МИНИСТЕРСТВО ОБРАЗОВАНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

Белорусский национальный технический университет

Кафедра «Английский язык № 1»

С. П. Личевская
О. А. Матусевич
И. Н. Баньковская

ПОСОБИЕ ПО ОБУЧЕНИЮ НАУЧНО-ТЕХНИЧЕСКОМУ ПЕРЕВОДУ

Минск
БНТУ
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для студентов специальности
1-38 01 04 «Микро- и наносистемная техника»

Рекомендовано учебно-методическим объединением
по образованию в области приборостроения

Минск
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2015

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Л66

Р е ц е н з е н т ы :
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Пособие предназначено сформировать у студентов навыки и развить умения понимания и правильного перевода научно-технических англоязычных текстов в соответствии со специальностью.

Пособие включает 10 уроков, содержащих аутентичные тексты, упражнения к ним, а также дополнительный материал для самостоятельной аудиторной и внеаудиторной работы студентов.

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ПРЕДИСЛОВИЕ

Данное пособие предназначено для обучения чтению и переводу научно-технической литературы с английского языка на русский. Оно адресовано студентам приборостроительного факультета, овладевшим базовой грамматикой и лексикой английского языка. Пособие рассчитано на 68 часов аудиторных занятий.

Цель пособия – сформировать у студентов навыки и развить умения анализировать различные элементы текста, понимать и правильно переводить научно-технические англоязычные тексты по специальности.

Пособие состоит из 10 уроков (Units), подборки дополнительных текстов для чтения и приложения. Каждый урок содержит учебный текст с комплексом упражнений по анализу содержания и переводу. Дополнительные тексты могут использоваться в качестве практикума в самостоятельной работе студентов. Эти тексты рассчитаны на совершенствование навыков работы с политехническим и отраслевым словарем. Приложение содержит правила чтения некоторых математических символов.

Текстовый материал представлен аутентичными текстами, содержащими информацию о различных электронных устройствах, таких как сенсоры, транзисторы, диоды, а также о современных технологиях изготовления и обработки микро- и наномасштабных материалов.

Упражнения, включенные в уроки, отражают лексические и грамматические особенности перевода. В систему лексических упражнений входят задания на перевод интернациональных и псевдоинтернациональных слов, терминологических словосочетаний разной структуры, многофункциональных слов. Упражнения на словообразование ставят целью научить студента переводить слова, в состав которых входят префиксы и суффиксы, часто встречающиеся в научно-технической литературе.

В систему грамматических упражнений входят упражнения на перевод страдательного залога, модальных глаголов, инфинитива и инфинитивных конструкций, причастия и причастных оборотов, герундия и др.

Unit 1
SEMICONDUCTORS

Exercise 1. Learn the following words and word combinations and their meanings.

bind (v) – связывать, присоединять
circuit requirements – схемные требования
common (adj) – распространенный
conduct (v) – проводить ток; служить проводником
convert (v) – преобразовывать, превращать
cornerstone of electronics – *зд.* основа электроники
household wiring circuit – домашняя проводка
in a fraction of a second – за долю секунды
insulator (n) – диэлектрик, изолятор, непроводник
local area – зона
maintain (v) – сохранять, поддерживать
porcelain (n) – фарфор, *зд.* керамика
possess (v) – владеть, иметь, обладать
property (n) – свойство
result in (v) – давать в результате, приводить к
semiconductor (n) – полупроводник
set apart (v) – отделять, разделять
silicon (n) – кремний
single (adj) – отдельный
solid-state physics – физика твердого тела
spot (n) – участок
to give off light – излучать свет
versatility (n) – универсальность
vitally important – существенно (жизненно) важно

Exercise 2. Read the text attentively and translate it into Russian.

Semiconductors

Most metals are good conductors of electricity; most glass and porcelain materials are not. Metals conduct well because they contain many free electrons. In glass and porcelain insulators, electrons are tightly bound to their atoms and cannot conduct current.

Semiconductors fall somewhere in the range between conductors and insulators. In their pure state, at room temperature, they can conduct only slightly because they have only a few free electrons. The most common semiconductors are silicon and germanium.

But semiconductors possess properties that set them apart from other materials and make them vitally important to the new technology. Their most important characteristic is their versatility. For example, they can be made to give off light when an electrical current is applied, or, conversely, to convert light into electrical current. Their level of conductivity can be raised or lowered significantly. Moreover, conductivity can be maintained at varying levels in different local areas within a single tiny square of semiconductor material. Thus we can have a tiny object which is a strong conductor in many local areas and an insulator in others. In addition, it is possible to change an insulating area to a conducting area, or vice versa, in a fraction of a second.

As a result designers can build electrical devices like switches right in the semiconductor material itself. In fact, it would be possible to build entire miniature versions of household wiring circuits within a single tiny block of semiconductor material. This ability of semiconductors to change their state and to maintain conductive and nonconductive areas or spots, as needed by circuit requirements, has made them the cornerstone of electronics and has resulted in the creation of a new branch of science called solid-state physics.

Exercise 3. Complete the table with the international words from the text according to their stress pattern and translate them into Russian.

Metal, material, component, atom, technology, characteristic, electronics, object, designer, local, electricity, electrical, version, electron, fundamental, second, result, physics, engineering, apparatus, effect.

1 ●○	2 ○●	3 ○●○	4 ○●○○	5 ○○●○	6 ○○●○○	7 ○○○●○

Exercise 4. Using the definitions given below guess the words and cross them out in the word square.

S	T	A	L	U	S	N	I
E	O	P	R	O	P	E	R
M	R	A	T	I	N	Y	T
I	R	B	Y	S	W	I	Y
C	O	I	T	N	I	T	C
O	T	L	I	G	R	I	H
N	C	O	N	R	T	W	D
D	U	C	V	E	B	I	N

1. A solid substance that has an electrical conductivity between that of an insulator and that of most metals.
2. A substance or device which does not readily conduct electricity.
3. To change or adapt the form, character, or function of something.
4. An attribute, quality, or characteristic of something.
5. Tie or fasten (something) tightly together.
6. Possession of the means or skill to do something.
7. Very small.
8. The network of wires used in an electrical system or device.
9. A device for making and breaking the connection in an electric circuit.

Exercise 5. Match the words with the opposite meaning.

1. raise	a) negative
2. conductor	b) darkness
3. positive	c) join
4. nonconductive	d) lower
5. set apart	e) conductive
6. single	f) disrupt
7. build	g) common
8. light	h) insulator
9. maintain	i) extrinsic
10. pure	j) change

Exercise 6. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
new	state	комнатная температура
strong	characteristic	стеклянный материал
circuit	temperature	новая отрасль
porcelain	electron	чистое состояние
important	requirement	схемное требование
room	current	керамический изолятор
free	material	электрический ток
pure	conductor	важная характеристика
glass	insulator	свободный электрон
electrical	branch	сильный проводник

Exercise 7. Match the following English words and word combinations with their Russian equivalents.

1. to give off light	a) за долю секунды
2. cornerstone of electronics	b) физика твердого тела
3. household wiring circuits	c) универсальность
4. conductivity	d) миниатюрная версия
5. in a fraction of a second	e) электрическое устройство
6. electrical device	f) излучать свет
7. miniature version	g) домашняя проводка
8. solid-state physics	h) отрасль науки
9. branch of science	i) проводимость
10. versatility	j) основа электроники
11. light-emitting diode	k) интегральная микросхема
12. integrated circuit	l) светодиод

Exercise 8. Mark the following phrases S (if they both mean the same) and D (if they are different).

1. two thirds / sixty-six percent	S / D
2. an average of thirty kilometers / exactly thirty kilometers	S / D
3. over eighteen degrees / less than eighteen degrees	S / D

4. a fifth / twenty percent S / D
5. more than half / forty-five percent S / D
6. the vast majority / ninety percent S / D
7. at least twice a week / two times a week or more S / D

Exercise 9. Answer the following questions.

1. Why do most metals conduct electrical current well?
2. What chemical elements are better conductors than the others?
3. What substance is called a semiconductor?
4. What is the difference between conductors and insulators?
5. Why are semiconductors vitally important to the new technology?
6. How can you raise or lower the level of conductivity of semiconductor materials?
7. What semiconductor characteristic helps to convert a conducting area into an insulating one?
8. Do you agree that semiconductors are the cornerstone of electronics?

Exercise 10. Make up the summary of the text in Exercise 2.

The title of the text is …
The text deals with …
It is reported that …
According to the text …
It should be stressed that …
The author comes to the conclusion that …
I found the text rather / very …

Exercise 11. Complete the sentences with the necessary preposition from the box.

to, at, between, from, by, into, of, on, within, in

1. … room temperature, semiconductors can conduct slightly because they have only a few free electrons.
2. This ability of semiconductors has resulted … the creation of a new branch of science.

3. Electrons are tightly bound … their atoms and cannot conduct current.

4. Their level … conductivity can be raised or lowered significantly.

5. Semiconductors possess properties that set them apart … other materials and make them vitally important to the new technology.

6. The principle of operation of thermionic diodes was discovered … Frederic Guthrie in 1873.

7. These materials can be made to convert light … electrical current.

8. Semiconductors fall somewhere in the range … conductors and insulators.

9. It would be possible to build entire miniature versions of household wiring circuits … a single tiny block of semiconductor material.

10. The materials chosen as suitable dopants depend … the atomic properties of both the dopant and the material to be doped.

Exercise 12. Divide the words into five columns according to their part of speech.

Noun	Adjective	Pronoun	Adverb	Conjunction

Glass, well, because, spot, free, a few, or, their, somewhere, state, conversely, square, itself, requirement, moreover, light, switch, thus, pure, ability, and, other, which, tiny, object, strong, only, them.

Exercise 13. Read the sentences and translate them into Russian. Define the Infinitive functions.

1. The development of electronics helped to build transistors, solar cells, many kinds of diodes including the light-emitting diode, the silicon controlled rectifier, and digital and analog integrated circuits.

2. Electrons cannot conduct current in glass and porcelain insulators.

3. The dependence of the electron energy distribution on temperature is accurate enough to explain why the conductivity of a semiconductor has a strong temperature dependency, as a semiconductor opera-ting at lower temperatures will have fewer available free electrons and holes able to do the work.

4. It is possible to change an insulating area to a conducting area in a fraction of a second.

5. The ability of semiconductors to change their state and to maintain conductive and nonconductive areas or spots, as needed by circuit requirements, has made them the cornerstone of electronics.

6. Silicon is used to create most semiconductors commercially.

7. The task of designers using semiconductor materials is to build modern electronics, including radio, computers, telephones, and many other devices.

8. To know the electricity basics is important for engineers of all specializations.

9. Enrico Fermi and Paul Dirac were the first to discover a phenomenon that describes the energies of single particles in a system comprising many identical particles that obey the Pauli Exclusion Principle.

10. In considering the chemical properties of metals, the first point to be noted is that they vary widely in degree of chemical activity.

11. They want to discuss this project next week.

12. There are so many questions to be tackled as soon as possible.

Exercise 14. Translate the following text into Russian in writing.

A semiconductor is a material that behaves in between a conductor and an insulator. At ambient temperature, it conducts electricity more easily than an insulator, but less readily than a conductor. At very low temperatures, pure or intrinsic semiconductors behave like insulators. At higher temperatures though or under light, intrinsic semiconductors can become conductive. The addition of impurities to a pure semiconductor can also increase its conductivity.

Examples of semiconductors include chemical elements and compounds such as silicon, germanium, and gallium arsenide. The conductivity of a semiconductor increases with temperature, light, or the addition of impurities because these increase the number of conductive valence electrons of the semiconductor. Valence or outer electrons are the carriers of the electrical current.

In an intrinsic semiconductor such as silicon, the valence electrons of an atom are paired and shared with other atoms, making covalent bonds that hold the crystal together. Under such circumstances, these valence electrons are not free to move around as electrical current. Temperature or light excites the valence electrons out of these bonds, freeing them to conduct current. The vacant positions left behind by the free electrons, also known as holes, can move around as well, contributing to the flow of electricity. The energy needed to excite the electron and hole is known as the energy gap.

Doping is the process of adding impurities to an intrinsic semiconductor to increase its ability to conduct electricity. The difference in the number of valence electrons between the doping material, or dopant, and host semiconductor results in negative (n-type) or positive (p-type) carriers of electricity. The dopant is known as an acceptor atom if it ‘accepts’ an electron from the semiconductor atom. It is known as a donor atom if it 'donates' an electron to the semiconductor atom.

For example, a silicon atom has four valence electrons, two of which are required to form a covalent bond. In n-type silicon, donor atoms such as phosphorus (P), with five valence electrons, replace some silicon and provide extra negative electrons. In p-type silicon, acceptor atoms with three valence electrons such as aluminium (Al) lead to an absence of an electron, or a hole, which acts like a positive electron. The extra electrons or holes conduct electricity.

When a p-type semiconductor region is placed adjacent to an n-type region, they form a diode, and the region of contact is called a p-n junction. A diode is a two-terminal device that conducts current in only one direction. Combinations of such junctions are used to make transistors and other semiconductor devices whose electrical behavior can be controlled by the appropriate electrical stimuli. The result of combining many transistors and other active components along with passive ones on a single chip of silicon is the integrated circuit, a complex electronic device designed to perform certain functions depending on the controlling signals.

Unit 2
CHANGING THE LEVEL OF CONDUCTIVITY OF A SEMICONDUCTOR

Exercise 1. Learn the following words and word combinations and their meanings.

bring about (v) – осуществлять, вызывать
building block – функциональный блок
carrier (n) – носитель
conductivity (n) – проводимость
crystalline solid – кристаллическое твердое тело
disrupt (v) – разрывать, разрушать
doping (n) – легирование
electron flow – поток электронов
free (v) – высвобождать, выпускать
hole (n) – электронная вакансия, отверстие, дыра
impurity (n) – примесь
in essence – по существу
inject (v) – инжектировать, вводить, впрыскивать
in series – последовательно, по порядку
interaction (n) – взаимодействие, взаимовлияние
minute (adj) – несущественный, незначительный
nucleus (n) – ядро
proper ratio – правильное соотношение
refer to (v) – относиться, ссылаться
solar cell – солнечный (фотогальванический) элемент
surplus (n) – избыток
to a great extent – в значительной степени, в большой мере
treat (v) – обрабатывать, подвергать обработке

Exercise 2. Read the text attentively and translate it into Russian.

