published https://www.biu.ac.il/