Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Кафедра
Мікроелектроніки

Special course of micro- and nanosystem technology

Робоча програма навчальної дисципліни (Силабус)

Реквізити навчальної дисципліни

Рівень вищої освіти	***Second (master's)***
Галузь знань	*17 Electronics, automation and electronic communications*
Спеціальність	*176 Micro- and nanosystem technology*
Освітня програма	*Micro- and nanoelectronics*
Статус дисципліни	*Normative*
Форма навчання	*Full-time*
Рік підготовки, семестр	*1 course, spring term*
Обсяг дисципліни	*4 credits (120 hours)*
Семестровий контроль/ контрольні заходи	*credit*
Розклад занять	
Мова викладання	*English*
Інформація про керівника курсу / викладачів	Lecturer/ Practical session: Ph.D. Sviechnikov G.S. svgeorge13@gmail.com
Розміщення курсу	e3b4tzc https://meet.google.com/lookup/czqemur5lm

Програма навчальної дисципліни

Description of the discipline, its purpose, subject of study and learning outcomes

The second half of the XX century was marked by a series of groundbreaking discoveries and their applied implementation in electronics (and not only in it), which led to a qualitative leap in electronics. Among them, integrated microelectronics (ME) has become one of the main technological achievements that have significantly determined the pace of development and priorities of scientific and technological progress of our time. This accent of ME remains today, thanks to its innovative approaches, first of all, in advanced technologies and materials, their fast industrial realizations.

Based on the general trends of microelectronics and its limitations, its main directions from the standpoint of extremity, manufacturability and competitiveness within the traditional methods and means of silicon technology on the example of limiting microminiaturization of the active element-transistor as a means of increasing speed, minimizing quality factor and minimizing ultra-large integrated circuits.

The knowledge acquired as a result of studying this course is used in the preparation of diploma projects and works.

Meta: nabuty znannya pro rozvytok suchasnoho etapu mikroelektroniky yak peredovoyi tekhnolohiyi elektronnoyi tekhniky rozvynuty uminnya: - analizuvaty osoblyvosti osnovnykh faktoriv obmezhennya suchasnoyi mikroelektroniky; - analizuvaty osoblyvosti funktsionuvannya komponentiv mikrosystemnoyi tekhniky; zdiysnyuvaty porivnyannya kharakterystyk komponentiv mikrosystemnoyi tekhniky i vyznachaty oblasti yikh ratsional’noho zastosuvannya.

P*urpose*: to acquire knowledge about the development of the modern stage of microelectronics as an advanced technology of electronic technology
develop skills:
- to analyze the features of the main limiting factors of modern microelectronics;
- to analyze the features of the functioning of the components of microsystem technology;
to compare the characteristics of the components of microsystem technology and determine the areas of their rational application.
A student who has studied the course should know:
• apparatus of concepts (terminology) of the discipline;
• main types of devices, principles of their operation, characteristics and parameters; Dependencies of characteristics and parameters on operating conditions, scope;
• basics of analysis and calculation of instruments of the discipline
• basic technical and technological solutions in the field of discipline
be able:
• use the element base o microelectronics to build devices and devices
• experimentally determine the main characteristics and parameters widely
used devices and devices of microelectronics
• work with technical literature and technical documentation
• solve problems related to the phenomena of microelectronics and apply their principles
solutions to describe practically important situations;
master:
• methods of problem statement and methods of conducting an experiment using elements of microelectronics;
• techniques and algorithms for solving problems of microelectronics
• research methods in the field of microelectronics.

Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

Discipline "Special course of micro- and nanosystem technology" is provided by courses of basic higher education in the field: "Physical Chemistry", "Solid State Electronics", "Statistical Physics", "Physics of Semiconductor Devices and Integrated Circuits", "Technological Fundamentals of Electronics", "O and professional training: "Technology of production of semiconductor devices and integrated circuits".

The content of the discipline

Introduction

Topic 1. Microminiaturization of transistors in silicon technology.

Topic 2. Transistor as an active element in microelectronics and its limitations energy efficiency.

Topic 3. Clean rooms in BIS and VLSI technology.