Changing the Level of Conductivity of a Semiconductor

Semiconductors are the materials, which by their conductivity are situated between conductors and insulators. The main property of these materials is conductivity increase by temperature rise. Common semiconducting materials are crystalline solids, but amorphous and liquid semiconductors are known. In their normal state, semiconductor atoms share electrons with their neighbors to form a tight structure that depends on the proper ratio of electrons to nuclei. Because of this balanced structure, semiconductor materials have few free electrons and cannot conduct current to any great extent. However, this orderly structure can be disrupted by introducing minute quantities of 'impurities' into the material (this is referred to as 'doping'). Some 'impurity' atoms will bond with some of the semiconductor atoms and free up electrons. The 'doped' part of the semiconductor will then be capable of conducting current. In the case of silicon, this change can be brought about by injecting tiny quantities of phosphorus. The segment so treated will now have conducting electrons within it and is referred to as an 'n' (for negative) type carrier. Alternatively, an impurity such as boron can be injected, and its interaction with the silicon atoms will produce a surplus of positive carriers in the treated segment. The positive carriers produced this way are referred to as 'holes' (because, in essence, they represent the absence of an electron). A silicon segment doped with boron is referred to as a 'p' (for positive) type carrier.

A p-n junction is formed by joining p-type and n-type semiconductors together in very close contact. P-n junctions are elementary 'building blocks' of almost all semiconductor electronic devices such as diodes, transistors, solar cells, LEDs, and integrated circuits; they are the active sites where the electronic action of the device takes place. For example, a common type of transistor, the bipolar junction transistor, consists of two p-n junctions in series, in the form n-p-n or p-n-p.

Exercise 3. Match the adverbs in A with their synonyms in B and the right Russian equivalents in C.

A	B	C
conversely	in addition	по сути, в сущности
moreover	nevertheless	наоборот
thus	in essence	вследствие, из-за
in fact	vice versa	следовательно, поэтому
however	due to	однако, тем не менее
because of	so	кроме того

Exercise 4. Match the chemical element in A with its definition in B and the right translation in C.

A	B	C
Glass	The chemical element of atomic number 5, a non-metallic solid	Кремний
Porcelain	The chemical element of atomic number 15, a poisonous, combustible non-metal which exists in two common allotropic forms, the white one is a yellowish waxy solid which ignites spontaneously in air and glows in the dark, and the red one is a less reactive form used in making matches	Германий
Silicon	A hard, brittle substance, typically transparent or translucent, made by fusing sand with soda and lime and cooling rapidly; used to make windows, drinking containers, and other articles	Стекло
Germanium	The chemical element of atomic number 32, a shiny grey semimetal; used in making of transistors and other semiconductor devices, but largely replaced by silicon	Фарфор
Phosphorus	The chemical element of atomic number 14, a non-metal with semiconducting properties; used in making electronic circuits	Бор
Boron	A white vitrified translucent ceramic; china	Фосфор

Exercise 5. Match the words with the similar meaning.

1. keep
2. insulator
3. bind
4. set apart
5. small
6. part
7. possess
8. produce

a) tiny
b) share
c) bond
d) have
e) maintain
f) make
j) segment
h) dielectric

Exercise 6. Find the English equivalents in B to the Russian words in A.

A	B		
1. примесь	a) ability	b) impurity	c) quantity
2. взаимодействие	a) influence	b) attitude	c) interaction
3. разрушать	a) to disrupt	b) to build	c) to bind
4. ядро	a) hole	b) particle	c) nucleus
5. избыток	a) surplus	b) property	c) spot
6. часть	a) area	b) segment	c) amount
7. высвобождать	a) to bond	b) to free	c) to conduct
8. соотношение	a) ratio	b) extent	c) requirement
9. дыра	a) area	b) hole	c) current
10. легирование	a) light	b) carrier	c) doping

Exercise 7. Translate the following terminological word combinations containing nouns only.

1. band gap
2. temperature dependence
3. silicon atoms
4. power socket
5. tungsten carbide
6. light energy source
7. vacuum tube
8. charge carrier injection
9. electron energy loss
10. consumption current

Exercise 8. Translate the following sentences into Russian paying attention to the words in bold type.

1. Donor impurities create states near the conduction band **while** acceptors create states near the valence band.

2. **Since** the Fermi level must remain constant in a system in thermodynamic equilibrium, stacking layers of materials with different properties lead to many useful electrical properties.

3. Typically, silicon serves as the chief component for commercially produced semiconductors, **although** a range of other materials, such as germanium, gallium arsenide, and silicon carbide can be utilized **as well**.

4. Semiconductor solar photovoltaic panels directly convert light energy into electrical energy and have become a key focus for many companies, **as** renewable green energy sources now have been thrust into the spotlight; this is **because of** government mandates requiring lower levels of greenhouse gas emissions.

5. The p-n junction's properties are **due to** the energy band bending that happens as a result of lining-up the Fermi levels in contacting regions of p-type and n-type material.

6. Note that charge carriers of the same polarity repel one another so that, in the absence of any force, they are distributed evenly **throughout** the semiconductor material.

7. Sensors can be classified **according to** the type of energy transfer that they detect.

8. When two atoms come close each energy level splits into an upper and a lower level, **whereby** they delocalize across the two atoms.

Exercise 9. Put the words in the questions in the correct order and answer them.

1. know / a / what / do / semiconductor / is / you?
2. the / does / when / of / conductivity / increase / semiconductors?
3. semiconductor / are / types / materials / what / the / of?
4. what / depend / structure / does / atoms / of / tight / semiconductor / a / on?
5. term / what / doping / does / the / mean?
6. a / extrinsic / is / semiconductor / if / has / it / or / some / intrinsic / impurities?
7. is / type / difference / negative / what / between / the / positive / and / carriers?
8. the / represents / absence / what / an / of / electron?
9. formed / p-n junction / how / a / is?
10. electronic / can / what / semiconductor / name / devices / you?

Exercise 10. Make up the summary of the text in Exercise 2.

The title of the text is …
The text is about …
The main idea of the text is …
The author starts by telling the readers about …
Much attention is given to …
According to the text …
The author goes on to say that …
I found the text interesting / important …

Exercise 11. Complete the sentences with the necessary preposition from the box.

from, to, into, from, with, out of, in, of, on, about, off, from

1. Some impurity atoms will bond … some of the semiconductor atoms and free up electrons.
2. Most modern diodes are based … semiconductor p-n junctions.
3. In the case of silicon, this change can be brought … by injecting tiny quantities of phosphorus.
4. The introduction of minute quantities of impurities … the material is referred … as doping.
5. The interaction of boron impurities with the silicon atoms will produce a surplus of positive carrier … the treated segment.
6. The doped part of the semiconductor will then be capable … conducting current.
7. In a p-n diode, conventional current can flow … the anode to the cathode, but not in the opposite direction.
8. The system will not disable sensors automatically when the screen turns ... .
9. Always verify that a sensor exists on a device before you attempt to acquire data … it.
10. When ionizing radiation strikes a semiconductor, it may excite an electron … its energy level and consequently leave a hole.

Exercise 12. Fill in the table with the derivatives from the words given below and translate them.

VERB	NOUN	ADJECTIVE
…	…	local
…	injection	…
to phosphorate	…	…
…	…	electrical
to convert	…	…
…	…	productive
…	purity	…
…	…	interactive
to equip	…	…
…	conductor	…
…	…	detectable

Exercise 13. Read the sentences and translate them into Russian. Define the Participle functions.

1. Conductivity can be maintained at varying levels in different local areas within a single tiny square of semiconductor material.
2. When working with semiconductors it is possible to change an insulating area to a conducting one.
3. The segment treated possessed conducting electrons within.
4. Such disordered materials lack the rigid crystalline structure of conventional semiconductors such as silicon and are generally used in thin film structures and thus are relatively insensitive to impurities and radiation damage.
5. This ability of semiconductors to change their state and to maintain conductive and nonconductive spots, as needed by circuit requirements, has made them the basics of electronics.
6. Dozens of other materials including germanium, gallium arsenide and silicon carbide are used.
7. Being influenced by temperature and pressure, the volume of any substance is not constant.
8. Depending on the material, wavelengths or colours from the infrared to the near ultraviolet may be produced.

Exercise 14. Translate the following text into Russian in writing.

Preparation of Semiconductor Materials

Semiconductors with predictable, reliable electrical properties are necessary for mass production. The level of chemical purity needed is extremely high because the presence of impurities even in very small proportions can have large effects on the properties of the material. A high degree of crystalline perfection is also required, since faults in crystal structure (such as dislocations, twins, and stacking faults) interfere with the semiconducting properties of the material. Crystalline faults are a major cause of defective semiconductor devices. The larger the crystal, the more difficult it is to achieve the necessary perfection. Current mass production processes use crystal ingots between 100 mm and 300 mm (4 – 12 inches) in diameter which are grown as cylinders and sliced into wafers.

Because of the required level of chemical purity and the perfection of the crystal structure which are needed to make semiconductor devices, special methods have been developed to produce the initial semiconductor material. A technique for achieving high purity includes growing the crystal using the Czochralski process. An additional step that can be used to further increase purity is known as zone refining. In zone refining, part of a solid crystal is melted. The impurities tend to concentrate in the melted region, while the desired material recrystallizes leaving the solid material more pure and with fewer crystalline faults.

In manufacturing semiconductor devices involving heterojunctions between different semiconductor materials, the lattice constant, which is the length of the repeating element of the crystal structure, is important for determining the compatibility of materials.

Unit 3
SEMICONDUCTOR DIODES

Exercise 1. Learn the following words and word combinations and their meanings.

application (n) – применение
available (adj) – доступный, применимый
biasing (n) – включение
forward ~ / reverse ~ - прямое / обратное включение
charge (n) – заряд
like ~s / opposite ~s – одноименные / разноименные заряды
current (n) – электрический ток
alternating ~ / direct ~ – переменный / постоянный ток
current flow – электрический ток
depletion region – обедненная область
fill up (v) – заполнять
junction (n) – переход (в полупроводниковом приборе)
p-n ~ – p-n переход
lead (n) – провод
manufacturing process – технологический процесс
oppositely charged – противоположно заряженный
outlet (n) – розетка
portable radio – рация
repel (v) – отталкивать
run on (v) – работать на …
shut down (v) – отключать
terminal (n) – полюс, клемма

Exercise 2. Read the text attentively and translate it into Russian.

Semiconductor Diodes

A charge is a force that repels like charges and attracts opposite charges. If a p-type carrier is joined to an n-type carrier (during the manufacturing process), and the combined segment is connected to a battery so that the lead from the positive terminal is connected to the ‘p’ side and the negative terminal joined to the ‘n’ side, current will flow through the circuit. (This type of connection is referred to as ‘forward biasing’).

Current flows because (positively charged) ‘holes’ in the p-region are repelled by the positive terminal and (negatively charged) electrons in the n-region are repelled by the negative terminal. Thus, carriers flow through the p-n junction (the area where the two segments join) and all across the combined segment, with the holes now attracted by the negative terminal and the electrons attracted to the positive terminal of the battery.

However, if the positive terminal of the battery is connected to the ‘n’ side of the joined segment, and the negative terminal is connected to ‘p’ side, there will be no current flow. (This is referred to as ‘reverse bia-sing’).

Current ceases to flow because the positive terminal strongly attracts the electrons in the n-region, the negative terminal attracts the ‘holes’ in the p-region, and a wide area depleted of electrons and ‘holes’ forms at the p-n junction. This area will, effectively, have become an insulator, shutting down the current.

The p-n semiconductor is an important electronic device and is referred to as a ‘diode’. Since it will permit current flow in only one direction, it can convert alternating current (AC) into direct current (DC), and it has many vital applications in industry and science. (Many devices run on direct current, for example, many types of motors, calculators, and portable radios. When one wants to use an AC source such as a household outlet to run these devices, a diode can be used to convert the AC current to direct current).

Exercise 3. Complete the table with the international words from the text according to their stress pattern and translate them into Russian.

Process, electrode, negative, effectively, segment, radio, diode, battery, electric, positive, minute, calculator, terminal, combined, germanium, region, industry, convert, motor, opposite, electronic, cubic.

1 ●○	2 ○●	3 ●○○	4 ○●○	5 ○●○○	6 ○○●○

Exercise 4. Complete the sentences with the correct words and cross them out in the word square. (The words go across or down).

1. Two adjectives that current can be
a___________, d_________
2. Two verbs that charges perform
r__________, a___________
3. Two adjectives that biasing is
f_________, r_________
4. Two adjectives that charges are
l_________, o________
5. Two verbs that current does
f________, c________
6. Two adjectives that terminals can be
p_________, n__________

P	O	S	I	T	I	V	E	O	S	T
D	R	F	B	V	F	K	J	P	G	C
G	E	O	R	S	H	E	Q	P	H	U
L	P	Q	I	F	L	O	W	O	P	N
N	E	M	T	O	U	X	E	S	Q	E
A	L	T	E	R	N	A	T	I	N	G
T	W	R	C	W	Y	L	W	T	Z	A
T	A	D	V	A	T	Z	Y	E	I	T
R	E	V	E	R	S	E	Z	A	W	I
A	B	J	Y	D	I	R	E	C	T	V
C	O	N	V	E	R	T	X	A	L	E
T	K	P	M	N	O	J	L	I	K	E

Exercise 5. Unjumble the letters to make the words from the text.

1. curciti	c ________
2. nirmatle	t ________
3. gisabin	b ________
4. ciutnjno	j ________
5. gemtsen	s ________
6. rirecar	c ________

7. runisatol i ________
8. vedeci d _______
9. letrecon e _______
10. rutrecn c _______
11. tetybra b _______
12. heacgr c _______

Exercise 6. Match the following English word combinations with their Russian equivalents.

