

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ
«ХАРКІВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ»

Методичні вказівки з англійської мови для студентів другого курсу
EEE інституту, за фахом Мікро- та наноелектроніка.
Methodological instructions in the English language for second year
students of EEE Institute, speciality Micro- and nanoelectronics.

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Укладачі: Т.І. Беркутова, В.В. Вракіна, С.В. Танько
Рецензент: канд. пед.наук Т.Є. Гончаренко

Кафедра іноземних мов

ПЕРЕДМОВА

Методичні вказівки з англійської мови для студентів другого курсу ЕЕЕ інституту за фахом Мікро- та Наноелектроніка.

Зміст матеріалу методичних вказівок передбачає наявність у студентів базових знань англійської мови та володіння загальною лексикою. Головна мета методичних вказівок-забезпечити формування навичок різних видів читання та аудіювання, а також опанування термінологією за фахом.

Методичні вказівки містять тексти професійно спрямованої тематики, аудіо, і різноманітні завдання до них, що потребують від студентів індивідуальної відповіді, висловлювання своїх думок, включають їх у комунікативний процес. Також методичні вказівки містять додаткові тексти, які студенти можуть опрацювати самостійно.

Методичні вказівки відповідають програмі вивчення іноземної мови у технічному ВНЗ і вимогам необхідного кваліфікаційного рівня.

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I. MICROELECTRONICS

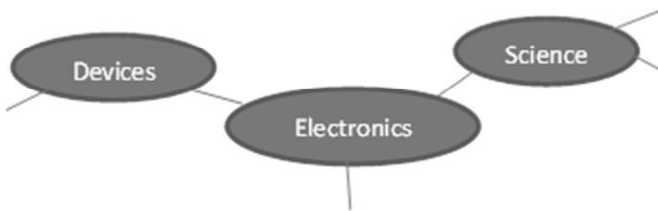
Vocabulary:

applied physics	прикладна фізика
generation, <i>n</i>	формування, генерація
scientific research	наукові дослідження
due to the efforts	завдяки зусиллям, управління ; обробка;
manipulation, <i>n</i>	перетворення
to replace vacuum tubes	замінювати електронні лампи
a piece of semiconductor	напівпровідниковий кристал
reduced weight	зменшена вага
power consumption	споживання(витрата) електроенергії
to carry out, <i>v</i>	здійснювати; виконувати
solid body	тверде тіло; кристал; напівпровідник
to respond, <i>v</i>	відповідати; реагувати
at a rate	зі швидкістю
integrated circuit (IC)	інтегральна схема
batch processing	пакетна обробка
to assemble, <i>v</i>	монтувати; збирати
to lower manufacturing	знизити продуктивність
to increase reliability	збільшити надійність
to align, <i>n</i>	вибудовувати у лінію, ставити до ряду; вирівнювати
application, <i>n</i>	застосування, використання; додаток

bulk, <i>n</i>	купа, маса
density, <i>n</i>	щільність; концентрація
device, <i>n</i>	пристрій, пристосування;
deposition, <i>n</i>	механізм; апарат, машина, прилад
to enable, <i>v</i>	відкладення, осадження
evaporation, <i>n</i>	давати можливість, право
	випарювання, ; пароутворення
feature, <i>n</i>	особливість, характерна риса;
	деталь, ознака, властивість
gear, <i>n</i>	механізм, пристрій, інструмент,
	прилад
humidity, <i>n</i>	вогкість, вологість
pervasive, <i>adj</i>	проникаючий, заповнюючий
to precede, <i>v</i>	передувати
semiconductor, <i>n</i>	напівпровідник
substrate, <i>n</i>	основа, підкладка
versatility, <i>n</i>	мінливість, різнобічність
wafer, <i>n</i>	підкладка, пластина

1. Answer these questions:

1. What springs to your mind when you hear the word “electronics”?
Put down as many associations as you can:



2. Using the mind map given above think of the definition to the term “electronics”.
3. How has electronics changed the life of people?
4. What do you know about the most important breakthroughs in electronics?
5. Can you imagine your life without electronic devices? Why?
6. What is the future of electronics?

2. Read the text below and answer the questions:

1. What does electronics study?
2. What discoveries contributed to its development?

TEXT 1.1

DEVELOPMENT OF ELECTRONICS

Electronics is a field of engineering and applied physics dealing with the design and application of electronic circuits. The operation of circuits depends on the flow of electrons for generation, transmission, reception and storage of information.

Today it is difficult to imagine our life without electronics. It surrounds us everywhere. Electronic devices are widely used in scientific research and industrial designing, they control the work of plants and power stations, calculate the trajectories of space-ships and help the people discover new phenomena of nature. Automatization of production processes and studies on living organisms became possible due to electronics.

The invention of vacuum tubes at the beginning of the 20th century was the starting point of the rapid growth of modern electronics. Vacuum tubes assisted in manipulation of signals. The development of a large variety of tubes designed for specialized functions made possible the progress in radio communication technology before the World War II and in the creation of early computers during and shortly after the war.

The transistor invented by American scientists W. Shockly, J. Bardeen and W. Brattain in 1948 completely replaced the vacuum tube. The transistor, a small piece of a semiconductor with three electrodes, had great advantages over the best vacuum tubes. It provided the same functions as the vacuum tube but at reduced weight, cost, power consumption, and with high reliability. With the invention of the transistor all essential circuit functions could be carried out inside solid bodies. The aim of creating electronic circuits with entirely solid-state components had finally been realized. Early

transistors could respond at a rate of a few million times a second. This was fast enough to serve in radio circuits, but far below the speed needed for high speed computers or for microwave communication systems.

The progress in semiconductor technology led to the development of the integrated circuit (IC), which was discovered due to the efforts of John Kilby in 1958. There appeared a new field of science – integrated electronics. The essence of it is batch processing. Instead of making, testing and assembling discrete components on a chip one at a time, large groupings of these components together with their interconnections were made all at a time. IC greatly reduced the size of devices, lowered manufacturing costs and at the same time they provided high speed and increased reliability.

3. Answer the questions:

1. What is electronics?
2. Where are electronic devices used?
3. What was the beginning of electronics development?
4. What made the progress in radio communication technology possible?
5. When was the transistor invented?
6. What aim was realized with the invention of the transistor?
7. When were integrated circuits discovered?
8. What advantages did the transistors have over the vacuum tubes?