Topic 4. Semiconductor fabrication plants

Topic 5. Features of the transition to 450 mm silicon wafers

Topic 6. The function of the active element in microcircuitry and evaluation of its energy efficiency.

Topic 7. Scaling process in microminiaturization of integrated circuit components.

Topic 8. Limits of microminiaturization of MOS transistor on scaling..

Topic 9. Limiting the length of the channel according to the mode of the transistor parameters.

Topic 10. SOI technology in MOS of small geometry.

Topic 11. Multy gate MOST .

Topic 12. Fin FET transistors

Topic 13. FD-SOI technologies

Topic 14. Planar technology using immersion ultraviolet lithography

Topic 15. X-ray lithography based on a laser on free electrons

Topic 16. Lithography in deep ultraviolet

Topic 17. The role of the stepper in photolithography

Topic 18. Parasitic parameters of MOS transistors and their evaluation.

Topic 19. Metallization and constraints in the block of interconnections

Topic 20. Electrical parameters of communication lines and their limitations.

Educational and methodical materials

Basic literature:

1. Елементи сучасної мікроелектроніки [Електронний ресурс] : навч. посіб. для студ. спеціальності 153 «Мікро- та наносистемна техніка», спеціалізації «Мікроелектронні інформаційні системи» / Г. С. Свєчніков, Ю. В. Діденко ; КПІ ім. Ігоря Сікорського. – Електронні текстові дані (1 IOP Concise Physics (December 1, 2014) Київ : КПІ ім. Ігоря Сікорського, 2018. – 248 с.
2. The Tao of Microelectronics (Iop Concise Physics: A Morgan & Claypool Publication) by Yumin Zhang 118 pages

Supplementary:

1. CMOS: Circuit Design, Layout, and Simulation (IEEE Press Series on Microelectronic Systems) 4th Edition by R. Jacob Baker Wiley-IEEE Press; 4th edition (July 11, 2019) 1280 pages

2. Fundamentals of Microelectronics 3rd Edition by Behzad Razavi Wiley; 3rd edition (April 20, 2021) 960 pages

Навчальний контент

Methods of mastering the discipline (educational component)

Lectures:

Lecture №1

Introduction to the course

Lecture №2

Topic 1. Microminiaturization of transistors in silicon technology.

Lecture №3

Topic 2. Transistor as an active element in microelectronics and its limitations energy efficiency.

Lecture №4

Topic 3. Clean rooms in LSI and VLSI technology.

Lecture №5

Topic 4. Silicon fabs

Lecture №6

Topic 5. Features of the transition to 450 mm silicon wafers

Lecture №7

Topic 6. The function of the active element in microcircuitry and evaluation of its energy

efficiency.

Lecture №8

Topic 7. Scaling process in microminiaturization of integrated circuit components.

Topic 8. Limits of microminiaturization of MOS transistor on scaling.

Lecture №9

Topic 9. Limiting the length of the channel according to the mode of the transistor parameters.

Lecture №10

Topic 10. KNI technology in MOS of small geometry.

Lecture №11

Topic 11. Multy gate MOST.

Lecture №12

Topic 12. Fin FET transistors

Lecture №13

Topic 13. FD-SOI technologies

Lecture №14

Topic 14. Planar technology using immersion ultraviolet lithography

Topic 15. X-ray lithography based on a laser on free electrons

Lecture №15

Topic 16. Lithography in deep ultraviolet

Lecture №16

Topic 17. The role of the stepper in photolithography

Lecture №17

Topic 18. Parasitic parameters of MOS transistors and their evaluation.

Topic 19. Metallization and constraints in the block of interconnections

Lecture №18

Topic 20. Electrical parameters of communication lines and their limitations.

Practical session

The main task of practical classes - in-depth study of individual sections of the course in order to consciously perceive the main material of this course and develop the ability to independently find the necessary information, as well as to develop skills and abilities to present the results.

Each student receives original material (article, conference report, book section) in the original language (English) on a particular issue in the course of the course.

It is necessary to make a quality translation, to understand the issue and if necessary to use additional material, which the student must inspire himself.

The processed material is presented in the form of a report, presentation in class.