1. depletion region	a) бытовая розетка
2. negative terminal	b) электронный прибор
3. household outlet	c) p-n переход
4. reverse biasing	d) отрицательная клемма
5. like charges	e) электрический ток
6. electronic device	f) одноименные заряды
7. alternating current	g) технологический процесс
8. semiconductor diode	h) обедненная область
9. manufacturing process	i) переменный ток
10. current flow	j) полупроводниковый диод
11. p-n junction	k) обратное включение

Exercise 7. Match the abbreviations in A with their definitions in B and the right Russian equivalents in C.

A	**B**	**C**
h. p.	et cetera	против, в сравнении с
e. g.	cubic centimetre	наружный диаметр
m. p.	id est	точка плавления
etc.	exempli gratia	постоянный ток
o. d.	versus	например
d. c.	melting point	футов в минуту
c. c.	feet per minute	кубический сантиметр
i. e.	outer diametre	и так далее
f. p. m.	horse power	лошадиная сила
vs	direct current	то есть

Exercise 8. Answer the following questions.

1. What does the term ‘charge’ mean?
2. What is forward biasing?
3. Why does an electrical current flow?
4. How is p-n junction formed?
5. Why doesn’t current flow during reverse biasing?
6. When does the area of the p-n junction become an insulator?
7. What converts alternating current into direct current?
8. Almost all appliances run on DC, don’t they?
9. Do you happen to know what branch of engineering is concerned with diodes?

Exercise 9. Make up the summary of the text in Exercise 2.

The text is under the headline …
The main idea of the text is …
According to the text …
The author points out …
It should be stressed that …
In conclusion the author says that …
I found the text useful …

Exercise 10. Translate the following terminological word combinations containing nouns only.

1. check valve
2. silicon crystal detector
3. radio receiver
4. heat sink
5. power supply device
6. tube diode
7. depletion layer
8. conduction band electron
9. transfer function analyzer
10. voltage drop
11. power rectifier diode

Exercise 11. Study the description of the forward biased junction diode and speak about the principles of its operation.

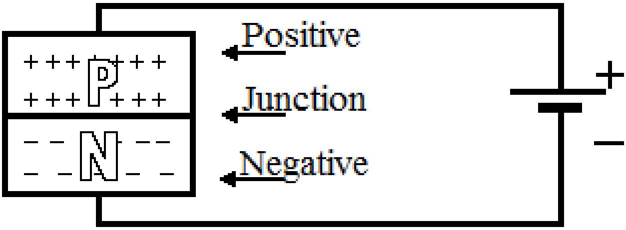

Fig. 1. Forward-biased junction diode

When the diode is not connected to any source of power, the p-n junction fills up with neutralizing positive and negative charges, and serves as an insulator (or depletion region) between the p- and n- regions of the diode. However, when the diode is connected to a power source, with the negative terminal of the power source connected to the negative region, and the positive terminal to the positive region, the regional negative and positive charges are repelled by those terminals (since like charges repel like charges) and are driven toward and across the p-n junction. Once they have crossed the junction, they are attracted to the oppositely charged terminal on the other side of the junction. They continue to move toward the oppositely charged terminals, and the diode will now conduct current as long as the power source is available.

Exercise 12. Complete the sentences with the necessary preposition from the box.

through, to, in, on, towards, at, into, between, for

1. A lot of devices such as motors, portable radios and calculators run … direct current.
2. This junction importance is the creating of a region … the p and n layers.
3. In a diode, current can flow easily … one direction but not the other, which is a basis for digital electronics.

4. Regional negative and positive charges continue to move … the oppositely charged terminals.

5. A diode can be used … converting alternating current … direct current.

6. When a diode is not connected … any source of power, the p-n junction serves as an insulator.

7. Carriers flow … the p-n junction and all across the combined segment.

8. This method is useful because it lets you determine the maximum rate … which a sensor can acquire data.

Exercise 13. Translate the following sentences into Russian paying attention to the use of the Complex Subject.

1. The work on a new discovery is sure to be easy.
2. Silicon is considered to be the 'universal' semiconductor material.
3. The fabrication of heterojunction bipolar transistors is known to be based on GaAs and other compounds.
4. The results of his research turned out to be even more interesting than we had expected.
5. This invention is certain to save much money.
6. Heterojunction bipolar transistors are expected to have a bright future in microwave integrated circuits.
7. The practical importance of this invention proved to be great.
8. Epitaxy, or ion implantation, is believed to be used to produce areas of different conductivity type.
9. Most semiconductor materials are known to be made by introducing controlled numbers of impurity atoms into a crystal, the process called doping.
10. Two independent lines of development are considered to lead to microscopic technique that produced the present integrated circuits.

Exercise 14. Read the sentences and translate them into Russian. Define the Participle functions.

1. Circuits that require current flowing in only one direction will typically consist of one or more diodes in the circuit design.

2. It has resulted in the creation of a new branch of science called solid-state physics.

3. The positive carriers produced this way are referred to as ‘holes’.

4. In semiconductors current being carried either by the flow of electrons or by the flow of positively charged ‘holes’ is often schematized in the electron structure of the material.

5. The first radio receiver using a crystal diode was built around 1900 by Greenleaf Whittier Pickard.

6. With most metals the Hall effect indicates electrons are the charge carriers, however, some metals have a mostly filled conduction band.

7. Organic semiconductors, that is, organic materials with properties resembling conventional semiconductors, are also known.

8. The experiment carried out by the sophomores showed good results.

9. Having been injected the silicon atoms produced a surplus of positive carriers in the treated segment.

10. Semiconductors are subject to optical charge carrier generation and therefore most are packaged in light blocking material.

Exercise 15. Translate the following text into Russian in writing.

Voltage References

A voltage reference is an electronic device which generates constant voltage that is little affected by variations in power supply, temperature, load, aging and other factors. Many voltage references are available in monolithic forms; however, in low-cost applications, especially in consumer products, a simple device known as a Zener diode is often emp-loyed.

A Zener diode has a constant voltage drop in a circuit when provided with a fairly constant current derived from a higher voltage elsewhere within the circuit. The active portion of a Zener diode is a reverse-biased semiconductor p-n junction. When the diode is forward biased, there is little resistance to current flow. When the diode is reverse-biased, very little current flows through it if the applied voltage is less than *Vz*. A reverse saturation current is a small leakage which is almost independent of the applied voltage. When the reverse voltage approaches the breakdown voltage *Vz*, the reverse current increases rapidly and, if not limited, will result in the diode overheating and destruction. For that reason, Zener diodes usually are used with current-limiting components, such as resistors, positive temperature coefficient (PTC) thermistors or current sources. The Zener voltage decreases as temperature of the junction rises.

Zener diodes fall into three general classifications: regulator diodes, reference diodes, and transient voltage suppressors. Regulator diodes are normally employed in power supplies where a nearly constant DC output voltage is required despite relatively large changes in input voltage or load impedance. Such devices are available with a wide range of voltage and power ratings, making them suitable for a wide variety of electronic equipment. Regulator diodes, however, have one limitation: they are temperature sensitive. Therefore, in applications in which the output voltage must remain within narrow limits during input-voltage, load-current, and temperature changes, a temperature-compensated regulator diode, called a reference diode, is required.

It makes sense to take advantage of the differing thermal characteristics of forward- and reverse-biased silicon p-n junctions. Like any silicon diode, a forward-biased junction has a negative temperature coefficient of approximately -2 mV/$^\circ$C, whereas a reverse-biased junction has positive temperature coefficient ranging from about 2 to 6 mV/$^\circ$C depending on the current and the diode type. Therefore, it is possible, by a selective combination of forward- and reverse-biased junctions, to fabricate a device with a very low overall temperature coefficient. The voltage changes of the two junctions are equal and opposite only at the specified current. For any other value of current, the temperature compensation may not be ideally accomplished. Nevertheless, even a simple back-to-back connection of two Zener diodes of the same type may significantly improve the overall temperature stability over a rather broad range of currents and temperatures. Naturally, the reference voltage from the combination is higher than from a single Zener diode. The so-called band gap references are often useful substitutes for Zener diodes. They have typically 10 times lower output impedance than low-voltage Zeners and can be obtained in a variety of nominal output voltages, ranging from 1.2 to 10 V. Currently, a large variety of high-quality voltage references with selectable outputs is available from many manufacturers.

Unit 4
LIGHT-EMITTING DIODES

Exercise 1. Learn the following words and word combinations and their meanings.

band gap – запрещённая зона
constituent (n) – компонент, составная часть
efficiency (n) – выход, эффективность, КПД
embody (v) – представлять
emit (v) – испускать, излучать
epoxy dome – эпоксидная оболочка
exhibit (v) – проявлять, показывать
halide-transport vapor phase epitaxy (HVPE) – галоидная передача газофазной эпитаксии
high-volume production – массовое производство
intractable (adj) – трудный, труднообрабатываемый
liquid-phase epitaxy (LPE) – жидкостная эпитаксия
lower level – нижний энергетический уровень
metal-organic-vapor-phase epitaxy (MOVPE) – металлоорганическая газофазная эпитаксия
operating current – рабочий ток
semiconductor chip – полупроводниковый кристалл
structural member – базовый элемент
yield (v) – приводить (к чему-либо)

Exercise 2. Read the text attentively and translate it into Russian. Check the pronunciation of the abbreviations in Exercise 4.

From the History of Light-Emitting Diodes

A light-emitting diode (LED) is a semiconductor device which emits visible, infrared or ultraviolet radiation due to flow of electric current through it. Essentially it is a p-n junction device with p- and n-regions made from the same or different semiconductors. The colour of the emitted light is determined by the energy of the photons, and in general, this energy is usually approximately equal to the energy band gap *Eg* of the semiconductor material in the active region of the LED. III-V semiconductors such as GaAs, GaP, AlGaAs, InGaP, GaAsP, GaAsInP, AlGaInP, etc. are the common constituents of an LED. However, which materials would be used for which LED depends on the choice of colour, performance and cost. Typically, a semiconductor chip embodying an LED is 250 × 250 μm² which is mounted on one of the electrical leads. The top of the chip is electrically connected to the other leads through a bound wire. The epoxy dome serves as a lens to focus the light and as a structural member to hold the device together. Operating currents at a forward voltage of about 2 V are usually in the range of 1–50 mA.

The external quantum efficiency, which is defined as the number of photons per each electron passing through the device, is roughly equal to the power efficiency of LEDs, and ranges from less than 0.1 % to more than 10 %. The performance of LEDs is typically in the range of 1 to 10 W^{-1}, although performance as high as 20 W^{-1} can also be achieved. This is comparable with 10–15 W^{-1} performance of an incandescent bulb. LEDs are very suitable for room illumination because, at the lower level, they can operate even at less than 0.1 W.

Red GaAsP LEDs exhibiting heterostructure were first introduced commercially by General Electric following the invention of Holonyak and Bevacqual. High-volume production of GaAsP LEDs did not, however, begin until 1968 when the introduction of GaP:ZnO LEDs was about to take place. Both GaAsP and GaP:ZnO LEDs exhibited an efficiency of about 0.1 W^{-1} and were available only in the colour red. In the late 1960s and the early 1970s it was discovered that nitrogen can provide an efficient recombination center in both GaP and GaAsP. The discovery led to the commercial introduction of red, orange, yellow, and green GaAsP:N and GaP:N LEDs with an improved performance in the range of 1 W^{-1}. Later it was found that both homostructure AlGaAs and heterostructure AlGaAs LEDs could offer potential performance advantages over GaAsP and GaP homojunction LEDs. Nevertheless, it was not easy to realize it in practice because more than a decade of development was needed to realize high-volume liquid-phase epitaxy (LPE) reactors capable of growing high-quality multilayered device structures. As a result, such LEDs did not become commercially available until the early 1980s. The performance of these LEDs was, however, significantly improved, which ranged now from 2 to 10 W^{-1} depending upon the structure employed. Thus, for the first time, LEDs broke the efficiency barrier of filtered incandescent bulbs, enabling them to replace light bulbs in many outdoor lighting applications.

As a result of continuous efforts in research, AlGaInP based orange and yellow LEDs with efficiencies higher than 10 W^{-1} were developed in the early 1990s. Interestingly, conventional techniques such as LPE or halide-transport vapor phase epitaxy (HVPE) proved intractable for the growth of these LEDs. The metal-organic-vapor-phase epitaxy (MOVPE) system which emerged as a powerful crystal-growth technique in the late 1960s and yielded high-performance AlGaAs LEDs in the late 1970s was eventually employed for a more controlled growth of heterostructure AlGaInP LEDs. The performance of these LEDs was satisfactory. In the early 1990s SiC based LEDs emerged as potential blue colour emitters. The development of the brighter blue LEDs, using ZnSe, which have shown promise in the research laboratory, was emerging as a major area in the 1990s.

Parallel to the development of visible LEDs infrared (IR) LEDs also attracted interests. Instead of being detected by eyes, these LEDs are detected by photodiodes or phototransistors. Therefore, IR LEDs can function as important tools for transmitting data. How fast these data will be transmitted depends on the switching speed of the IR LEDs. Therefore, this switching speed is quite unimportant for visible LEDS, this is an important performance parameter for IR LEDs.

Exercise 3. Find the English equivalents in B to the Russian words in A.

A	B		
1. определять	a) emit	b) depend	c) determine
2. видимый	a) internal	b) visible	c) comparable
3. приблизительно	a) typically	b) usually	c) roughly
4. стоимость	a) cost	b) junction	c) performance
5. изменять	a) vary	b) improve	c) realize
6. хотя	a) hence	b) essentially	c) although
7. достигать	a) prove	b) achieve	c) embody
8. подходящий	a) suitable	b) movable	c) reasonable
9. изобретение	a) discovery	b) invention	c) introduction
10. обеспечивать	a) provide	b) define	c) do

Exercise 4. Match the abbreviations in A with their definitions in B and the right Russian equivalents in C.