4. Guess the meaning of the following international words and phrases:

Electrons; physics; information; microelectronics; industrial design; to calculate trajectories; phenomena of nature; automatization of production processes; organisms; vacuum tubes; specialized functions; progress in radio communication technology; transistor; electrode; components; to realize; communication system; technology; discrete components; chip.

5. Find equivalents in the text:

Прикладна фізика; передача та прийом інформації; потік електронів; наукові дослідження; промислове проектування; виявляти явища природи; відповідний пункт; сприяти управлінню сигналами; швидке зростання; створення перших комп'ютерів; напівпровідниковий кристал; споживання електроенергії; висока надійність; твердотільні компоненти; високошвидкісний комп'ютер; мікрохвильові системи

зв'язку; напівпровідникова технологія; область науки; інтегральна схема; пакетна обробка; збирання дискретних компонентів на кристалі; знизити продуктивні витрати; забезпечити високу швидкість.

- 6. Make a 2-3 minute report about the importance of electronics.
Support your ideas with different examples.**



7. What is the topic «Microelectronics » associated with in your mind? Put your ideas into separate words.

8. Make up a logical abstract on the subject (include definition, microelectronic components, applications of microelectronics, etc.) using the words from your lists. Discuss it with your groupmates.

9. Read an abstract about microelectronics:

As a subdivision of electronics, **microelectronics** relates to the design, manufacture, utilization, and study of really small electronic designs and components. By studying these very small and microscopic elements electronic components are manufactured. It basically utilizes tiny or microcomponents to manufacture electronic devices.

In comparison to all the other subdivisions in electronics, Microelectronics seems to be rapidly evolving as the most in-demand field of electronics. The main reason this field continues to expand is that of the increase in demand for such small and less expensive devices.

Generally, these devices are made from semiconductor materials (silicon and graphite); these materials are the most commonly used elements in the manufacture of microelectronic devices. Most of the elements in normal electronic designs are available in a microelectronic design as well. This could include transistors, capacitors, inductors, resistors, and also diodes.

Apparently, they were first made to replace transistor tubes, which were vacuum tubes that were used to channel electrical signals into binary code. They are used in almost all electronics nowadays, and they allow us to have things like personal computers, digital watches, televisions, and many other electronics that we use today.

The fact that they are reducing in size and becoming smaller and smaller, in turn, allows us to make things smaller and lighter which is obviously considered a perk. On the downside, they are quite very difficult to replace and much harder to detect when they fail when compared to the old t-tubes.

10.Does this definition of microelectronics differ from yours in exercises 8? What is the difference?

TEXT 1.2

THE WORLD OF MICROELECTRONICS

A great role belongs to microelectronics in our national economy. Its appearance and intensive development was caused by the necessary of using a great quantity of active elements: diodes, transistors, variable capacitors.

Semiconductor elements are usually presented in a micro-miniaturized form: they are arranged in a single crystal, though their quantity sometimes exceeds hundreds of thousands. But this is a unique apparatus, a very

complicated circuit which performs quite a number of processes. Such devices have acquired the name of integrated circuits. The «cleverest» of them perform the function of «logical thinking» and carry out a rather complicated operation of processing information. They have been called microprocessors.

At the base of modern microelectronic devices lie semiconductor elements. Microelectronics itself is based on planar technology and photolithography. Integral circuit is a complicated structure with its ways, sluices and quick-working gates for the flows of electrons which are carried if information. They are able to act at command just as to work independently. And that means that the electrons can create a new process, direct operations, think over and carry out such complicated calculations that are inaccessible even to a great number of qualified specialists. The level of the development of microelectronics defines the level of all computers and data processing as well as diverse complicated systems of electronic automation.

Exercise 1. Agree or disagree with the following sentences:

1. Integral circuit is a simple structure.
2. The appearance of microelectronics was caused by the necessity of using many active elements: diodes, transistors, different capacitors.
3. Integrated circuits have been called microprocessors.
4. Integrated circuit is a simple structure where flows of electrons are not carriers of information.
5. Electrons cannot create new process, think over and carry on complicated calculations.

Exercise 2. Answer the following questions:

1. What caused the appearance of microelectronics?
2. What devices acquired the name of integrated circuits?
3. What is at the base of microelectronics?
4. Why is the development of microelectronics so important for our national economy?

Exercise 3. Agree or disagree with the following statements:

1. People understand that sending and receiving information electronically offers only difficulties.
2. Sending and receiving data electronically takes only a fraction of time.
3. Computers can sort information in a flash.
4. Computers are electronically linked to a special data bank of information.

TEXT 1.3

1. Read and translate the text below.

MICROFABRICATION

Microfabrication or **micromanufacturing** are the terms to describe processes of fabrication of miniature structures, of micrometre sizes and smaller. Historically the earliest micromanufacturing was used for semiconductor devices in integrated circuit fabrication and these processes have been covered by the terms “semiconductor device fabrication”, “semiconductor manufacturing”, etc. Miniaturization of various devices presents challenges in many areas of science and engineering: physics, chemistry, material science, computer science, ultra-precision engineering, fabrication processes, and equipment design. It is also giving rise to various kinds of interdisciplinary research. The major concepts and principles of micromanufacturing are laser technology, microlithography, micromachining and microfinishing (nanofinishing).

Microfabrication technologies originate from the microelectronics industry, and the devices are usually made on silicon wafers even though glass, plastics and many other substrates are in use. Micromachining, semiconductor processing, microelectronic fabrication, semiconductor fabrication, MEMS fabrication and integrated circuit technology are terms used instead of microfabrication, but microfabrication is the broad general term.

Traditional machining techniques such as “electro-discharge machining”, “spark erosion machining”, and “laser drilling” have been scaled from the

millimeter size range to micrometer range, but they do not share the main idea of microelectronics originated microfabrication: replication and parallel fabrication of hundreds or millions of identical structures. This parallelism is present in various imprint, casting and molding techniques, which have successfully been applied in the microregime. For example, injection moulding of compact discs involves fabrication of micrometersized spots on the disc.