The student must be prepared to answer all questions from the audience regarding his project

*examples of project topics (semester 2 *):*

1. *The Future of Silicon*
2. *Vertical Silicon Nanowire Platform for Low Power Electronics and Clean Energy Applications*
3. *Moving To GAA FETs*
4. *Transistor Options Beyond 3nm*

** The topics of the projects are updated every semester*

Individual work of a student / graduate student

To stimulate independent work of students, encourage them to self-improvement and acquaintance with the latest information technologies in the credit module is provided as an individual task for independent work additionally made the study of the following theoretical material:

Name of the topic submitted for self-study	*Number of hours*
1. Planar technologies with complete depletion of silicon on the insulator	10 hours
2. Soitec FD-2D substrates Best energy efficiency and performance	18 hours
3. Application of carbon nanostructures in micro and nanoelectronics	20 hours
4. New applications for high quality High K materials in VLSI technology	18 hours

Quality control of mastering the program of the discipline is provided by means of oral individual and frontal questioning of students on the subject of content modules. The course includes modular thematic surveys during the defense of reports of practical classes.

Політика та контроль

Course policy (educational component)

Attendance at all classes is mandatory.

Completion of all tasks is a prerequisite for admission to the test.

The practical project must be defended. The work must be presented in electronic and printed form. The printed version must be designed according to the requirements of the university and must contain a title page. The defense procedure consists of answers to the questions of the teacher and students on the topic of the work. For incorrect answers or incorrect registration of work the assessment is reduced according to requirements of RSO. If more than a third of the questions are answered incorrectly, the defense will not be credited.

The maximum score of the project is 45 points

Types of control and rating system for evaluation of learning outcomes (RSO)

Calendar control: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus. To successfully pass the first calendar control: the student must score at least 20% of the maximum total rating during the semester. To successfully pass the second calendar control, the student must score at least 40% of the maximum rating.

Semester control is carried out in the form of an exam.

Students who scored the required number of points during the semester have the opportunity to:

- not to pass the exam, but to get a grade "automatically" in accordance with the rating obtained in the discipline;
- pass an exam to increase the score.

If the student receives a grade lower than the rating, the student does not keep the grade obtained "automatically".
Students whose semester rating is "unsatisfactory" are required to take an exam.
Students who are not admitted to the exam in this discipline according to the semester rating are required to increase it to a level of at least 60%.
The rating is determined by the sum of the scored rating points in accordance with the rating scale calculation system.
The student's rating score is calculated according to the following rules;
1. Calendar control - 2x20
2. practical project -45

Calendar control: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.
Semester control: exam / test
Conditions of admission to semester control: semester rating more than 60 points.
Таблиця відповідності рейтингових балів оцінкам за університетською шкалою:

Кількість балів	*Оцінка*
100-95	Відмінно
94-85	Дуже добре
84-75	Добре
74-65	Задовільно
64-60	Достатньо
Менше 60	Незадовільно
Не виконані умови допуску	Не допущено

Additional information on the discipline (educational component)

Examples of questions for semester control.

1. The global trend in recent years in the field of microelectronics is as follows:
2. Methods of increasing the speed of active elements in microelectronics (block diagram).
3. At lk <lk * and lk ~ Wdr the conditions of smooth approximation are no longer fulfilled and the effects begin to dominate, short channel, namely:
4. What does the two-dimensional nature of the potential distribution in a short-channel device?
5. At the same time the highest packing density (xmin) and the maximum possible frequency (tmin) in the IC, why is equal to the power P released per unit area
6. What is an IDM Company, an example?
7. Technical difficulties of transition to 450 mm substrate
8. Three categories of factories in the electronics industry, characteristics of Giga factories
9. What is the limit of the displacement on the substrate in the three-dimensional SOI MOST
10. UTSOI (ultra-thin SOI) ultrathin SOI MOST main advantages over bulk CMOS

Робочу програму навчальної дисципліни (силабус):

Складено доцентом кафедри мікроелектроніки , к.ф-м.н. Свєчніковим Г.С

Ухвалено кафедрою мікроелектроніки (протокол №22 від 23.06.2023 р.)

Погоджено Методичною комісією факультету[1] (протокол № 06/23 від 29.06.2023 р.)

[1] Методичною радою університету – для загальноуніверситетських дисциплін.