A	B	C
AlGaAs	Gallium arsenide phos-phide	Арсенид галлия
AlGaInP	Nitrogen-doped gallium phosphide	Индия-галлия фосфид
GaAs	Aluminum indium gallium phosphide	Легированный азотом фосфид галлия
GaAsP	Zinc oxide-doped gallium phosphide	Галлия-мышьяка-индия фосфид
GaAsInP	Gallium phosphide	Селенид цинка
GaAsP:N	Silicon carbide	Фосфид галлия
GaP	Aluminum gallium arse-nide	Легированный азотом ар-сенофосфид галлия
GaP:N	Nitrogen-doped gallium arsenide phosphide	Алюминия-галлия-индия фосфид
GaP:ZnO	Zinc selenide	Карбид кремния
InGaP	Gallium arsenide	Арсенофосфид галлия
SiC	Indium gallium phosphide	Арсенид алюминия-галлия
ZnSe	Gallium arsenide indium phosphide	Легированный оксидом цинка фосфид галлия

Exercise 5. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
electrical	lead	массовое производство
operating	bulb	полупроводниковый прибор
switching	device	базовый элемент
forward	current	электрический провод
volume	efficiency	лампа накаливания
structural	speed	скорость переключения
quantum	voltage	квантовый выход
semiconductor	member	рабочий ток
incandescent	production	прямое напряжение

Exercise 6. Using the definitions given below guess the words and cross them out in the word square.

D	I	A	C	I	P	E	J
A	P	T	I	E	F	R	U
R	H	I	F	N	O	R	N
N	O	O	F	C	A	M	C
O	T	N	E	Y	N	T	T
S	N	E	L	E	C	N	I
C	O	N	S	T	I	E	O
D	I	O	D	E	T	U	N

1. A semiconductor device with two terminals, typically allowing the flow of current in one direction only.
2. A region of transition in a semiconductor between a part where conduction is mainly by electrons and a part where it is mainly by holes.
3. A particle representing a quantum of light or other electromagnetic radiation; it carries energy proportional to the radiation frequency but has zero rest mass.
4. A component part of something.
5. The capabilities of a machine, product, or vehicle.
6. The emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which cause ionization.
7. An object or device which focuses or otherwise modifies the direction of movement of light, sound, electrons, etc.
8. The ratio of the useful work performed by a machine or in a process to the total energy expended or heat taken in.

Exercise 7. Say if the following sentences are true or false. Correct the false ones.

1. The tip of the chip is electrically connected to the other leads.
2. The color of the emitted light is determined by the energy band gap.
3. The epoxy dome serves as a lens to focus the light.
4. Switching speed is an important performance parameter for IR LEDs.

5. Operating currents at a reverse voltage of about 2 V are usually in the range of 1–50 mA.

6. LEDs are not very suitable for room illumination.

7. High-volume production of GaAsP LEDs did not, however, begin until 1968.

8. How fast data will be transmitted depends on the quantum efficiency of the IR LEDs.

9. Which materials would be used for which LED doesn't depend on performance, cost and colour.

Exercise 8. Make up the summary of the text in Exercise 2.

The text is under the headline …
The text deals with …
It is pointed out that …
Much attention is given to …
Further the author says that …
I think this text is …

Exercise 9. Form adjectives from the following nouns.

Noun	Adjective
1. vision	a) …
2. radiation	b) …
3. colour	c) …
4. difference	d) …
5. electricity	e) …
6. equality	f) …
7. connection	g) …
8. structure	h) …
9. operation	i) …
10. thickness	j) …
11. base	k) …
12. strength	l) …

Exercise 10. Cross out the odd word. All the words in the line should belong to one part of speech.

1. Orange, yellowish, interestingly, infrared, external.
2. Emit, radiation, determine, mount, achieve.
3. Approximately, essentially, typically, efficiency, roughly.
4. Or, with, of, by, to.
5. Flow, emitter, active, junction, semiconductor.
6. Powerful, transistor, terminal, bulb, device.
7. Act, work, measurement, indicate, operate.

Exercise 11. Restore the original sentences and translate them.

1. Very / illumination / LEDs / suitable / room / are / for.
2. Than / at / can / they / operate / 0.1W / even / less.
3. Significantly / the / these / was / of / LEDs / improved / performance.
4. By / infrared / or / LEDs / phototransistors / detected / are / photodiodes.
5. As / LEDs / for / function / data / important / IR / transmitting / tools / can.
6. Visible / the / quite / speed / for / switching / is / LEDs / unimportant.
7. LED / appliance / emits / an / is / an / which / radiation / ultraviolet.

Exercise 12. Think of the questions using the following sentences.

1. AllnGaP based orange and yellow LEDs with efficiencies higher than 10 W^{-1} were developed in the early 1990s.

When ____?

What ____?

2. A light-emitting diode is a semiconductor device which emits visible, infrared or ultraviolet radiation.

What ____?

What radiation ____?

3. The production of filtered incandescent bulbs enabled to replace light bulbs in many outdoor lighting applications.

What ____?

Where ____?

4. Infrared LEDs can function as important tools for transmitting data.

What kind ____?

What purpose ____?

5. The application of necessary materials depends on the choice of colour, performance and cost.

What ____?

Does ____?

Exercise 13. Read the sentences and translate them into Russian. Define the Participle functions.

1. The colour of the emitted light is determined by the energy of the photons.
2. Typically, a semiconductor chip embodying an LED is 250 × × 250 μm² which is mounted on one of the electrical leads.
3. Red GaAsP LEDs exhibiting heterostructure were first introduced commercially by General Electric.
4. AllnGaP based orange and yellow LEDs were developed in the early 1990s.
5. The development of the brighter blue LEDs, using ZnSe, was emerging as a major area in the 1990s.
6. Instead of being detected by eyes, these LEDs are detected by photodiodes or phototransistors.
7. How fast these data will be transmitted depends on the switching speed of the IR LEDs.
8. LEDs broke the efficiency barrier of filtered incandescent bulbs, enabling them to replace light bulbs in many outdoor lighting applications.
9. The top of the chip is electrically connected to the other leads through a bound wire.
10. Operating currents at a forward voltage of about 2 V are usually in the range of 1–50 mA.
11. The external quantum efficiency is defined as the number of photons per each electron passing through the device.

Exercise 14. Translate the following text into Russian in writing.

Switch on Wallpaper to Light Your Home

New 'light-emitting wallpaper' could be developed to replace traditional light bulbs and cut carbon emissions from lighting in the next few years. Several companies are involved into research activities in this sphere. For example, a Welsh company developing the technology has been awarded a £454,000 grant from the Carbon Trust to help get it into homes, business and on the roads.

This technology is known as organic light emitting diodes (OLED) one. It can be coated onto a thin flexible film to cover walls like wallpapers. Today it is already used for flat screen televisions, computers and mobile phone displays.

One of the main advantages of this technology is the need of a very low operating voltage – of just three to five volts, and as a result, it can be powered by solar panels or batteries. So it can be used outside to light road signs and barriers without the need for mains electricity.

The technology is up to be 2.5 times more efficient than current energy-saving light bulbs, and could also be used to lower the energy use of television screens.

Organic LEDs have been around for some time but widespread use has been hindered by the high cost, reliability and short operating lifetime of the systems.

Nowadays new chemicals are being developed, and their improvement allows low-energy devices to replace existing technology. New material is a chemical that in a flat panel display screen everyone can put it in the device and it emits light. In a light people can put it anywhere. They also can paint it on a wall or wallpaper.

The OLED technology could be used to make flexible screens that could be rolled up after use. It gives everyone all kinds of potential for how they do lighting. It is also necessary to mention, that the light of OLED is a very natural, sunlight-type of lighting with the full colour range.

Lighting is a major producer of carbon emissions. And this technology has the potential to produce ultra-efficient lighting for a wide range of applications, tapping into a huge global market.

Unit 5
SENSORS

Exercise 1. Learn the following words and word combinations and their meanings.

burglar alarm – охранная сигнализация
chunk (n) – порция, кусок
fiber optics strand – волоконно-оптическая жила (кабеля)
furnace (n) – печь, топка
hard-to-reach (adj) – труднодоступный
headquaters (n pl) – база, *зд.* обрабатывающий центр
hostile surrounding – агрессивная среда
outer space – космическое пространство
power-train system – трансмиссия
precision (n) – точность
prolific (adj) – продуктивный
spy satellite – разведывательный спутник, спутник-шпион
smoke detector – индикатор (датчик) дыма
surveillance (n) – наблюдение, контроль
to go out of tolerance – выходить из-под контроля
tough (adj) – жёсткий, упругий
vehicle (n) – транспортное средство, автомобиль
weather vane – флюгер

Exercise 2. Read the text attentively and translate it into Russian.

Sensors

A sensor is a device that is sensitive to certain conditions in its environment, such as light, temperature, pressure, motion, and the presence of particular substances. Ordinary cameras are sensors, as are spy satellites, thermostats, smoke detectors, weather vanes, and burglar alarms. Sensors are particularly helpful when they can be placed in hard-to-reach locations such as outer space, hot furnaces, working engines, deep water, and the internal organs of human beings. In such situations they provide information that can be obtained in no other way.

In addition to their ability to ‘read’ some condition of a particular environment, sensors must be able to report back to ‘headquarters’, so that the information can be utilized. From outer space, the reporting will be by radio; from deep sea waters, it will probably be through fiber optics strands. A host of other reporting methods are used.

Sensors are also particularly helpful in situations where constant surveillance is necessary. In very high precision manufacturing processes, sensors may be used to provide an immediate warning when some phase of the operation goes out of tolerance. Hospital patients who are critically ill may have sensors attached to them to warn immediately of any change in vital functions.

Sensors have become particularly important in the computer age due to the computer's ability to accept and analyze huge chunks of data with great speed. This is important in complex manufacturing operations and in military situations where reaction time is often extremely critical.

The combination of the sensor and the chip is a particularly potent one; the ability of the chip to control a machine, or a physical process, makes possible a high degree of automation. Silicon, the most familiar semiconductor material, makes a particularly good sensor because of its sensitivity to many environmental conditions; it is also a tough material, quite resistant to hostile surroundings.

Modern automobiles are prolific users of sensors. A typical vehicle may contain as many as eight sensors in its power-train system alone.

Exercise 3. Match the following English word combinations with their Russian equivalents.

1. particular substance	a) высокая точность
2. constant surveillance	b) труднодоступное место
3. manufacturing process	c) внешние условия
4. deep sea water	d) волоконно-оптическая жила
5. hard-to-reach location	e) жизненная функция
6. power-train system	f) особое вещество
7. vital function	g) производственный процесс
8. fiber optics strand	h) трансмиссия
9. environmental conditions	i) морская глубина
10. high precision	j) постоянный контроль

Exercise 4. Using the definitions given below guess the words and cross them out in the word square.

U	F	P	T	E	N	V	I
L	S	L	E	S	A	T	R
A	P	E	M	L	L	E	O
R	A	H	P	I	T	E	N
E	C	E	E	R	A	T	M
M	S	N	B	S	T	N	E
A	O	E	U	T	U	R	E
C	R	S	S	A	N	C	E

1. An artificial body placed in orbit round the earth or another planet in order to collect information or for communication.
2. The physical universe beyond the earth's atmosphere.
3. A specific type of matter, especially a homogeneous material with a definite composition.
4. A device which detects or measures a physical property and records, indicates, or otherwise responds to it.
5. The natural world, as a whole or in a particular geographical area, especially as affected by human activity.
6. The degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch.
7. Giving or ready to give help.
8. A device for recording visual images in the form of photographs, movie film, or video signals.

Exercise 5. Translate the following terminological word combinations containing Participle I.

1. piezoceramic sensing element
2. translating equipment
3. detecting data
4. controlling electrode
5. cooling bed
6. emitting diode layer

7. lighting mains
8. measuring accuracy
9. producing country
10. closing switch
11. switching amplifier
12. driving frequency
13. colour rendering index
14. engineering approximation

Exercise 6. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
smoke	vane	флюгер
deep	time	прочный материал
weather	water	космическое пространство
burglar	optics	время реакции
outer	surrounding	датчик дыма
fiber	detector	спутник-шпион
reaction	satellite	сигнализация
spy	alarm	агрессивная среда
tough	space	глубоководный участок
hostile	material	оптоволокно

Exercise 7. Translate the following noun plus noun word combinations. Pay attention to the difference in meaning depending on the noun position.

1. diode chip – chip diode
2. junction rectifier – rectifier junction
3. beam cathode – cathode beam
4. alloy process – process alloy
5. action field – field action
6. finger contact – contact finger
7. control accuracy – accuracy control

Exercise 8. Put the words in the questions in the correct order and answer them.

1. a / is / to / what / sensitive / sensor ?
2. examples / of/ you / sensors / do / any / know?
3. sensors / are / when / helpful / especially?
4. mention / hard-to-reach / can / what / locations / you?
5. is / function / the / what / of / sensor / a / main?
6. people / medical / do / manufacturing / how / and / sensors / in / help / process / treatment?
7. and / computer / are / engineering / in / why / important / sensors / military?
8. popular / silicon / the / semiconductor / is / isn't / most / material / it?

Exercise 9. Make up the summary of the text in Exercise 2.

The text is under the headline …
It is devoted to …
The author points out that …
According to the text …
It is reported that …
The author comes to the conclusion that …
I found the text interesting because …

Exercise 10. Complete the sentences with the necessary preposition from the box.

into, with, of, to, of, by, on, in, to, from

1. A sensor is often defined as a device that receives and responds … a signal or stimulus.
2. When we say 'electrical', we mean a signal which can be channeled, amplified, and modified … electronic devices.
3. The sensor's output signal may be … the form … voltage, current, or charge.
4. Any sensor is an energy converter. No matter what you try to measure, you always deal … energy transfer … the object of measurement … the sensor.

5. A room temperature thermometer inserted … a hot cup of liquid cools the liquid while the liquid heats the thermometer.

6. Sensors became extremely important because … the computer's ability to process data.

7. Whether you're awake or asleep, a working smoke alarm is constantly … alert, scanning the air for fire and smoke.

Exercise 11. Cross out the odd word. All the words in the line should belong to one part of speech.