Microfabrication is actually a collection of technologies which are utilized in making microdevices. Some of them have very old origins, not connected to manufacturing, like lithography or etching. Polishing was borrowed from optics manufacturing, and many of the vacuum techniques come from 19th century physics research. Electroplating is also a 19th century technique adapted to produce micrometre scale structures, as are various stamping and embossing techniques.

To fabricate a microdevice, many processes must be performed, one after the other, many times repeatedly. These processes typically include depositing a film, patterning the film with the desired micro features, and removing (or etching) portions of the film. For example, in memory chip fabrication there are some 30 lithography steps, 10 oxidation steps, 20 etching steps, 10 doping steps, and many others are performed. The complexity of microfabrication processes can be described by their “mask count”. This is the number of different pattern layers that constitute the final device. Modern microprocessors are made with 30 masks while a few masks suffice for a microfluidic device or a laser diode. Microfabrication resembles multiple exposure photography, with many patterns aligned to each other to create the final structure.

Microfabricated devices are not generally freestanding devices but are usually formed over or in a thicker support substrate. For electronic applications, semiconducting substrates such as silicon wafers can be used. For optical devices or flat panel displays, transparent substrates such as glass or quartz are common. The substrate enables easy handling of the micro device through the many fabrication steps. Often many individual devices are made together on one substrate and then singulated into separated devices toward the end of fabrication.

Microfabrication is carried out in cleanrooms, where air has been filtered of particle contamination and temperature, humidity, vibrations and electrical disturbances are under stringent control. Smoke, dust, bacteria and cells are micrometers in size, and their presence will destroy the functionality of a microfabricated device. Cleanrooms provide passive cleanliness but the wafers are also actively cleaned before every critical step.

2. Define the following words as parts of speech and give the initial words of the following derivatives.

Earliest, integrated, fabrication, processing, repeatedly, handling, productive, deposition, contaminated, reconstruct, completely, sophisticated, actually.

3. Match the following terms with their definitions:

- | | |
|------------------|--|
| 1) miniaturize | a) a thin coating or layer |
| 2) substrate | b) make dirty, impure or diseased |
| 3) semiconductor | c) putting to practical use |
| 4) contaminate | d) easy to see through |
| 5) transparent | e) to take or construct (something, especially electronic equipment) on a very small scale; reduce in size |
| 6) particle | f) the semiconductor base on which other material is deposited, especially in the construction of intergrated circuits |
| 7) application | g) a body with finite mass that can be treated as having negligible size, and internal structure |
| 8) film | h) a substance, such as germanium or silicon, that has an electrical conductivity that increases with temperature and is intermediate between that of a metal and an insulator |

4. Read the following statements and decide if they are true or false. In case the statement is false, correct it.

1. Historically semiconductor devices were made with the help of microfabrication.
2. Only a few technologies are used in making microdevices.
3. Modern microprocessors are composed of many different masks.
4. Silicon wafers can be employed in production of many electronic devices.

5. Some devices can be mounted on one substrate and then separated toward the end of fabrication.

6. Different contaminations can affect the functionality of a microdevice.

5. Divide the text into logical parts and entitle them.

6. Using the information from the text speak about the fabrication of microdevices.

7. Write a short summary of the text.

TEXT 1.4

1. Read and translate the text below.

MICRO ELECTRO MECHANICAL SYSTEMS

The term MEMS, for Micro Electro Mechanical Systems, was coined in the 1980's to describe new, sophisticated mechanical systems on a chip, such as micro electric motors, resonators, gears, and so on. Today, the term MEMS in practice is used to refer to any microscopic device with a mechanical function, which can be fabricated in a batch process (for example, an array of microscopic gears fabricated on a microchip would be considered a MEMS device but a tiny laser-machined stent or watch component would not). In Europe, the term MST for Micro System Technology is preferred, and in Japan MEMS are simply referred to as "micromachines". The distinctions in these terms are relatively minor and are often used interchangeably.

Though MEMS processes are generally classified into a number of categories – such as surface machining, bulk machining – there are indeed thousands of different MEMS processes. Some produce fairly simple geometries, while others offer more complex 3-D geometries and more versatility. A company making accelerometers for airbags would need a completely different design and process to produce an accelerometer for inertial navigation. Changing from an accelerometer to another inertial device such as a gyroscope requires an even greater change in design and process, and most likely a completely different fabrication facility and engineering team.

In one viewpoint MEMS application is categorized by the type of use: sensor, actuator, structure.

In another view point MEMS applications are categorized by the field of application:

- Inkjet printers.
- Accelerometers in modern cars for a large number of purposes including airbag deployment in collisions.
- Accelerometers in consumer electronics devices such as game controllers, personal media players / cell phones. Also used in PCs to park the hard disk head when free-fall is detected, to prevent damage and data loss.
- MEMS gyroscopes used in modern cars and other applications to detect yaw.
- Silicon pressure sensors e.g. car tire pressure sensors, and disposable blood pressure sensors.
- Optical switching technology which is used for switching technology and alignment for data communications.
- Bio-MEMS applications in medical and health related technologies.
- Interferometric modulator display (IMOD) applications in consumer electronics (primarily displays for mobile devices).

2. Make 5 questions to the text and interview your partner about MEMS.

3. Speak about MEMS applications.

4. Say what new information you have learnt from the text.

5. Make an oral summary of the text.

TEXT 1.5

SCIENTISTS MAKE MOLECULE-SIZED ELECTRIC MOTOR.

Scientists have made the smallest electric motor ever created. It is a feat of scientific genius that most of us could never even try to understand. Dr. Charles Sykes and his team from America's Tufts University created the motor from a single molecule just a billionth of a metre wide. Dr Sykes is in

contact with the Guinness Book of World Records to have his motor recognised as the smallest ever. The current world-record holder is a 200-nanometre-long nano-tube made from carbon. Dr Sykes' creation is an incredible 200 times smaller. Naturally, the researchers hope their creation has uses for mankind. It will be used to power the tiniest machines ever built, and be used by doctors in nano-surgery and robotic surgery.

It is the first time an electric motor has been made from a single molecule. Scientists can make molecules convert energy from light and chemical reactions into movement, but Dr Sykes' invention is the first to be classed as a motor – something that can continually generate power. There is some mind-boggling science behind Sykes' device. A combination of chemicals and metals produces the miniscule motor that rotates 50 times a second. Dr Sykes was excited about the future of his discovery, saying: "The next thing to do is to get the thing to do work that we can measure - to [link] it to other molecules, lining them up next to one another so they're like miniature cog-wheels."

