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

Кафедра
Мікроелектроніки

Photonic and optoelectronic devices

Робоча програма навчальної дисципліни (Силабус)

Реквізити навчальної дисципліни

Рівень вищої освіти	***Третій (освітньо-науковий)***
Галузь знань	*15 Automation and instrumentation*
Спеціальність	*153 Micro- and nanosystem technology*
Освітня програма	*Micro- and nanosystem technology*
Статус дисципліни	*selective*
Форма навчання	*Full-time*
Рік підготовки, семестр	*2 course, autumn term*
Обсяг дисципліни	*5 credits (150 hours)*
Семестровий контроль/ контрольні заходи	*credit*
Розклад занять	
Мова викладання	*English*
Інформація про керівника курсу / викладачів	Lecturer/ Practical session: Ph.D. Svuchnikov G.S. svgeorge13@gmail.com
Розміщення курсу	Code fdznkke https://meet.google.com/lookup/bcxsaasirf

Програма навчальної дисципліни

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

Light has found applications in data transmission, such as optical fibers and waveguides and in optoelectronics. It consists of a series of electromagnetic waves, with particle behavior. Photonics involves the proper use of light as a tool for the benefit of humans. It is derived from the root word “photon”, which connotes the tiniest entity of light analogous to an electron in electricity. Photonics have a broad range of scientific and technological applications that are practically limitless and include medical diagnostics, organic synthesis, communications, as well as fusion energy. This will enhance the quality of life in many areas such as communications and information technology, advanced manufacturing, defense, health, medicine, and energy

Technology affects us all. For the most part, it makes life easier, safer and more enjoyable. This allows us to explore unknown territory and produce things that were impossible only a few years ago. And much more awaits us. One of the technologies that causes many of these changes is photonics - it is evolving rapidly and will soon have the same status as something like electronics, an old technology that affects so many parts of our lives today.

Photonics is all around us, from communications and healthcare, to materials processing in manufacturing, to lighting and photovoltaics, and to everyday products such as DVD players and mobile phones.

Today, photonics is one of the key technologies to address the great challenges of the 21st century, such as energy, mobility, health, communications, the environment and security. There are few technologies that control our daily lives as much as photonics.

Photonics is a broader concept that includes as one of its components and optoelectronics Photonics covers a wide range of optical, electro-optical and optoelectronic devices and their various applications.

Photonics is made up of many different technologies including optical fibers, lasers, detectors, quantum electronics, fibers, and materials
Just as the electronics revolutionized the 20th century, photonics is doing the same in the 21st century.

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

Purpose: to acquaint students with the latest achievements in the field of photonics and optoelectronics, teaching the discipline is based on preparing students in the field of physical principles of operation, typical construction schemes, manufacturing technology of modern photonic and optoelectronic devices, as well as the formation of students' knowledge and skills to conduct information retrieval within the research task.
The student who studied the course must
know:
• apparatus of concepts (terminology) of the discipline;
• main types of photonics devices, principles of their operation, characteristics and parameters; Dependencies of characteristics and parameters on operating conditions, scope;
• basics of analysis and calculation of photonics devices
• basic technical and technological solutions in the field of photonics

be able:
• determine the main physical causes of certain electrical and optical properties of materials that used in modern photonic and optoelectronic devices,
• correct selection of materials for use in photonic and optoelectronic elements.
• practically use effects in semiconductor and dielectric materials to create photonic and optoelectronic devices;
• use the element base of photonics to build devices and devices
photonics
• experimentally determine the basic characteristics and parameters widely
used devices and devices of photonics
• work with technical literature and technical documentation

possess:
• methods of problem statement and methods of conducting an experiment using elements of photonics;
• techniques and algorithms for solving problems of photonics;
• research methods in the field of photonics.

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

Discipline " Photonics: Principles and Devices" is provided by courses of basic higher education in the field of:, "Solid State Electronics", "Statistical Physics", "Physics of Semiconductor Devices and Integrated Circuits", "Optoelectronics".

When studying the discipline, the apparatus of mathematical physics, probability theory and mathematical statistics is use

3. The content of the discipline

Introduction to the course

Topic 1. Physical foundations of optoelectronic radiation sources.

Topic 2. Types of radiative recombination in semiconductors. Radiation recombination. Non-radiative recombination.

Topic 3. Photometric and energy characteristics of optical radiation. Energy and light parameters. Colorimetric parameters.

Topic 4. Conditions of laser radiation Design and manufacturing technology
semiconductor lasers. lasers with optical and electronic excitation.
Topic 5. Design and manufacturing technology of LEDs. Technical parameters of light diodes.

Topic 6. The main characteristics and parameters of light emitting diodes. Select the type of light emitting diode. Infrared light emitting diodes. LED sources of high brightness and white light.

Topic 7. Devices of coherent radiation.

Topic 8. Laser Diodes - structure, Modes, Rate Equation,Quantum efficiency, Resonant frequencies, Radiation pattern

Topic 9.Single-Mode Lasers - DFB (Distributed-FeedBack) laser, Distributed-Bragg Reflector,

Topic 10. Modulation Light-source Linearity

Topic 11. Noise in Lasers

Topic 12. Semiconductor photodetectors.

Topic 13. Principles of photo receiving devices. Characteristics, parameters and models
photodetectors.

Topic 14. Photodiodes with p-i-n structure. Basic characteristics and parameters

Topic 15. Avalanche photodiodes. Phototransistors. Photoresistors. Photothyristors. Main characteristics and parameters

Topic 16. Si- photonics, problems and prospects

Topic 17. Integration with CMOS technology

Topic 18. Radiation sources for Si-photonics.

Topic 19. Photodetectors

Topic 20. Waveguide structures based on KNI

Topic 21. Si- photonics for data centers

Topic 22. Organics in photonics.

