COURSE DESCRIPTION CARD - SYLLABUS

Course name
Micro and nano electromechanical systems [N1Mech2>MiNUE]

Course

Field of study
Mechatronics

Year/Semester
4/8

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
8

Laboratory classes
16

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

Lecturers

Prerequisites

Students should have a basic knowledge of mechanics, electrical and electronic engineering acquired in previous semesters of study. Knowledge of basic solid state physics and the ability to analyse dynamic systems is required. In addition, fundamentals of programming and computer modelling.

Course objective

The aim of the course "Micro and Nano Electromechanical Systems" is to introduce students to the principles of operation, design methods, and manufacturing technologies of micro- and nanoelectromechanical systems (MEMS and NEMS). Students will gain knowledge about the properties of materials used in these systems, their impact on functionality and construction, as well as modeling and simulation methods. The course develops the ability to analyze the technical parameters of MEMS and NEMS, understand the principles of operation of example devices, and explore their applications in modern engineering.

Course-related learning outcomes

Knowledge:
- The student knows the basic principles of micro- and nanoelectromechanical systems (MEMS and NEMS).
- Understands the technological processes used in the fabrication of micro- and nanoelectromechanical

components.
- Has knowledge of the properties of the materials used in MEMS and NEMS and their influence on the functioning of the systems.
- Has knowledge of modelling and simulation methods for micro and nano electromechanical systems.

Skills:
- Can analyse and interpret the technical parameters and performance characteristics of MEMS and NEMS.
- Is able to select appropriate materials and technologies for applications in micro- and nano-electromechanical systems.
- Is able to use simulation tools to model and analyse the performance of micro- and nano-systems.
- Be able to design a simple MEMS/NEMS system and evaluate its functionality.

Social competences:
- Understands the need for lifelong learning; can inspire and organise the learning process of others.
- Understands the importance of innovative micro- and nano-electromechanical technologies in the development of modern engineering.
- Is able to work in a team on projects in the field of micro- and nano-electromechanical systems.
- Demonstrates a willingness to independently improve knowledge and keep up to date with the latest trends in MEMS and NEMS.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Graded by an exam consisting of min. 5 open general questions. Each correct answer to a question is worth 1 point. The smallest grading unit is 0.25 points, meaning each correct answer is divided into 4 quarters (totaling 1 point). Grading scale: 0 - 2,25 pkt → (2,0); 2,50 - 3,00 pkt → (3,0); 3,25 - 3,50 pkt → (3,5); 3,75 - 4,00 pkt → (4,0); 4,25 - 4,50 pkt → (4,5); 4,75 - 5,00 pkt → (5,0).Laboratory: Graded on the basis of correct execution of the exercises and a report on each laboratory exercise as indicated by the laboratory instructor. Before the exercises possible short entry tests, after the end of the exercises an exit test. In order to obtain a final grade for laboratory exercises, all exercises must be passed (positive evaluation from tests and reports).

Programme content

The subject introduces students to the design, operation and applications of MEMS and NEMS systems. Physical fundamentals and materials used in micro- and nanotechnology, manufacturing technologies, modelling and simulation methods and selected applications will be discussed. Students will also be introduced to methods of investigating MEMS/NEMS parameters and their practical use in various engineering fields.

Course topics

Lectures (7 meetings, 2 hours each):
1. Introduction to MEMS and NEMS - definitions, history, basic concepts, differences between micro- and nanoelectromechanical systems.
2. MEMS/NEMS materials and mechanical properties - silicon, metals, polymers and composite materials; impact of miniaturisation on mechanical and electrical properties.
3. MEMS and NEMS fabrication technologies - lithography, etching, thin film deposition, micro-assembly techniques.
4. Modelling and analysis of micro- and nano-systems - computational methods, fundamentals of numerical simulations, modelling of dynamic systems.
5. Measurement methods and characterisation of MEMS/NEMS - microscopic techniques (AFM, SEM), electrical and mechanical methods for parameter testing.
6. MEMS and NEMS applications - sensors, actuators, biotechnology, medicine, aerospace and automotive.
7. Trends and future of micro and nanotechnology - development of new technologies, limitations and challenges, future research directions.

Teaching methods

Lectures and presentations, modelling and simulation of systems. Laboratory exercises with simulation of the operation of MEMS/NEMS systems, studies of interactions (including mechanical and thermal) with MEMS/NEMS structures using a microscope, demonstrations of the fabrication of micro- and nano-scale components.

Bibliography

Basic:
M. J. Madou, Manufacturing Techniques for Microfabrication and Nanotechnology, CRC Press, 2011.

Additional:
S. E. Lyshevski, Nano- and Micro-Electromechanical Systems: Fundamentals of Nano- and Microengineering, CRC Press, 2011.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	24	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	51	2,00