1. Read the headline. Guess if a-h below are true (T) or false (F).

- a. Scientists have made the second-smallest motor ever invented. T / F
- b. The motor was made with just a single molecule. T / F
- c. The molecule in the motor has a width of a millionth of a metre. T / F
- d. The motor is 200 times smaller than the current world-record holder. T / F
- e. Scientists can also make molecules create movement from light. T / F
- f. Sykes' creation is the third molecule device to be accepted as a motor. T / F
- g. Dr Sykes' molecule motor spins at a rate of 50 times a second. T / F
- h. Next, Dr Sykes will make cog wheels for the world's smallest watch. T / F

2. Match the following synonyms from the article.

- 1. created
- 2. recognised
- 3. current
- a. transform
- b. applications
- c. tiny

- | | |
|--------------|---------------|
| 4. uses | d. accepted |
| 5. surgery | e. made |
| 6. single | f. connect |
| 7. convert | g. present |
| 8. classed | h. operations |
| 9. miniscule | i. labelled |
| 10. link | j. sole |

3. Phrase match. Sometimes more than one choice is possible.)

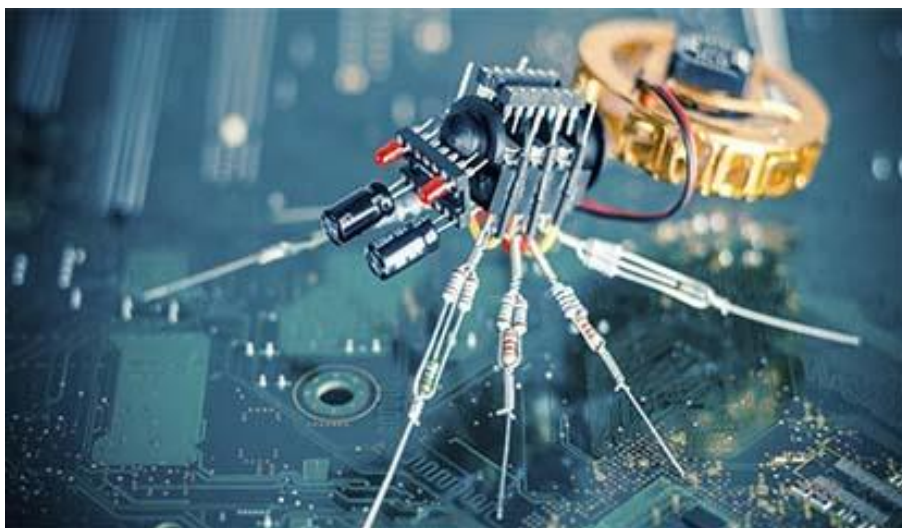
- | | |
|---------------------------------|-------------------------|
| 1. the smallest electric | a. behind Sykes' device |
| 2. a feat of scientific | b. record holder |
| 3. just a billionth of | c. the tiniest machines |
| 4. The current world- | d. of his discovery |
| 5. used to power | e. genius |
| 6. chemical | f. wheels |
| 7. some mind-boggling science | g. motor ever created |
| 8. excited about the future | h. to one another |
| 9. lining them up next | i. a metre wide |
| 10. they're like miniature cog- | j. reactions |

II Nanoelectronics

Vocabulary:

unique physical phenomena – унікальні фізичні явища;
 bulk matter – основна, вихідна маса речовини;
 to pertain to, *v* – мати відношення до;
 a realm of – область, сфера;
 infinite bulk system – нескінченна внутрішня структура;
 quantum dots – квантові домішки, квантові точки;
 superlattice, *n* – надграти, кристалічні надграти;
 space structures and shapes – просторові структури та форми;
 catalytic properties – каталітичні властивості;

broad interdisciplinary research area – широка міждисциплінарна сфера дослідження;
confinement of elementary excitation – обмеження елементарного збудження;
coupled finite systems – зв'язкова кінцева система;
ubiquity of the phenomenon – повсюдність явища
far-reaching potential applications – вельми перспективні потенційні галузі застосування;
implication on – вплив на.



TEXT 2.1

1. Read and translate the text below.

NANOTECHNOLOGY

Paragraph 1

The term nanotechnology refers to science and technology in dimensions smaller than one thousand nanometers. One nanometer is a of a meter. The research in nanotechnology is going primarily in two directions, construction of objects atom by atom and production of nano-sized machines.

Paragraph2

Imagine if we could build objects by assembling the atoms. We could build whatever we wanted, from a diamond to a flower. We would simply assemble the necessary atoms in the correct way to make anything we wanted. If you got hungry, you wouldn't have to cook. You would just order what you wanted from a machine and it would assemble the food for you, atom by atom. If you needed new clothes, you wouldn't have to go to the store or even sew, a machine would assemble the atoms into a beautiful outfit.

Paragraph 3

Another branch of nanotechnology research involves making nano-sized machines for different purposes. These nano-sized robots could go into your body and cure diseases. If you got sick you wouldn't need to have surgery. You would just drink a solution that contained the little nano-robots and they would repair your body from the inside, like little mechanics.

Paragraph4

This research, like many other kinds of research, raises ethical questions. Should we build objects including life forms for our purposes? How would you feel about having mechanical parts in your body? What would be the motivation to work if machines could produce everything (Would we even want to work)?

Paragraph 5

Nanotechnology raises interesting questions, but it has a lot of potential. If we could use nanotechnology to produce food and objects, it would mean the end of hunger and poverty. Perhaps we could even travel long distances almost instantly by disassembling our atoms in one place and reassembling them in our destination. The sky is the limit to what we could do with nanotechnology!

2. Select the correct answer.

1. Which word in paragraph 2 means "putting together."
a) ethical b) assembling c) hunger d) correct
2. Which word in paragraph 3 means "have" surgery.
a) cure b) ethical c) research d) undergo
3. Which word in paragraph 4 means "moral."
a) atom b) solution c) ethical d) research
4. Which word in paragraph 5 means "not having food to eat."
a) hunger b) destination c) poverty b) sky

3. Which paragraph answers the following questions?

1. How could we use nanotechnology to manufacture things?
2. What is nanotechnology?
3. What are some of the more outrageous potential uses of nanotechnology?
4. How could you use nanotechnology robots in medicine?
5. What are some ethical questions raised by nanotechnology?