1. Light, temperature, vital, camera, motion.
2. Particularly, supply, regularly, subsequently, repeatedly.
3. In, to, of, out of, and.
4. Comprise, generate, circuit, merge, occur.
5. Provide, reaction, analyze, utilize, accept.
6. These, it, since, anything, our.
7. Sensor, develop, chip, thermostat, alarm.
8. Response, define, device, signal, stimulus.

Exercise 12. Form the adjectives from the following nouns.

Noun	**Adjective**
1. depth	a) …
2. necessity	b) …
3. physics	c) …
4. help	d) …
5. sensitivity	e) …
6. addition	f) …
7. information	g) …
8. resistance	h) …
9. hostility	i) …
10. type	j) …
11. length	k) …
12. commerce	l) …

Exercise 13. Open the brackets using the Passive Voice verb forms.

1. For accuracy, most sensors (to calibrate) against known standards.
2. The sensitivity then (to define) as the magnitude or time of response of an instrument or circuit to an input signal, such as a current.
3. New types of sensors (to develop) recently.
4. A mercury-in-glass thermometer (to demonstrate) by scientists many years ago.
5. Sensors (to use) in everyday objects such as touch-sensitive elevator buttons and lamps which dim or brighten by touching the base.
6. The functions of the ideal sensors just (to discuss).
7. Most sensors (to influence) by the temperature of their environment.
8. It is supposed that this type of sensors (to patent) next year.

Exercise 14. Translate the following sentences into Russian paying attention to the words in bold type.

1. The term sensor should be distinguished from transducer. **The latter** is a converter of one type of energy into another, **whereas the former** converts any type of energy into electrical.
2. An example of a transducer is a loudspeaker which converts an electrical signal into a variable magnetic field and, **subsequently**, into acoustic waves.
3. An actuator may be described **as opposite to** a sensor – it converts electrical signal into generally nonelectrical energy.
4. **Generally**, the sensor's input signals (stimuli) may have almost any conceivable physical or chemical nature (e. g., light flux, temperature, pressure, vibration, displacement, position, velocity, ion concentration, etc.).
5. **For instance**, a motion detector for a security system should be sensitive to movement of humans and not responsive to movement of smaller animals, like dogs and cats.
6. Microelectromechanical systems (MEMS) are microdevices, having different forms and usages. Usually they are made **in accordance to** the basic stages of microelectronic technology.

7. MEMS technologies are being used in a wide range of micro devices **such as** movement (accelerometers, gyroscopes) and pressure sensors, micro generators, mirrors, microphones, etc.

8. Russian MEMS Association is proud to be the first at the domestic market to offer microelectromechanical processes to Russian MEMS players of electronics, radioelectronics and automotive industries, **as well as** those MEMS participants engaged in health monitoring of buildings and structures, telecommunications and data communication, safety systems, medicine, environment monitoring and light emission detection.

9. **In the case of** microsensors, the device typically converts a measured mechanical signal into an electrical signal.

Exercise 15. Translate the following text into Russian in writing.

What Are MEMS?

MEMS means different things to different people. The acronym MEMS stands for microelectromechanical systems and was coined in the United States in the late 1980s. Around the same time the Europeans were using the phrase microsystems technology (MST). It could be argued that the former term refers to a physical entity, while the latter is a methodology. The word ‘system’ is common to both, implying that there is some form of interconnection and combination of components. As an example, a microsystem might comprise the following:

• A sensor that inputs information into the system;

• An electronic circuit that conditions the sensor signal;

• An actuator that responds to the electrical signals generated within the circuit.

Both the sensor and the actuator could be MEMS devices in their own right. MEMS is an appropriate term as it specifically relates to mechanical (micro) devices and also includes wider areas such as chemical sensors, microoptical systems, and microanalysis systems.

There is also a wide variety of usage of terms such as transducer, sensor, actuator, and detector. Sensors input information into the system from the outside world, and actuators output actions into the external world. Detectors are merely binary sensors. While these definitions do not specifically relate to energy conversion devices, they are simple, unambiguous, and will suffice for this volume.

Micromachined transducers are generally (but not exclusively) those that have been designed and fabricated using tools and techniques originating from the IC industry. In general, there are two methods for silicon micromachining: bulk and surface. The former is a subtractive process whereby regions of the substrate are removed; while with the latter technique layers are built up on the surface of the substrate in an additive manner.

Micromachining has been demonstrated in a variety of materials including glasses, ceramics, polymers, metals, and various other alloys. Why, then, is silicon so strongly associated with MEMS? The main reasons are given here:

- Its wide use within the microelectronic integrated circuit industry;
- Well understood and controllable electrical properties;
- Availability of existing design tools;
- Economical to produce single crystal substrates;
- Vast knowledge of the material exists;
- Its desirable mechanical properties.

The final point is, of course, particularly desirable for mechanical microsensors. Single crystal silicon is elastic (up to its fracture point), is lighter than aluminum, and has a modulus of elasticity similar to stainless steel. Its mechanical properties are anisotropic and hence are dependent on the orientation to the crystal axis.

Silicon itself exists in three forms: crystalline, amorphous, and polycrystalline (polysilicon). High purity, crystalline silicon substrates are readily available as circular wafers with typical diameters of 100 mm (4 inches), 150 mm (6 inches), 200 mm (8 inches), or 300 mm (12 inches) in a variety of thicknesses. Amorphous silicon does not have a regular crystalline form and contains many defects. Its main use has been in solar cells, photo-sensors, and liquid crystal displays. Both amorphous and polysilicon can be deposited as thin films, usually less than about 5 μm thickness. Other materials that are often used within the MEMS fabrication process include glasses, quartz, ceramics, silicon nitride and carbide, alloys of various metals, and a variety of specialist materials that are used for very specific purposes.

Unit 6
SENSOR CLASSIFICATION

Exercise 1. Learn the following words and word combinations and their meanings.

baseline (n) – параметр, исходные данные
conversion mechanism – конверсор
direct sensor – датчик прямого действия
excitation signal – сигнал возбуждения
in response to – в ответ на
measured value – измеренное (фактическое) значение
reference (n) – исходная точка, назначение
in ~ to – относительно
relate to (v) – относиться, быть связанным
relative sensor – относительный датчик
special case – частный случай
stimulus (n) – стимул, воздействие
external ~ – внешний раздражитель
input ~ / output ~ – входной / выходной сигнал
strain (n) – нагрузка, деформация
strain gauge – тензодатчик, тензометр
subsequently (adv) – впоследствии, потом
thermocouple (n) – термопара
~ wire – термоэлектродная проволока
temperature gradient – перепад (градиент) температуры
temperature-sensitive resistor – терморезистор, термистор
whereas (conj) – несмотря на то, что

Exercise 2. Read the text attentively and translate it into Russian.

Sensor Classification

All sensors may be of two kinds: passive and active. A passive sensor does not need any additional energy source and directly generates an electric signal in response to an external stimulus; that is, the input stimulus is converted by the sensor into the output signal. The examples are a thermocouple, a photodiode, and a piezoelectric sensor. Most of passive sensors are direct ones. The active sensors require external power for their operation, which is called an excitation signal. That signal is modified by the sensor to produce the output signal. The active sensors sometimes are called parametric because their own properties change in response to an external effect and these properties can be subsequently converted into electric signals. It can be stated that a sensor's parameter modulates the excitation signal and that modulation carries information of the measured value. For example, a thermistor is a temperature-sensitive resistor. It does not generate any electric signal, but by passing an electric current through it (excitation signal), its resistance can be measured by detecting variations in current and/or voltage across the thermistor. These variations (presented in ohms) directly relate to temperature through a known function. Another example of an active sensor is a resistive strain gauge in which electrical resistance relates to a strain. To measure the resistance of a sensor, electric current must be applied to it from an external power source.

Depending on the selected reference, sensors can be classified into absolute and relative. An absolute sensor detects a stimulus in reference to an absolute physical scale that is independent of the measurement conditions, whereas a relative sensor produces a signal that relates to some special case. An example of an absolute sensor is a thermistor because its electrical resistance directly relates to the absolute temperature scale of Kelvin. Another very popular temperature sensor – a thermocouple – is a relative sensor. It produces an electric voltage that is function of a temperature gradient across the thermocouple wires. Thus, a thermocouple output signal cannot be related to any particular temperature without referencing to a known baseline. Another example of the absolute and relative sensors is a pressure sensor or a manometer. An absolute-pressure sensor produces signal in reference to vacuum – an absolute zero on a pressure scale. A relative-pressure sensor produces signal with respect to a selected baseline that is not zero pressure (e. g., to the atmospheric pressure). Another way to look at a sensor is to consider all of its properties, such as what it measures (stimulus), what its specifications are, what physical phenomenon it is sensitive to, what conversion mechanism is employed, what material it is fabricated from, and what its field of application is.

Exercise 3. Complete the table with the international words from the text according to their stress pattern and translate them.

Sensor, operation, control, potential, stimulus, passive, physical, generate, resistor, parametric, energy, signal, information, proportion, parameter, mechanism, temperature, function, relative, modified, produce.

1 ●○	2 ○●	3 ●○○	4 ○●○	5 ○●○○	6 ○○●○

Exercise 4. Using the definitions given below guess the words and cross them out in the word square.

O	D	E	X	C	I	T	R
I	E	N	O	I	T	A	O
D	S	T	R	T	T	O	T
O	U	L	A	H	S	R	S
T	M	U	I	E	I	E	I
O	I	S	N	R	M	L	S
H	T	O	C	O	U	P	E
P	S	M	R	E	H	T	R

1. A thermoelectric device for measuring temperature, consisting of two wires of different metals connected at two points, a voltage being developed between the two junctions in proportion to the temperature difference.
2. A thing that rouses activity or energy in someone or something.
3. The application of energy to a particle, object, or physical system, in particular.
4. A semiconductor diode that, when exposed to light, generates a potential difference or changes its electrical resistance.
5. An electrical resistor whose resistance is greatly reduced by heating, used for measurement and control.
6. A device having resistance to the passage of an electric current.
7. The magnitude of a deformation, equal to the change in the dimension of a deformed object divided by its original dimension.

Exercise 5. Match the words with the opposite meaning.

1. active	a) output
2. direct	b) always
3. input	c) internal
4. general	d) passive
5. rest	e) additional
6. external	f) dependent
7. sometimes	g) unknown
8. independent	h) indirect
9. known	i) operation
10. basic	j) special

Exercise 6. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
external	gradient	термоэлектродная проволока
strain	sensor	сигнал возбуждения
excitation	scale	датчик давления
pressure	stimulus	перепад температуры
special	gauge	частный случай
measured	mechanism	внешний раздражитель
conversion	signal	конверсор
physical	wire	тензометр
temperature	case	физическая шкала
thermocouple	value	фактическое значение

Exercise 7. Find the English equivalents in B to the Russian words in A.

A	B		
1. вырабатывать	a) to operate	b) to perform	c) to generate
2. источник	a) source	b) variation	c) scale
3. преобразовывать	a) to rotate	b) to convert	c) to relate
4. воздействие	a) value	b) application	c) stimulus
5. внешний	a) external	b) input	c) relative

6. проволока	a) reference	b) gradient	c) wire
7. нести	a) carry	b) carry out	c) modify
8. свойство	a) baseline	b) property	c) specification
9. обнаруживать	a) to detect	b) to glow	c) to change
10. влияние	a) response	b) strain	c) effect

Exercise 8. Answer the following questions.

1. What types of sensors do you know?
2. How does a passive sensor operate?
3. Give some examples of passive sensors.
4. What are passive sensors called?
5. What is the principle of operation of an active sensor?
6. Why are active sensors called parametric ones?
7. What active sensors can you name? How do they work?
8. How are sensors classified depending on the selected reference?
9. What is the difference between absolute and relative sensors?
10. Do you know any examples of absolute and relative sensors?
11. What properties of sensors are taken into account by scientists to investigate them?

Exercise 9. Make up the summary of the text in Exercise 2.

The title of the text is …
The text is devoted to …
The author points out that …
It is reported that …
Much attention is given to …
Further the author says that …
I found the text important because …

Exercise 10. Translate the following sentences paying attention to emphatic structures.

1. The problem of handling many discrete electronic devices began to concern the scientists as early as 1950.

2. It was microelectronics development that solved the problem of assembling the complete device by wiring the components together with metallic conductors.

3. The fabrication of the field-effect transistor in quantity did not become practical until the early 1960s.

4. It was the prominent scientist A. F. Yoffe who made a great contribution to the study of semiconductor physics.

5. These molecules are too small to be seen even with the microscope, but strong experimental evidence shows that they do exist.

6. Surrounding this nucleus are electrons, the actual number depending upon the atom being considered.

7. The silicon wafer substrate must be practically defect-free when the active device density may be as high as 10^5 to 10^6 per chip.

Exercise 11. Divide the words into five columns according to their part of speech.

Noun	Adjective	Verb	Adverb	Preposition

Value, additional, directly, output, define, external, convert, subsequently, into, parameter, require, sensitive, through, variation, carry, independently, relate, without, direct, power, sometimes, own, across, gauge, relative.

Exercise 12. Put the verbs in brackets into the correct form of Conditional I and translate the sentences into Russian.

1. If thin wires are used in this device they (to melt).

2. If the magnetic circuit (to consist) of non-magnetic material, the field will be proportional to the current.

3. If the operators (to use) some additional components they will be able to actuate the relay.

4. If the body (to heat), the motion of its atoms will be more intensive.

5. If we utilize a coil with half a number of turns, we (to get) a much lower electromotive force.

6. If this gas is heated in a closed vessel, its volume (not to increase).

7. If you change the conditions of the experiment you (to obtain) better results.

8. If these liquids are heated they (to expand).

Exercise 13. Translate the following sentences into Russian paying attention to the words in bold type.

1. Of course, **one** should not be confused by an obvious fact that transmission of energy can flow both ways. It may be with a positive sign **as well as** with a negative sign; **that is**, energy can flow **either** from an object to the sensor **or** from the sensor to the object.

2. Surprisingly, **even though** these microactuators are extremely small, they frequently can cause effects at the macroscale level; **that is**, these tiny actuators can perform mechanical feats far larger than their size would imply.