Topic 23. Organic LEDs, structure and principle of operation.

Topic 24.Recent progress of organic light-emitting diode microdisplays

Topic 25. Solar converters based on organic materials

Topic 26. Novel Organic and Polymeric Materials for Solar Energy

Topic 27. Voltage and optic losses in organic photovoltaic devices OPVs

Topic 28. Organic electronic devices for solar energy conversion and storage

4. Navchal'ni materialy ta resursy

Basic :

1.Игнатов А. Н. Оптоэлектронные приборы и устройства: Учеб. пособие – М.: Эко-Трендз, 2006. – 272с.
2. Э. Розеншер, Б. Винтер Оптоэлектроника Москва: Техносфера,2004. - 592 с..
3.Тарасов В.В., Якушенков Ю.Г. Двух- и многодиапазонные оптико-электронные системы с матричными приемниками излучения. – М.:Университетская книга; Логос, 2007. – 192 с.
4.Гребнев А. К. и др. Оптоэлектронные элементы и устройства / А.К.Гребнев, В.Н. Гридин, В.П. Дмитриев; Под. ред. Ю.В. Гуляева. - М.: Радио и связь, 1998. - 336 с.
5. Якушенков Ю.Г. Теория и расчет оптико-электронных приборов:Учебник для студентов вузов. – 4-е изд., перераб. и доп. – М.: Логос, 1999. – 480

Supplementary:

1. *Волоконно-оптические датчики. Вводный курс для иженеров и научных работников. Под ред. Э. Удда Москва: Техносфера, 2008. – 520 с.*
2. *Румянцев К.Е. Волоконно-оптическая сенсорика: Учебное пособие. Таганрог: ТРТУ. 1996. 108с.*

3. *Ермаков О.Н. Прикладная оптоэлектроника Москва: Техносфера, 2004, - 416с.*
4. *http://www.ph4s.ru/book_optoelektr.html*

Навчальний контент

5. Methods for defining primary discipline (lighting component)

Л Lectures::

General aspect, introduction *Lecture 1*
Introduction
A brief digression into the history and state of affairs in photonics and optoelectronics today. Lecture

Section I. Physical bases of work of optoelectronic sources of radiation.
General ideas, properties, features, advantages and disadvantages.
Lecture 2-7

Topic 1.1. Types of radiative recombination in semiconductors. Radiation recombination. Non-radiative recombination.
Topic 1.2. Photometric and energy characteristics of optical radiation. Energy and light parameters. Chlorimetric parameters.
Topic 2.3. The main characteristics and parameters of light diodes. Select the type of light emitting diode. Infrared light emitting diodes. LED sources of high brightness and white light

Section 2. Semiconductor LEDs and lasers. Lecture 8-15
General ideas. Properties. Constructive implementation. Approaches to design and manufacture, their features, advantages and disadvantages, features of use.
Topic 2.1. Laser Diodes - structure, Modes, Rate Equation,Quantum efficiency, Resonant frequencies, Radiation pattern.
Topic 2.2. Single-Mode Lasers - DFB (Distributed-FeedBack) laser, Distributed-Bragg Reflector
Topic 2.3. Modulation Light-source Linearity. Noise in Lasers

Section 3. Semiconductor photodetectors Lecture 16-22
General ideas. Properties. Constructive implementation. Approaches to design and manufacture, their features, advantages and disadvantages, features of use.
Topic 3.1. . Principles of photo receiving devices. Characteristics, parameters and models of photodetectors.
Topic 3.2. Photodiodes with p-i-n structure. Main characteristics and parameters Topic 3.3. Avalanche photodiodes. Phototransistors. Photoresistors. Photothyristors. Main characteristics

Section 4. Si- photonics, problems and prospects Lecture 23-30
Topic 4.1. Integration with CMOS technology. Waveguide structures based on SOI.
Topic 4.2. Radiation sources for Si-photonics.
Topic 4.3 Photodetectors.
Topic 4.4. Si- photonics for data centers

Section 5. Organics in photonics. Lecture 31-36
General ideas, features, advantages and disadvantages, features of use.
Topic 5.1. Organic LEDs, structure and principle of operation.
Topic 5.2. Recent progress of organic light-emitting diode microdisplays
Topic 5.3. Solar converters based on organic materials
Topic 5.4. Novel Organic and Polymeric Materials for Solar Energy

Topic 5.5. Voltage and optic losses in organic photovoltaic devices OPVs. Organic electronic devices for solar energy conversion and storage

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. *Photonic Integration & the Future of Optical Networking*
2. *Polymer Optoelectronics. Microdisplays*
3. *Phosphorescent organic light emitting diodes*

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

4. ***Independent 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 of VTS

1.Methods of receiving optical radiation. Direct detection, heterodyne reception 14 hours

2 Photonic crystals 18 hours

3 Cascading solar cells 14 hours

4 OLED micro displays 10 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

5. 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.

6. Types of control and rating system for assessing 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 have scored the required number of points for a positive assessment 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

7. Additional information on the discipline (educational component)

- **a list of questions to be submitted for semester control (for example, as a supplement to the syllabus);**

1 . Two types of organic LEDs (molecule size.) - The main differences

2. Chromatic dispersion what is it? (Two types)

3. Project Sniper is a new paradigm of architecture of multi-core processors from IBM (what is how it is implemented)

4. INTEL ideology in the photonic communication network - What is the circuit embodiment (what do)

5. IN Cables by optical module and type of gasket are divided into:

6. Two main types of photonic crystal fiber

7. Why the cultivation of GaN single crystals is not an easy task

8. The main advantages of high-power LEDs compared to traditional light sources

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 (протокол № 06/23 від 29.06.2023 р.)