TEXT 2.2

1. Read and translate the text below.

NANOTECHNOLOGY AND NANOMATERIALS

Nanoscience and nanotechnology pertain to the synthesis, characterization, exploration, exploitation, and utilization of nanostructured materials, which are characterized by at least one dimension in the nanometer (1 nm = 10^{-9} m) range.

A focus of frontline interdisciplinary research today is the development of the conceptual framework and the experimental background of the science of nanostructured materials and the perspectives of its technological

applications. The implications of quantum size and shape effects on the energetics, nuclear–electronic level structure, electric-optical response and dynamics, reveal new unique physical phenomena that qualitatively differ from those of the bulk matter and provide avenues for the control of the function of nanostructures. Current applications in the realm of nanoelectronics, nanooptoelectronics, and information nanoprocessing are addressed, and other directions highlighted.

Nanostructures and their ensembles

Nanostructured systems constitute a bridge between single molecules and infinite bulk systems. Individual nanostructures involve clusters, nanoparticles, nanocrystals, quantum dots, nanowires, and nanotubes, while collections of nanostructures involve arrays, assemblies, and superlattices of individual nanostructures. Table 1 lists some typical dimensions of nanomaterials.

Table 1. Nanostructures and their assemblies

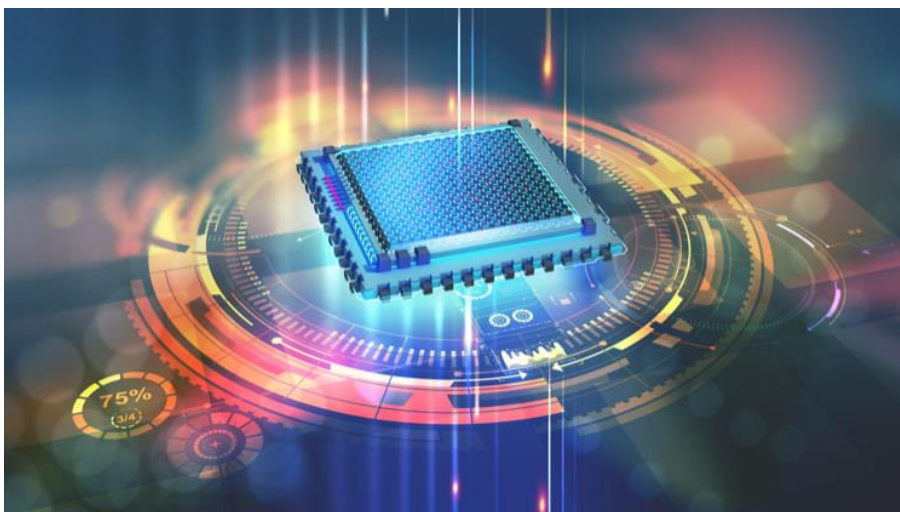
Nanostructure	Size	Material
Clusters	Radius: 1–10 nm	Insulators, semiconductors, metals, magnetic materials
Nanocrystals		
Quantum dots		
Other nanoparticles	Radius: 1–100 nm	Ceramic oxides
Nanobiomaterials	Radius: 5–10 nm	Membrane protein
Photosynthetic reaction center		
Nanowires	Diameter: 1–100 nm	Metals, semiconductors, oxides, sulfides, nitrides
Nanotubes		Carbon, layered chalcogenides
Nanobiorods	Diameter: 5 nm	DNA
2D arrays of nanoparticles	Area: several nm ² –μm ²	Metals, semiconductors, magnetic materials
Surfaces and thin films	Thickness: 1–1000 nm	Insulators, semiconductors, metals, DNA

3D superlattices of nanoparticles	Radius: several nm	Metals, semiconductors, magnetic materials
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The conceptual framework and practice of nanoscience encompasses both nanostructures and their ensembles. In this broad context, the physical and chemical properties of nanostructures are distinct from both the single atom or the molecule and from the bulk matter of the same chemical composition. These fundamental differences between the nanoworld on the one hand, and the molecular and condensed phase worlds on the other hand, pertain to the spatial structures and shapes, phase changes, energetics, electronic–nuclear level structure, spectroscopy, response, dynamics, chemical reactivity, and catalytic properties of large, finite systems and their assemblies. Central issues in this broad, interdisciplinary research area of nanoscience pertain to size effects, shape phenomena, confinement of elementary excitations, level structure of elementary excitations, and the response to external electric and optical excitations of individual finite systems and of coupled finite systems. The ubiquity of these phenomena reflects on quantum effects in finite nanostructures.

2. Answer the following questions:

1. What does nanoscience and nanotechnology pertain to?
2. Do the physical phenomena in nanomaterials differ from the ones in the bulk matter? What way?
3. What can an individual nanostructure involve?
4. What does the fundamental difference between the nanoworld and the molecular and condensed phase worlds lie in?
5. What does the interdisciplinary research area of nanoscience pertain to?
6. How do you understand the terms spectroscopy and spectrometry? Suggest their fields of application.



3. Make up a dialogue. Discuss the issues of interdisciplinary research area of nanoscience, and nanostructured materials and the perspectives of their application.

TEXT 2.3

NANOELECTRONICS, NANOOPTOELECTRONICS, AND INFORMATION NANOPROCESSING

One of the most important and far-reaching potential applications of nanomaterials will be in the field of nanoelectronics. While the field of molecular electronics was fraught with some conceptual–practical difficulties in the context of connecting molecular devices to the “outside world”, these issues were solved by nanodevice fabrication, the design of surfacenanodevice chemical contacts, and chemical engineering of

molecularnanoparticles or biomolecular-nanoparticle hybridization. This multidisciplinary research–technology area of nanoelectronics has dual goals:

1. The utilization of a single, individual nanostructure (e.g., cluster, nanoparticle, nanocrystal, quantum dot, nanowire, or nanotube) for the processing of optical, electrical, magnetic, chemical, or biological signals.
2. Providing nanostructured materials, consisting of assemblies of nanostructures, for electronic, optoelectronic, chemical-catalytic, or biological-diagnostic applications.