3. Some substances are efficient conductors, others are poor **ones**.

4. A thermocouple is **one** of the examples of passive sensors.

5. **One** good way to watch a sensor is to consider all of its properties **such as** stimulus, physical phenomenon, conversion mechanism, material and application field.

6. This vision of MEMS **whereby** microsensors, microactuators and microelectronics and other technologies, can be integrated onto a single microchip is expected to be **one** of the most important technological breakthroughs of the future.

7. Sensors also have an impact on what they measure; **for instance**, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer.

8. **In summary**, there are two types of sensors: direct and complex. **The former** converts a stimulus into an electrical signal or modifies an electrical signal by using an appropriate physical effect, **whereas the latter** in addition needs one or more transducers of energy before a direct sensor can be employed to generate an electrical output.

9. The sensor's place in a device is **either** intrinsic **or** extrinsic; it may be positioned at the input of a device to perceive the outside effects and to signal the system about variations in the outside stimuli.

10. Depending on the complexity of the system, the total number of sensors may vary from **as** little **as one** (a home thermostat) to many thousands (a space shuttle).

Exercise 14. Translate the following text into Russian in writing.

Understanding Sensors

A sensor (also called detector) is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an (today mostly electronic) instrument. For example, a mercury-in – glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, most sensors are calibrated against known standards.

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics.

A sensor is a device which receives and responds to a signal when touched. A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. For instance, if the mercury in a thermometer moves 1 cm when the temperature changes by 1 °C, the sensitivity is 1 cm/°C. Sensors that measure very small changes must have very high sensitivities. Technological progress allows more and more sensors to be manufactured on a microscopic scale as microsensors using MEMS technology. In most cases, a microsensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches.

Motion Sensors

There are two basic kinds of motion detector sensors that are categorized according to their detect motion. Active sensors emit energy into the immediate area. Passive sensors do not emit any energy, but instead read changes in the energy in the surrounding area.

Active motion sensors work by sending out bursts of ultrasonic sound waves, after which the sensor waits for the energy to be reflected back. A good example of an active motion sensor is an automatic garage door opener. If there is nobody in the immediate area, the waves will return in the same pattern in which they were released. If there is someone, however, the energy will bounce back in a disturbed pattern. Active motion detectors are created with sensors that will send an alarm signal in the event that the pattern is disturbed. In the example of the garage door opener, the disturbed pattern (disturbed by the appearance of the car) triggers the sensor to open the garage door.

Passive motion detectors are more commonly used to secure businesses and residential homes than active motion sensors. They are also known as passive infrared (PIR) sensors because they detect and measure incoming infrared energy. They are sometimes also called pyroelectric detectors. Anybody, including animals and humans, will emit infrared energy because it creates heat. The amount emitted depends on the temperature of the body, but in humans, it is usually between 9 and 10 micrometers.

Most PIR sensors can actually detect emissions in the range of 8 to 12 micrometers. They do this with use of a photo detector. The photo detector coverts light in these wavelengths into an electrical current, which is run through a tiny computer housed in the unit. The alarm is triggered when the photo detector detects large or fast variations in the distribution of the emitted infrared energy. Normal movement in humans will naturally create such variations. Smaller variations are ignored by the computer to allow for naturally occurring events in the supervised area, such as the slow rise of heat as the sun rises for the day.

Oftentimes, PIR systems are combined with a basic photo-sensor motion detector. You frequently see these at a shopping mall, near the entrance to a store. When someone walks between them, the motion detector will sometimes emit a tone. Photo sensors usually consist of a laser beam and a light sensor. When the light is interrupted by the motion of a person crossing it, the sensor notices the brief drop in the light level, and alerts the control box, which will either sound an alarm or emit that bell sound you often hear in stores.

Unit 7
TRANSISTORS

Exercise 1. Learn the following words and word combinations and their meanings.

accurately (adv) – точно
amplification (n) – усиление
band leader – дирижер
base current – базовый ток, ток базы
baton (n) – дирижёрская палочка
depletion region – обеднённая зона
entire (adj) – полный, целый, весь
faithfully (adv) – точно
forward-biased diode – диод с прямым включением
guide (n) – проводник
linger (v) – задерживаться
marching band – оркестр
modulate (v) – регулировать, понижать частоту
reactivate (v) – возобновлять
rectification (n) – выпрямление
regenerate (v) – преобразовывать
reverse-biased diode – диод с обратным включением
sail (v) – плавно двигаться
strengthened (adj) – усиленный
strip (n) – полоса, *зд.* область
switching (n) – переключение

Exercise 2. Read the text attentively and translate it into Russian.

Transistors

The transistor is an important semiconductor device that is used for amplification, switching, and rectification (changing direct current to alternating current).

Transistors are present in almost every electronic device that we buy. In its important role as an amplifier, the transistor takes a very weak signal (as from a distant radio station) and uses it as a guide to regenerate a strengthened (but faithfully reproduced) signal in a strong current drawn from an external source. This is like a band leader using a weak signal (the movements of a baton) to modulate a very strong signal (the sound of the instruments) as the entire marching band (the external energy source) follows the baton.

If (in the manufacturing process) we join a diode containing a large n-region and a narrow p-region to another large n-segment, and connect the two n-regions to a battery, no current will flow, because a wide depletion region (an insulator) will form at the p-n junction between the n-segment connected to the positive terminal of the battery and the p-strip, just as it would in a reverse-biased diode.

However, if we connect the p-region to the positive terminal of a separate battery and allow a weak current to flow, electrons in the forward-biased n-region will be attracted to the p-strip and will sail through the p-n junction, across the p-strip, through the second p-n junction and into the reverse-biased n-region. They will not linger in the p-strip, because it is so narrow and because they are already coming under the attraction of the strong positive terminal linked to the reverse-biased n-region.

In electronics terminology, the forward-biased n-region is called the 'emitter'; the narrow p-strip is called the 'base' and the reverse-biased n-region is called the 'collector'.

The flow of current from the emitter to the collector can be increased or decreased by varying the strength of the base current (The base current is the transistor's 'baton'). The important point is that the large emitter current is controlled by and is proportional to the small base current. By placing a signal on the base current, we can obtain a greatly amplified (but accurately reproduced) version of the signal in the emitter current. Amplification is, in fact, one of the most important functions of the transistor. The transistor can also serve as a switch. Reducing the base current to the point where no emitter current flows, and raising to reactivate emitter current, etc., provides this switching action.

Transistors appear in many other forms, and they are the most important of the semiconductor devices.

Exercise 3. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
external	signal	область с прямым включением
positive	action	протекание тока
strengthened	flow	отдельная батарея
direct	radio station	положительная клемма
current	battery	действие переключения
distant	source	постоянный ток
forward-biased	charge	внешний источник
switching	current	отрицательный заряд
negative	region	отдаленная радиостанция
separate	terminal	усиленный сигнал

Exercise 4. Match the words with the similar meaning.

1. join	a) independent
2. use	b) remain
3. important	c) gauge
4. transistor	d) raise
5. decrease	e) total
6. accurately	f) essential
7. increase	g) reduce
8. entire	h) connect
9. linger	i) exactly
10. separate	j) apply

Exercise 5. Translate the following terminological word combinations containing adjectives.

1. remote control unit
2. light sensitive material
3. external circuit
4. positive output voltage

5. transformer secondary winding
6. optical detection apparatus
7. angular momentum
8. refractive index gradient
9. protective relay coordination
10. electronic packaging technology
11. random access memory
12. extremely pure germanium mixer diode

Exercise 6. Unjumble the letters to make the words from the text.

1. aglins	s_______
2. sratroisnt	t_______
3. cordnouct	c_______
4. ucoser	s_______
5. ceroletscin	e_______
6. ilapacmfitino	a_______
7. hcgsiwtin	s_______
8. cerfitire	r_______
9. tvemonem	m______
10. goneir	r_______

Exercise 7. Say if the following sentences are true or false. Correct the false ones.

1. The transistor is an important semiconductor device that is used for rectification, amplification and switching.
2. Transistors are present in almost every electrical device.
3. The flow of current from the emitter to the collector can be increased or decreased by varying the strength of the base current.
4. Amplification is one of the most unimportant functions of the transistor.
5. In its important role as an amplifier, the transistor takes a very strong signal.

6. If we join a diode containing a large n-region and a narrow p-region to another large n-segment, and connect the two n-regions to a battery, no current will flow.

7. The forward biased n-region is called the 'emitter' in electronics terminology.

8. The large emitter current is controlled by and is inversely proportional to the small base current.

Exercise 8. Make up the summary of the text in Exercise 2.

The text is under the headline …
The main idea of the text is …
It is announced that …
The author reports on …
Further the author says that …
According to the text …
I found this text too hard to understand …

Exercise 9. Study the description of the NPN junction transistor and speak about the principles of its operation.

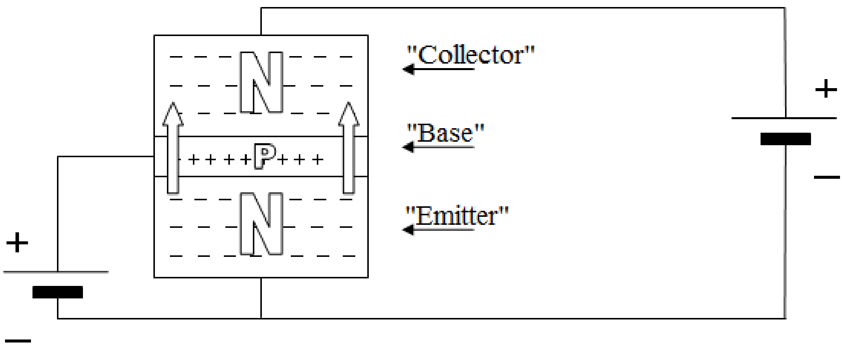

Fig. 2. NPN junction transistor

When the narrow *p* region (called the "base" is connected to the positive terminal of a second power source, a weak current consisting of "holes" (positive charges) flows into the base. The holes attract electrons (negative charges) from the forward biased *n* region (called the "emitter") which flow into the *p* strip and then into the reverse biased region (called the "collector"). The flow of electrons into the collector is controlled ("modulated") by the base current and a signal on the base current can be reproduced in the much stronger current flowing from the emitter.

Exercise 10. Form adjectives from the following nouns.

Noun	Adjective
1. alternation	a) …
2. weakness	b) …
3. importance	c) …
4. manufacture	d) …
5. electronics	e) …
6. width	f) …
7. proportion	g) …
8. distance	h) …
9. narrowness	i) …
10. separation	j) …

Exercise 11. Complete the sentences with the necessary preposition from the box.

from, to, over, than, on, in, between, of, in, for, into

1. A transistor allows a variable current, from an external source, to flow between two of its terminals depending … the voltage or current applied … a third terminal.

2. … 1947 W. Shockley, J. Bardeen and W. Brattain succeeded … building the first practical point-contact transistor at Bell Labs.

3. Bell put the transistor … production at Western Electric in Allentown, Pennsylvania.

4. … the next two decades, transistors gradually replaced the earlier vacuum tubes in most applications and later made possible many new devices such as integrated circuits and personal computers.

5. The bipolar junction transistor was the first type … transistor to be mass-produced.

6. The field-effect transistor, sometimes called a unipolar transistor, uses either electrons or holes … conduction.

7. The base is physically located … the emitter and the collector and is made … lightly doped, high resistivity material.

8. A cross section view of a BJT indicates that the collector-base junction has a much larger area … the emitter-base junction.

Exercise 12. Read the sentences and translate them into Russian. Define the Infinitive functions.

1. A transistor is used to amplify and switch electronic signals.
2. To produce complete electronic circuits is one of the important tasks of the transistors.
3. Another possibility was to employ a standard controller.
4. Desirable properties of the bipolar transistors let capture nearly all market share for digital circuits.
5. The essential usefulness of a transistor comes from its ability to harness a small signal.
6. It is often easy and cheap to utilize a standard microcontroller and write a computer program.
7. Besides, they observed how the transistor could turn current on or off in a circuit as an electrically controlled switch.
8. German inventor Oskar Heil was the second to patent a Field Effect Transistor or FET in 1934.
9. In considering the chemical properties of metals, the first point to be noted is that they vary widely in degree of chemical activity.
10. This workshop is too small to install necessary equipment.

Exercise 13. Translate the sentences into Russian paying attention to the use of the Complex Subject.

1. A transistor is said to be acted as a switch, and this type of operation is common in digital circuits.
2. Some transistors are known to be packaged individually.
3. A transistor is sure to revolutionize the field of electronics.
4. Physicist Julius Lilienfeld was found not to publish any research articles about his devices.

5. The diodes are proved to have two separate but very close metal contacts on the semiconductor substance.

6. The terminals of a transistor are certain to be labeled as base, collector, and emitter.

7. Desirable properties of the bipolar junction transistor are likely to improve soon.

8. A transistor is reported to control its output signal in proportion to the input one.

9. This information seems to be of utmost importance.

10. The results of the experiment turned out to be inaccurate.

Exercise 14. Translate the following sentences into Russian paying attention to the words in bold type.

1. The atomic weight of oxygen is greater than **that** of carbon.

2. The speed of fast molecules means **that** they slip past the molecules **that** they meet without these having time to detect them in their course.

3. The disadvantage of the device is **that** it is not easy to adjust.

4. There are two methods of measuring the conductivity of semiconductors. The first **one** which is used more commonly has a number of advantages.

5. **One** is to carry out a lot of experiments to make sure that this observation is adequate.

6. **One** of the most widely used semiconductor materials is silicon.

7. The combination of the sensor and the chip is a particularly potent **one**.

8. Unipolar transistors such as the FETs have only **one** kind of charge carrier.

9. Atomic force microscopy (AFM), a type of scanning probe microscopy (SPM) technique, was developed by G. Binnig, C.F. Quate and C. Gerber in 1986. Its use has been growing steadily ever **since**.

10. **Since** a diode will permit current flow in only one direction, it can convert alternating current (AC) into direct current (DC), and it has many vital applications in industry and science.

11. Carbon nanotubes have found many applications **since** their discovery in the early 1990s.

Exercise 15. Translate the following text into Russian in writing.

Some Facts about Transistors

In 1947, John Bardeen and Walter Brattain, working at Bell Telephone Laboratories, were trying to understand the nature of the electrons at the interface between a metal and a semiconductor. They realized that by making two point contacts very close to one another, they could make a three terminal device - the first ‘point contact’ transistor. They quickly made a few of these transistors and connected them with some other components to make an audio amplifier. This audio amplifier was shown to chief executives at Bell Telephone Company, who were very impressed that it didn't need time to ‘warm up’ (like the heaters in vacuum tube circuits). They immediately realized the power of this new technology.

This invention was the spark that ignited a huge research effort in solid state electronics. Bardeen and Brattain received the Nobel Prize in Physics, 1956, together with William Shockley, ‘for their researches on semiconductors and their discovery of the transistor effect’. Shockley had developed the so-called junction transistor, which was built on thin slices of different types of semiconductor material pressed together. The junction transistor was easier to understand theoretically, and could be manufactured more reliably.

For many years, transistors were made as individual electronic components and were connected to other electronic components (resistors, capacitors, inductors, diodes, etc.) on boards to make an electronic circuit. They were much smaller than vacuum tubes and consumed much less power. Electronic circuits could be made more complex, with more transistors switching faster than tubes.

However, it did not take long before the limits of this circuit construction technique were reached. Circuits based on individual transistors became too large and too difficult to assemble. There were simply too many electronic components to deal with. The transistor circuits were faster than vacuum tube circuits, and there were noticeable problems due to time delays for electric signals to propagate a long distance in these large circuits. To make the circuits even faster, one needed to pack the transistors closer and closer together.

Unit 8
TRANSISTORS (CONTINUED)

Exercise 1. Learn the following words and word combinations and their meanings.

along with – наряду
bipolar junction transistor (BJT) – биполярный транзистор
comprise (v) – включать, содержать
digital circuit – цифровая схема
digital computing – цифровые вычисления
Digital Revolution – цифровая революция
digitize (v) – оцифровывать
field effect transistor (FET) – полевой транзистор
logic gate – логический элемент
machinery (n) – машинное оборудование
power supply – источник питания
switching ~ - импульсный источник питания
printing press – печатная машина
random access memory (RAM) – оперативная память
rank (v) – ранжировать, располагать в определенном порядке
rest on (v) – основываться на
terminal (n) – клемма, вывод
transconductance (n) – активная межэлектродная проводимость
transistorized circuit – схема на транзисторах
vanishingly (adv) – крайне, ничтожно
variable valve – управляемый вентиль
voltage feedback – обратная связь по напряжению

Exercise 2. Read the text attentively and translate it into Russian.

Transistors (continued)

The transistor is a solid state semiconductor device which can be used for amplification, switching, voltage stabilization, signal modulation and many other functions. It acts as a variable valve which, based on its input voltage, controls the current drawn by it from a connected voltage supply. Transistors are divided into two main categories: bipolar junction transistors (BJTs) and field effect transistors (FETs). Transistors have three terminals where the application of voltage to the input terminal increases the conductivity between the other two terminals and hence controls current flow through those terminals. The physics of this ‘transistor action’ are quite different between the BJT and FET. In analog circuits, transistors are used in amplifiers, audio amplifiers, radio frequency amplifiers, regulated power supplies, and in computer, especially in switching power supplies. Transistors are also used in digital circuits where they function similarly to electrical switches. Digital circuits include logic gates, RAM and microprocessors.

The transistor is considered by many to be one of the greatest inventions in modern history, ranking in importance with inventions such as the printing press, the automobile and the telephone. It is the key active component in practically all modern electronics. Its importance in today's society rests on its ability to be mass produced using a highly automated process that achieves vanishingly low transistor costs.

Although millions of individual transistors are still used, their vast majority are fabricated into integrated circuits along with diodes, resistors, capacitors and other components to produce complete electronic circuits. A logic gate comprises about twenty transistors whereas an advanced microprocessor can use as many as 289 million ones.

The transistor's low cost, flexibility and reliability have made it an almost universal device for non-mechanical tasks, such as digital computing. Transistorized circuits are replacing electromechanical devices to control appliances and machinery as well, because it is often less expensive and more effective to simply use a standard microcontroller and write a computer program to carry out the same mechanical task using electronic control than to design an equivalent control function mechanically.

Because of the low cost of transistors and hence digital computers, there has come the trend to digitize information. With digital computers offering the ability to quickly find, sort and process digital information, more and more effort has been put into making information digital. Much media today is delivered in digital form, finally being converted and presented in analog form by computers. Areas influenced by the Digital Revolution are television, radio and newspapers.

The bipolar junction transistor (BJT) was the first type of transistor to be commercially mass-produced. The terminals are named emitter, base and collector. Two p-n junctions exist inside the BJT, collector-base junction and base-emitter junction. Although commonly described as a current operated device, the collector current is actually controlled by the voltage difference between base and emitter terminals. The BJT is commonly used with voltage feedback to control the base voltage, but sometimes the base is driven by a current input. The BJT achieves higher transconductance compared with the FET, so it is preferred for linear amplification. Bipolar transistors can be turned on with light as well as electricity. Devices designed for this purpose are called phototransistors.

Exercise 3. Complete the table with the international words from the text according to their stress pattern and translate them into Russian.

Modulation, million, mechanical, category, analog, universal, automobile, transistor, equivalent, television, collector, individual, regulated, computing, university, telephone, practically, automated, effective, emitter, revolution.

1 ●○○	2 ○●○	3 ●○○○	4 ○●○○	5 ○○●○	6 ○○●○○

Exercise 4. Match the words with the similar meaning.

1. application	a) operate
2. fabricate	b) capacitor
3. invention	c) single
4. condenser	d) improved
5. function	e) use
6. advanced	f) information
7. individual	g) manufacture
8. data	h) discovery

Exercise 5. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
printing	frequency	входная клемма
variable	stabilization	печатная машина
low	gate	принцип действия транзистора
voltage	modulation	логический элемент
input	press	низкая стоимость
signal	terminal	радиочастота
transistor	supply	модуляция сигнала
radio	cost	управляемый вентиль
power	action	источник питания
logic	valve	стабилизация напряжения

Exercise 6. Match the following English word combinations with their Russian equivalents.

1. connected voltage supply	a) усилитель звука
2. field effect transistor	b) оперативная память
3. integrated circuit	c) импульсный источник питания
4. audio amplifier	d) полевой транзистор
5. collector-base junction	e) электрический прибор
6. switching power supply	f) линейное усиление
7. linear amplification	g)подключенный источник напряжения
8. random access memory	h) переход коллектор-база
9. current operated device	i) обратная связь по напряжению
10. voltage feedback	j) интегральная схема

Exercise 7. Translate the following terminological word combinations containing adjectives.

1. random orientation
2. compound semiconductor crystal
3. crystalline particle
4. epitaxial growth
5. technological advance
6. seed crystal

7. practical point-contact transistor
8. microwave radar receiver
9. low-frequency application
10. simple pulse generator

Exercise 8. Put the words in the questions in the correct order and answer them.

1. is / transistor / what / used / for / a?
2. of / do / what / know / types / you / transistors?
3. digital / transistors / and / are / circuits / how / in / applied / analog?
4. circuit / electronic / how / a / make / complete / to?
5. transistor / advantages / have / a / what / does?
6. widely / circuits / nowadays / are / why / transistorized / used?
7. was / media / by / Revolution / what / influenced / the / Digital?
8. terminals / you / of / transistor / could / the / name / a?
9. exist / junctions / inside / transistor / what / junction / the / bipolar?
10. a / designed / what / phototransistor / is / for?

Exercise 9. Make up the summary of the text in Exercise 2.

The title of the text is …
The text is devoted to …
The author points out that …
It is reported that ...
Further the author says that …
I found the text important because …

Exercise 10.Complete the sentences with the necessary preposition from the box.

by, to, between, on, into, of, with, in, for, into

1. Following its release in the early 1950s the transistor revolutionized the field … electronics, and paved the way for smaller and cheaper radios, calculators, and computers, among other things.

2. More and more effort has been put … making information digital.

3. Much media today is delivered … digital form.

4. Areas influenced … the Digital Revolution are television, radio and newspapers.

5. The BJT is commonly used … voltage feedback to control the base voltage.

6. The collector current is actually controlled by the voltage difference … base and emitter terminals.

7. The BJT achieves higher transconductance compared with the FET, so it is preferred … linear amplification.

8. Bipolar transistors can be turned … with light as well as electricity.

9. FETs are further divided … depletion mode and enhancement mode type.

10. Mode refers … the polarity of the gate voltage with respect to the source when the device is conducting.

Exercise 11. Choose the right variant of the modal verb and translate the sentences into Russian.

1. This semiconductor device is faulty; you cannot / should not rely on its readings.

2. A robot must / can obey the orders that are given by human beings.

3.Heat ought / may be converted into mechanical energy.

4. Can / may you solve the problem right now?

5. Forces are to / can exist without motion.

6. He will be able / could to pass an exam in physics next month.

7. The current must / should be as small as possible not to melt the wires.

8. This article might / may be translated with a dictionary.

9. You will be able to / can to cut soft metal with greater speed than hard metal.

10. These students couldn't / were not allowed to practice in the rolling mill yesterday.

11. Nowadays transistors ought to / may be divided into two main categories.

12. At the Technical University students should / can get good knowledge in all spheres of engineering.

Exercise 12. Choose the correct form.

1. The (importance / important) of semiconductors for modern science cannot be (underestimate / underestimated).
2. Polythene cables have numerous (advantages / advantageous).
3. (Plastics / plastic) materials are relatively new (insulated / insulating) materials.
4. The method proved to be (efficient / efficiently).
5. What (resistance / resistive) materials are in common use today?
6. Energy is the (capacitance / capacity) for (do / doing) work.
7. Uranium is a (comparison / comparable / comparatively) rare element.
8. The most important problems in (atom / atomic) power (generated / generation) are connected with the reactor.

Exercise 13. Read the sentences and translate them into Russian. Define the Participle functions.

1. The transistor operates as a variable valve based on its input voltage.
2. Having delivered a lecture the professor was taking part in the discussion.
3. The transistors can be used in audio amplifiers, radio frequency amplifiers, and in computer, especially in switching power supplies.
4. What do you think of the method being used?
5. All transistors are divided into two main categories such as BJT and FET.
6. Being thanked for his help, he left the laboratory.
7. The completed work was given to the supervisor.
8. When told the title of her coursework, she realized she couldn't write it by herself.
9. Knowing you wanted to take part in the conference, I helped you to carry out some experiments.
10. Having been broken, the material had a black, silken fracture.
11. BJTs come in two types, or polarities, known as PNP and NPN based on the doping types of the three main terminal regions.

Exercise 14. Translate the following text into Russian in writing.

Field-Effect Transistor

The field-effect transistor (FET), sometimes called a unipolar transistor, uses either electrons or holes for conduction. The terminals of the FET are named source, gate and drain. A voltage applied between the gate and source controls the current flowing between the source and drain. In FETs the source-drain current flows through a conducting channel near the gate. This channel connects the source terminal to the drain terminal. The channel conductivity is varied by the electric field generated by the voltage applied between the gate-source terminals. In this way the current flowing between the source and drain is controlled.

FETs are divided into two families: junction FET (JFET) and insulated gate FET (IGFET).

The IGFET is more commonly known as metal oxide semiconductor FET (MOSFET). Unlike IGFETs, the JFET gate forms a diode with the channel which lies between the source and drain. Functionally, this makes the N-channel JFET the solid state equivalent of the vacuum tube triode which, similarly, forms a diode between its grid and cathode. Also, both devices operate in the depletion mode, they both have a high input impedance, and they both conduct current under the control of an input voltage. MESFETs are JFETs, in which the reverse biased p-n junction is replaced by a semiconductor-metal Schottky-junction. These, and the HEMFETs (high electron mobility FETs), in which a 2-dimensional electron gas with very high carrier mobility is used for charge transport, are especially suitable for use at very high frequencies (microwave frequencies; several GHz).

FETs are further divided into depletion mode and enhancement mode types. Mode refers to the polarity of the gate voltage with respect to the source when the device is conducting. For N- channel depletion mode FETs the gate is negative with respect to the source while for N-channel enhancement mode FETs the gate is positive. For both modes, if the gate voltage is made more positive the source-drain current will increase. For P-channel devices the polarities are reversed. Nearly all JFETs are depletion mode types and most IGFETs are enhancement mode types.

Transistor Usage

In the early days of transistor circuit design, the bipolar junction transistor, or BJT, was the most commonly used transistor. Even after MOSFETs became available, the BJT remained the transistor of choice for digital and analog circuits because of their ease of manufacture and speed. However, the MOSFET has several desirable properties for digital circuits, and since major advancements in digital circuits have pushed MOSFET design to state-of-the-art. MOSFETs are now commonly used for both analog and digital functions.

Transistors are commonly used as electronic switches, for both high power applications including switched-mode power supplies and low power applications such as logic gates.

From mobile phones to televisions, vast numbers of products include amplifiers for sound reproduction, radio transmission, and signal processing. The first discrete transistor audio amplifiers barely supplied a few hundred milliwatts, but power and audio fidelity gradually increased as better transistors became available and amplifier architecture evolved.

Transistors are commonly used in modern musical instrument amplifiers, where circuits up to a few hundred watts are common and relatively cheap. Transistors have largely replaced valves in instrument amplifiers. Some musical instrument amplifier manufacturers mix transistors and vacuum tubes in the same circuit, to utilize the inherent benefits of both devices.

The ‘first generation’ of electronic computers used vacuum tubes, which generated large amounts of heat and were bulky, and unreliable. The development of the transistor was key to computer miniaturization and reliability. The ‘second generation’ of computers, through the late 1950s and 1960s featured boards filled with individual transistors and magnetic memory cores. Subsequently, transistors, other components, and their necessary wiring were integrated into a single, mass-manufactured component: the integrated circuit. Transistors incorporated into integrated circuits have replaced most discrete transistors in modern digital computers.