The distinction between classes (1) and (2) is always practical and sometimes also conceptual. While class (2) is aimed toward the miniaturization of electronic circuitry and of catalytic and biological templates, class (1) is aimed toward the realization of single-electron nanodevices. There are already significant advances in the utilization of single nanostructures for single-electron memory devices based on Coulomb blockade and on a single-electron transistor. Progress for the class (2) system involves scanning probe tips in arrays, LED and laser diodes of semiconductor nanostructures, arrays of semiconductor quantum dots, and nanowires. Nanocircuits making use of carbon nanotubes were described. Metallic and semiconducting properties of multiwalled nanotubes have been constructed by the stepwise burning of layers and by chirality control. These approaches allow for the use of nanotubes in nanocircuitry, with special potential advances in the use of Y junction nanotubes. Another significant area involves nanomaterials for optoelectronics, where functional devices, based on confinement, low potential for photonic switching and optical communication.

The information paradigm in nanostructures may involve two alternative routes. First, the bottom-up approach, starting from a single nanostructure being based on nanofabrication, miniaturization, and assembly of nanostructures to produce a nanostructured computer. Resonant tunneling devices deserve special mention in this context, since they have already demonstrated success in multivalued logic and memory circuits. Second, the top-down approach will utilize and apply the conceptual framework of supramolecular chemistry and self-assembly of nanostructures to produce organized suprastructures for information processes. Spintropic memory based on magnetic, semiconducting nanoparticles, provides a promising direction.

1. Answer the following questions:

1. Why is the field of electronics one of the most important and far-reaching potential applications?

2. What are the dual goals of multidisciplinary research-technology area of nanoelectronics?
3. How do you understand the term *Coulomb blockage* and how is it used in physics?
4. What are the advances in the utilization of single nanostructures?
5. What do the stepwise burning of layers and chirality control allow for?
6. Why do resonant tunneling devices deserve special mention in the context of nanostructured computers?

2. Look through the text and find the sentences that refer to potential applications of nanomaterials and their advances.

3. Put 4 questions of different types (a general, a special, an alternative and a disjunctive) to the text. Discuss these questions with the group.

4. Use the Internet to find more material about nanoelectronics, nanooptoelectronics, and information nanoprocessing.

Summarize the material and be ready to tell the group about it in brief or give a presentation in Power Point.

LISTENING 2.4

‘Developing science of Nanotechnology’

Listen to the audio https://youtu.be/gJxs_6IAg8Q and do the tasks below:

Choose the correct letter A, B or C in questions 1-3.

1. The speaker says that one problem with nanotechnology is that
 - a. it could threaten our way of life.
 - b. it could be used to spy on people.
 - c. it is misunderstood by the public.

2. According to the speaker, some scientists believe that nano-particles
 - a. should be restricted to secure environments.
 - b. should be used with more caution.

- c. should only be developed for essential products.
3. In the speaker's opinion, research into nanotechnology
- a. has yet to win popular support.
 - b. could be seen as unethical.
 - c. ought to be continued.

Complete the notes below in question 4 – 10. Write ONE WORD ONLY.

Uses of Nanotechnology

Transport

- Nanotechnology could allow the development of stronger
4_____
- Planes would be much lighter in weight.
- 5_____ travel will be made available to the masses.

Technology

- Computers will be even smaller, faster, and will have a greater
6_____
- 7_____ energy will become more affordable.

The Environment

- Nano-robots could rebuild the ozone layer.
- Pollutants such as 8_____ could be removed from water more easily.
- There will be no 9_____ from manufacturing.

Health and Medicine

- New methods of food production could eradicate famine.
- Analysis of medical 10_____ will be speeded up.
- Life expectancy could be increased.



SUPPLEMENTARY TEXTS

Text A. History of Electronic Engineering

Electronic engineering as a profession sprang from technological improvements in the telegraph industry in the late 1800s and the radio and the telephone industries in the early 1900s. People were attracted to radio by the technical fascination it inspired, first in receiving and then in transmitting. Many who went into broadcasting in the 1920s were only 'amateurs' in the period before World War I.

The modern discipline of electronic engineering was to a large extent born out of telephone, radio, and television equipment development and the large amount of electronic systems development during World War II of radar,

sonar, communication systems, and advanced munitions and weapon systems. In the interwar years, the subject was known as radio engineering and it was only in the late 1950s that the term electronic engineering started to emerge.

The electronic laboratories (Bell Labs in the United States for instance) created and subsidized by large corporations in the industries of radio, television, and telephone equipment began churning out a series of electronic advances. In 1948, came the transistor and in 1960, the IC to revolutionize the electronic industry. In the UK, the subject of electronic 7 became distinct from electrical engineering as a university degree subject around 1960. Before this time, students of electronics and related subjects like radio and telecommunications had to enroll in the electrical engineering department of the university as no university had departments of electronics. Electrical engineering was the nearest subject with which electronic engineering could be aligned, although the similarities in subjects covered (except mathematics and electromagnetism) lasted only for the first year of the three-year course.

Text B. Micromachines

Micromachines are mechanical objects that are fabricated in the same general manner as integrated circuits. They are generally considered to be between 100 nanometres to 100 micrometres in size, though that is debatable. The applications of micromachines include accelerometers that detect when a car has hit an object and trigger an airbag. Complex systems of gears and levers are another application.

Most micromachines act as transducers; in other words, they are either sensors or actuators.

Sensors convert information from the environment into interpretable electrical signals. One example of a micromachine sensor is a resonant chemical sensor. A lightly damped mechanical object vibrates much more at one frequency than any other, and this frequency is called its resonance frequency. A chemical sensor is coated with a special polymer that attracts certain molecules and when those molecules attach to the sensor, its mass increases. The increased mass alters the resonance frequency of the mechanical object, which is detected with circuitry.

Actuators convert electrical signals and energy into motion of some kind. The three most common types of actuators are electrostatic, thermal, and

magnetic. Electrostatic actuators use the force of electrostatic energy to move objects. Two mechanical elements, one that is stationary (the stator) and one that is movable (the rotor) have two different voltages applied to them, which creates an electric field. The field competes with a restoring force on the rotor (usually a spring force produced by the bending or stretching of the rotor) to move the rotor. The greater the electric field, the farther the rotor will move. Thermal actuators use the force of thermal expansion to move objects. When a material is heated, it expands and amount depending on material properties. Two objects can be connected in such a way that one object is heated more than the other and expands more, and this imbalance creates motion. The direction of motion depends on the connection between the objects.

Text C. Nanotechnology

Nanotechnology, shortened to “nanotech”, is the study of the controlling of matter on an atomic and molecular scale. Nanotechnology deals with structures of the size 100 nanometers or smaller in at least one dimension, and involves developing materials or devices within that size. Nanostructures are assembled a single atom, molecule, or atomic layer at a time, as part of a vast new field of research in nanomaterials synthesis and assembly.

Generally, structures smaller than a nanometer tend to behave much like individual atoms, while materials that are hundreds of nanometers or greater in size exhibit properties of the continuum. Nanoscale properties and behaviors can be quite different as the result of unique physical and chemical interactions. The preponderance of surfaces and interfaces, and the physical confinement of matter and energy, can alter nearly all properties of materials (physical, chemical, optical, etc.), and thus produce extraordinary new behaviors. Examples include generating light from dark materials, improving efficiencies of catalysts by orders of magnitude, and turning soft and ductile materials like gold into solids with hardness equivalent to bearing steel.

The final ingredient to nanotechnology is the ability to characterize and predict nanoscale properties and behavior. New experimental tools that are able to “see”, “touch”, and measure the behavior of individual nanostructures allow scientists and engineers to identify subtle differences in structure and properties that control nanoscale properties. By coupling new experimental techniques with advanced computational tools, researchers can develop, verify, and refine models and simulations that will allow the full potential for nanotechnology to be explored.

There has been much debate on the future implications of nanotechnology. Nanotechnology has the potential to create many new materials and devices with a vast range of applications, such as in medicine, electronics and energy production. On the other hand, nanotechnology raises many of the same issues as with any introduction of new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

Text D. Transistors and semiconductors.

One of the important advances in the development of electronics is the invention of semiconductor materials, a form of matter situated between metals and insulators in their ability to conduct electricity.

The semiconductor is an electric conductor with resistivity in the range between metals and insulators, in which the electric charge – carrier concentration increases with the increasing temperature range. Semiconductors are usually materials which have energy – band gaps smaller than 2 e V . Semiconductors can be crystalline or amorphous and are classified as elemental and compound, intrinsic and extrinsic semiconductors.

Elemental semiconductors are single-element semiconductor materials such as silicon or germanium. Compound semiconductors are materials containing more than one element, for example, III-V compounds such as gallium, arsenide, aluminium, arsenide, cadmium sulfide and copper oxide.

Unlike the vacuum tube where current flow arises from the motion of charge carriers within a vacuum, semiconductor devices develop current flow from the motion of charge carriers within a crystalline solid.

Electrical conduction is possible by the motion of electrons or holes. A perfect semiconductor is essentially an insulator at absolute zero temperature, since its conduction band is vacant. As the temperature increases electrons are thermally excited from the valence into the conduction band and the conductivity increases. The electrons are negative charge carriers, while the holes are positive carriers.

An important property of semiconductors is the ability to change their resistivity over several orders of magnitude by doping.

A transistor is an active semiconductor device with three or more electrodes. It is called active since the transistor is capable of amplification

and current, voltage and power gain. A transistor is an electron device in which electronic conduction takes place within a semiconductor.

Transistors revolutionized radioengineering and electronics replacing bulky vacuum tubes and becoming indispensable in many applications. Having small size, great mechanical ruggedness, long lifetime and high reliability, transistors make it possible to design compact, small-dimensioned electronic devices which consume very little power and to produce devices which cannot be made with vacuum tubes.

High-frequency applications of transistors include amplifiers, oscillators and mixers in communications system. They provide useful power gains with noise performance superior to that of vacuum tubes.

Text E. Types of impurities

Impurities are substances inside a confined amount of liquid, gas, or solid, which differ from the chemical composition of the material or compound.

Impurities are either naturally occurring or added during synthesis of a chemical or commercial product. During production, impurities may be purposely, accidentally, inevitably, or incidentally added into the substance.

Impurities can be added to semiconductors to modify their electrical properties. This addition is termed doping. Silicon doped with pentavalent substitutional impurities such as phosphorus, arsenic, and antimony will have a higher electron density due to the easily ionized fifth electrons of the impurities. The hole concentration in such a silicon crystal is reduced since the np product remains constant. Dopants which increase the electron density are called donors. Dopant concentration is denoted N_p .

The addition of trivalent dopants such as boron, gallium, and indium to silicon will attract electrons and reduce the electron density. Again, since the np product remains constant, the hole density must increase. Dopants which reduce the electron density are called acceptors. Acceptor concentration is denoted N_a .

In an extrinsic (doped) semiconductor the current-carrier type introduced by doping predominates. Donor-doped material is called n-type because the majority of carriers are electrons. The electrons in such semiconductors are the majority carriers, while the holes are the minority carriers. Acceptor-doped materials are called p-type. Here the holes are the majority carriers and electrons are the minority carriers.

Resistivity is determined by the concentration of n and p carriers.

Lifetime is the average time required for excess minority carriers to recombine with majority carriers. Recombination occurs at “traps” caused by impurities and imperfections in the semiconductor crystal. Semiconductor junctions are formed in material grown as a single continuous crystal to obtain the lattice perfection required, and extreme precautions are taken to ensure exclusion of unwanted impurities during processing. However, in some applications short lifetime is desired, and in such cases gold doping is used to achieve this.

Carrier mobility is the property of a charge carrier which determines its velocity in an electric field. Mobility also determines the velocity of a minority carrier in the diffusion process. High mobility yields a short transit time and good frequency response.

Text F. Methods of multiplexing data.

Conventional optical fiber communications systems employ optical fibers to transport information in optical telecommunication networks. An electrical signal carrying information is used to modulate the light emitted by an optical source, typically a laser diode. The modulated light is then propagated through an optical fiber link comprising, in modern systems, at least one erbium-doped fiber amplifier (EDFA) and, in some systems, dispersion compensation modules (DCM). The light emerging from the optical fiber link illuminates an optical detector converting the information encoded on the optical signal back into an electrical signal. In early development stages of optical communication systems, the only way to increase the bit rate was to increase the modulation speed of the laser. In the later evolution of multichannel fiber transmission systems, two distinct methods of multiplexing data have been introduced: wavelength division multiplexing (WDM) and coherence division multiplexing (CDM).

Currently, WDM communication systems are the only multichannel optical systems deployed commercially. To increase the optical fiber capacity, WDM communication systems employ multiple lasers and wavelengthselective passive components to multiplex and de-multiplex a plurality of distinct optical channels onto a single fiber. A plurality of laser sources, each modulated by a single information channel, have distinct frequencies lying on an internationally agreed frequency grid, and are typically separated by 50, 100 or 200 GHz within the transparency range of the optical fiber.

A traditional WDM communication system comprises a plurality of WDM transmitters, a wavelength division multiplexer and a wavelength

division de-multiplexer interconnected by an optical link, and a plurality of WDM optical receivers.

Each WDM transmitter operating at a specified distinct wavelength is capable of accepting an electrical input carrying an information channel. If the information channel is coded in an optical domain, then the optical signals have to be converted into an electrical domain by plurality of transponders to drive WDM transmitters. The number of individual information channels in modern WDM communication systems varies from 8 to 128.

A conventional optical link comprises one or more spans. Each span customarily comprises at least one optical amplifier (EDFA), a segment of optical fiber, and, optionally, a dispersion compensation module (DCM). The number of spans depends on the WDM system design and length of the transmission line. For a conventional long haul link, each span has a length of between 80 and 120 km. The maximum length of a link, which is determined by the requirement to regenerate the optical signal, is typically about 600 km. The multiplexed optical signal transmitted via the optical link is routed to the wavelength division de-multiplexer for de-multiplexing back into individual channels. In each individual channel, the optical signal is received and detected by a respective WDM receiver. A number of WDM receivers corresponds to the number of WDM transmitters. Each WDM optical receiver detects the respective optical signal and processes it to provide recovered clock and data for the subsequent system electronics.

WDM communication systems though significantly enhancing capacity of communication networks have certain technical limitations. To add more WDM channels to the system, one has to broaden the optical bandwidth determined by the spectral band of the optical amplifier, or reduce spacing between the adjacent channels. Broadening the spectral band of the optical amplifier requires new types of amplifiers operating in a wider band than conventional EDFAs. To reduce spacing between WDM channels, new WDM transmitters, multiplexers and de-multiplexers should be used with narrower transmission band and tight performance specifications which are not commercially available at this time. In multichannel WDM systems, a substantial inventory of spare parts is required with specific optical characteristics, such as WDM transmitter wavelength. Beyond these technological difficulties, there are principal limitations, such as nonlinear effects and optical dispersion. Nonlinear effects in the optical link, particularly four-wave mixing, cause channel crosstalk and lead to significant performance degradation for the overall system. The effect of four-wave mixing is intensified as the number of equally spaced (in frequency) channels increases and (or) as the power per channel increases. Non-zero fiber

dispersion is vital for minimization of nonlinear effects. In some types of the optical fiber, such as Dispersion Shifted Fiber (DSF⁵) having low dispersion in the range of 1550 nm, multichannel WDM transmission is not feasible.

Text G. Latest developments in WDM technology

The system and method employing both wavelength and coherence division multiplexing address the limitations of the existing WDM technology in the present invention. The invention utilizes the benefits of existing WDM systems and enhances their capacity to a theoretical limit. It is a principal advantage of the present invention that impairments of WDM and disadvantages of CDM communication systems are substantially diminished or eliminated by loading one or more WDM transmission channels with a plurality of CDM transmission channels, and using an optical spectral range of one WDM channel for transmitting multiple CDM channels.

It is yet another significant advantage of the method and system of the present invention that the overall count of transmission channels is substantially increased, and the number of CDM channels added or dropped can be varied without changing the WDM physical infrastructure.

It is still another important advantage of the present invention that it utilizes a specially designed broadband optical source characterized by substantial noise reduction compared to the conventional broadband source used in the conventional CDM communication systems.

The invention provides a multichannel optical communication system for transmitting optical signals via an optical fiber. The system comprises a plurality of individual WDM transmission channels. A desired number of individual WDM transmission channels of this plurality is selected for transmission of WDM optical signals. Each WDM optical signal is transmitted via respective WDM transmission channel on a unique wavelength within a designated bandwidth. At least one WDM channel is assigned to transmit CDM optical signals. For CDM transmission, a CDM transmission unit is disposed within this at least one WDM transmission channel. The CDM transmission unit comprises one or more CDM transmission channels for transmitting CDM optical signals within the designated bandwidth of assigned at least one individual WDM transmission channel.

A broadband optical source significantly different from conventional broadband sources is used for transmitting CDM optical signals within one WDM transmission channel. According to one embodiment of the present invention a broadband optical source having continuous spectrum within one

WDM channel comprises a semiconductor optical amplifier (SOA) for reducing relative intensity noise (RIN) originated from beating between different frequency components of this spectrum. According to another embodiment of the present invention a broadband optical source with reduced RIN has a discrete spectrum with equally spaced individual spectral lines wherein spacing between the spectral lines exceeds an electrical detection bandwidth of transmitted CDM optical signals.

The invention provides a method of multichannel optical transmission via optical fiber. According to the method, a plurality of individual WDM transmission channels is provided. A requested number of individual WDM transmission channels are selected for transmitting WDM optical signals. At least one WDM transmission channel is selected for transmitting CDM optical signal within a designated range of wavelengths assigned to this channel.

A light beam is generated by a broadband source within the spectral range of this WDM transmission channel. This beam is split into a plurality of optical paths, one path chosen as a reference path, and other paths assigned to CDM transmission channels. In each CDM channel, the light beam is phase modulated and delayed by several coherence times relative to the reference path and other CDM channels. At the output of the optical link WDM and CDM channels are de-multiplexed, and information channels detected.

Навчальне видання

**Методичні вказівки
з англійської мови для студентів 2го курсу ЕЕЕ інституту,
за фахом Мікро- та наноелектроніка.**

Укладачі: БЕРКУТОВА Тетяна Іванівна
ВРАКІНА Вікторія Вікторівна,
ТАНЬКО Євгенія Владиславівна

Англійською та українською мовами
Відповідальний за випуск *доц. Тетяна Гончаренко*
Роботу до видання рекомендувала *доц Тетяна Гончаренко*
В авторській редакції