Unit 9
ELECTRONICS

Exercise 1. Learn the following words and word combinations and their meanings.

adequately (adv) – в достаточной мере
amendable (adj) – корректируемый, исправимый
appreciate (v) – оценивать
commercial device – технический прибор
core (n) – ядро
embrace (v) – охватывать, включать, содержать
emerge (v) – всплывать, появляться
finite time – ограниченное время
gaseous state – газообразное состояние
indefiniteness (n) – неопределённость
inherent (adj) – присущий, свойственный
inversely proportional – обратно пропорциональный
liberate (v) – высвобождать
magnetic moment – магнитный момент
momentum (n) – импульс, скорость движения
quoted above – указанный, приведенный выше
reasonable accuracy – достаточная точность
retain (v) – сохранять, удерживать
rest mass – масса покоя
stream (n) – поток
value (n) – значение, величина
wavelength (n) – длина волны
wave motion – волновое движение

Exercise 2. Read the text attentively and translate it into Russian.

Electronics

The subject of electronics should, in its broadest sense, embrace all phenomena that are associated with the electron, the fundamental unit of electricity. What is the electron? The fullest possible answer to this question can only emerge from a study of its properties. When the electron is isolated from other electrons and from matter, it behaves like a small body having a negative electric charge $1{\cdot}601 \times 10^{-19}$ coulomb, a magnetic moment $1{\cdot}164 \times 10^{-29}$ joule x metre/A turn and a rest-mass $9{,}11 \times \times 10^{-31}$ kg. When the electron is part of an atom it retains the charge, magnetic moment and mass just mentioned but it is only able to exist for any finite time in certain almost fixed states of energy. A stream of electrons may be regarded as a large number of small bodies all moving in the same direction; or it may be regarded as a wave motion characterized by a wavelength inversely proportional to the momentum of the individual electrons. The reason for the indefiniteness inherent in the statements just made is that the electron is one of the fundamental concepts of science, and as such is not amendable to exact definition.

However, it should be noted that there is not the slightest question about the figures quoted above for the charge, magnetic moment and mass of the electron so long as charge, magnetic moment and mass are adequately defined. The classical experiments of J. J. Thomson and R. A. Millikan have established beyond any doubt that the electron is a massive, charged magnet and that the values of the mass, the charge and the magnetic moment are known with reasonable accuracy.

In order to understand and to appreciate the concepts and the principles upon which the operation of electronic devices depends, the following questions must be answered:

1. How are the electrons liberated?
2. How is the flow of electrons controlled?
3. How are these electrons employed in useful devices?

According to modern theory, all matter is electrical in nature. The atom, one of the fundamental units that enters into the structure of all matter, consists of a nucleus, or central core, of positive charge which contains nearly all the mass of the atom. Negatively charged electrons surround this nucleus. The atom as a whole is electrically neutral, so that the charge on the nucleus must be balanced by the charge of the electrons that surround it. Since all chemical substances consist of groups of these atoms bound more or less closely to one another, then all matter, whether in the solid, the liquid, or the gaseous state, is a potential source of electrons. All three states of matter are actually employed in commercial devices as the source of electrons.

Exercise 3. Using the definitions given below guess the words and cross them out in the word square.

L	L	N	O	R	T	C	E	L	E
I	A	A	R	G	E	Y	C	A	L
B	C	H	M	E	L	E	R	R	I
E	I	C	U	T	E	S	T	U	Q
R	M	S	E	N	C	T	R	C	U
A	E	T	M	O	M	N	O	C	I
T	H	R	E	A	M	U	N	A	D
E	C	S	U	E	L	C	I	C	S

1. The branch of physics and technology concerned with the design of circuits using transistors and microchips, and with the behavior and movement of electrons in a semiconductor, conductor, vacuum, or gas.

2. A substance which is not solid but which flows and can be poured, for example water.

3. The property of matter that is responsible for electrical phenomena, existing in a positive or negative form.

4. The degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard.

5. The positively charged central core of an atom, containing most of its mass.

6. The quantity of motion of a moving body, measured as a product of its mass and velocity.

7. A motionless state.

8. A continuous flow of liquid, air, or gas.

9. A stable subatomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids.

10. Relating to chemistry or the interactions of substances as studied in chemistry.

11. To release (gas, energy, etc.) as a result of chemical reaction or physical decomposition.

Exercise 4. Match the following English word combinations with their Russian equivalents.

A	B
1. in its broadest sense	a) с достаточной точностью
2. so that	b) вне всякого сомнения
3. may be regarded as	c) в соответствии с
4. it should be noted that	d) нет ни малейшего сомнения
5. beyond any doubt	e) следует отметить, что
6. with reasonable accuracy	f) можно рассматривать как
7. according to	g) в самом широком смысле
8. there is not the slightest question	h) (для того) чтобы

Exercise 5. Match the words with the similar meaning.

1. embrace	a) basic
2. accuracy	b) notion
3. fundamental	c) research
4. number	d) hold
5. inherent	e) include
6. investigation	f) appropriate
7. emerge	g) substance
8. concept	h) quantity
9. retain	i) precision
10. matter	j) appear

Exercise 6. Translate the following terminological word combinations containing Participle II.

1. radio-controlled electronic probe
2. coupled cathodic-anodic process
3. automated attendant exchange
4. stimulated emission of radiation
5. deposited integrated circuit
6. cooled cell radiometer
7. integrated optic device
8. weighted noise level

9. dissipated energy
10. buried wiring
11. decreased pressure
12. well-defined beam

Exercise 7. Translate the following noun plus noun word combinations. Pay attention to the difference in meaning depending on the noun position.

1. process control – control process
2. cost reduction – reduction cost
3. test operation – operation test
4. size reduction – reduction size
5. materials research – research materials
6. area analysis – analysis area
7. conductor cable – cable conductor
8. approach action – action approach

Exercise 8. Put the following sentences into the questions given in brackets.

1. The electron is only able to exist for any finite time in certain states of energy. (special)
2. According to modern theory, all matter is electrical in nature. (alternative)
3. All three states of matter are actually employed in commercial devices. (general)
4. The electron is one of the fundamental concepts of science. (indirect)
5. The charge on the nucleus must be balanced by the charge of the electrons that surround it. (special)
6. When the electron is part of an atom it retains the charge, magnetic moment and mass. (special)
7. A completely new science has established around electronic phenomena. (disjunctive)
8. All chemical substances consist of groups of atoms. (question to the subject)

Exercise 9. Say if the following sentences are true or false. Correct the false ones.

1. The electron is the fundamental unit of magnetism.
2. When the electron is part of an atom it retains the conductivity, twisting moment and mass.
3. The electron is able to exist in almost fixed states of energy.
4. A stream of electrons may be regarded as an oscillatory motion characterized by a period.
5. It is impossible to define the term 'electron' correctly.
6. Due to the electron's discovery a completely new science established itself around magnetic phenomena.
7. All matter is electrical in nature according to modern history.
8. Negatively charged electrons contain nearly all the mass of the atom.
9. There are three basic states of matter such as solid, liquid and plasma.

Exercise 10. Make up the summary of the text in Exercise 2.

The text is about … .
The text (article) deals with … .
The author informs the reader(s) of … .
The author starts telling the readers about (that) … .
The text describes … .
It is announced that … .
According to the text … .
I found the text …

Exercise 11. Complete the sentences using the necessary prepositions from the box.

with, of, until, in, to, under, from, of, into, by

1. When the electron is part ... an atom it retains the charge, magnetic moment and mass.
2. The answer … this question can only emerge … a study of the properties of the electron.

3. How are these electrons employed … useful devices?

4. The charge … the nucleus must be balanced … the charge of the electrons that surround it.

5. Electronics deals … electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits, and associated passive interconnection technologies.

6. Various forms of communication infrastructure complete circuit functionality and transform the mixed components … a regular working system.

7. … 1950 the field of electronics was called "radio technology" because its principal application was the design and theory of radio transmitters, receivers, and vacuum tubes.

8. The study of semiconductor devices and related technology is considered a branch of solid-state physics, whereas the design and construction of electronic circuits to solve practical problems come … electronics engineering.

Exercise 12. Translate the following sentences into Russian paying attention to the modal verbs.

1. Electronic devices must be built to fine limits if they are to function in the predicted manner.

2. Electrons can be removed by the application of a very high electric field.

3. This field of force might be a simple static electric or a magnetic field.

4. First we should consider the arrangement of atoms in metals, i. e, in substances having thermal and electrical conductivities.

5. A stream of electrons may be regarded as a large number of small bodies all moving in the same direction.

6. Although the methods by which electrons may be obtained have been considered, the remaining two questions have still to be answered.

7. From the purely physical point of view, electronics could be defined as the study of the motion of electrons in, or the interaction of electrons with, a field of force.

8. The fields might be very complicated ones.

Exercise 13. Translate the following sentences into Russian paying attention to the use of the Complex Object.

1. Electronics states all phenomena to be associated with the electron, the unit of negative electricity.
2. Scientists believe the success of silicon in microelectronics to be largely attributed to excellent properties of SiO_2 interface and ease of thermal oxidation of silicon.
3. The students understood the electron to be one of the fundamental concepts of science.
4. They heard the engineer make a report about the discovery of new nanomaterials.
5. Then he let us carry out experiments with a new substance.
6. Modern theory proved the atom to have a nucleus.
7. Scientists know oxygen concentration to influence many silicon wafer properties.
8. Epitaxial growth in combination with oxide masking and diffusion allows the device designer to make an almost limitless variety of structures.
9. The professor wanted the students to understand the two most important processes for the deposition of thin films: chemical vapour deposition and evaporation.
10. The advantages of plasma etching can make scientists use this method in manufacture of semiconductor materials and other devices which require fineline lithography.

Exercise 14. Translate the following sentences paying attention to the Gerunds.

1. Mankind has come far in the attempt of arranging atoms, from chipping flint for arrowheads to machining aluminium for spaceships.
2. Genetic engineers build orderly polymers by combining molecules in a particular order.
3. Researchers in university and industrial laboratories around the globe have already begun theoretical work and experiments aimed at developing molecular switches, memory devices and other structures that could be incorporated into a protein-based computer.

4. Enzymes assemble large molecules by 'grabbing' small molecules from water around them, then by holding them together so that a bond forms.

5. Second generation nanomachines will serve as improved devices for assembling molecular structures.

6. With today's bulk technology of micromachining engineers make patterns on silicon chips by throwing atoms and photons at them.

7. Their having received good results at such temperatures caused a great surprise among the researchers.

8. Silicon resembles carbon in forming a series of volatile hydrates.

Exercise 15. Translate the following text into Russian in writing.

Electronics Components

Integrated Circuits and Moore’s Law

You've probably heard of Moore’s Law, an electronics statement which in a nutshell predicts that the number of transistors that can be placed on a single integrated circuit doubles about every two years.

Gordon Moore, one of the founders of Intel, first stated his prediction in 1965. Back then, the prediction was even more ambitious. Originally, Moore’s Law said that the transistor count would double every year, not every two years. In the mid-1970s, the pace slowed a bit, so the prediction was scaled back.

Moore’s Law states that the increase in complexity of electronic technology is exponential, not incremental as most technologies are. For example, consider the automotive industry, where gas mileage gets incrementally better every year. Gordon Moore said that if Moore’s law applied to automobiles, a Rolls-Royce would get half a million miles per gallon, and it would be cheaper to buy a new one than pay to park the one you have.

Several times over the years, scientists have feared that the end of Moore’s law was on the horizon, as the chip manufacturing technology was approaching some physical limit that could not be exceeded, such as the wavelength of the light used to etch the circuits.

But each time, some new technological breakthrough has enabled manufacturers to simply bypass the old limit. Moore’s law has held true now for nearly fifty years and is expected to continue into the foreseeable future.

One possible explanation for the uncanny accuracy of Moore’s law is that it has become a self-fulfilling prophecy. Integrated circuit manufacturers rely on Moore’s law to set their own engineering goals, and they then work feverishly to achieve those goals. Thus, Moore’s law has become the objective of the semiconductor industry.

What Exactly Is an Integrated Circuit?

An integrated circuit (also called an IC or just a chip) is an entire electronic circuit consisting of multiple individual components such as transistors, diodes, resistors, capacitors, and the conductive pathways that connect all the components, all made from a single piece of silicon crystal.

To be clear, an integrated circuit isn't a really small circuit board that has components mounted on it. In an integrated circuit, the individual components are embedded directly into the silicon crystal.

Previous circuit fabrication techniques relied on mounting smaller and smaller parts on smaller and smaller circuit boards, but an integrated circuit is all one piece. Instead of just two or three p-n junctions (as in a diode or a triode), an integrated circuit has thousands of individual p-n junctions. In fact, many modern integrated circuits have millions or even billions of them, all fashioned from a single piece of silicon.

The earliest integrated circuits were simple transistor amplifier circuits with just a few transistors, resistors, and capacitors.

Now, integrated circuits are unbelievably complex. The most advanced Intel computer chip has 2.6 billion transistors.

Most of the integrated circuits you'll work with for hobby projects will be much more modest, having something on the order of a few dozen transistors. For example, the 555 timer IC has 20 transistors, 2 diodes, and 15 resistors and costs about a dollar.

Unit 10
CARBON NANOTUBES

Exercise 1. Learn the following words and word combinations and their meanings.

akin (adj) – похожий, сходный
arrangement (n) – размещение, расположение
assume (v) – принимать, обретать (форму)
beguiling (adj) – заманчивый, притягательный
building block – стандартный (компоновочный) блок
carbon nanotube – углеродная нанотрубка
Central Processing Unit (CPU) – центральный процессор
dual identity – двойное сходство
entire (adj) – полный, целый, весь
exceedingly (adv) – весьма, очень, сильно, чрезвычайно
extend (v) – расширять, распространять
fishing pole – удочка
flat-panel display – дисплей с плоским экраном
graphitelike (adj) – графитоподобный
honeycomb pattern – сотовидная модель
long-lasting – долговечный, с длительным сроком службы
roll (v) – свертывать, скатывать
satellite cable – спутниковое телевидение
sheet (n) – слой, лист
stack (n) – кипа, стопка

Exercise 2. Read the text attentively and translate it into Russian.

Carbon Nanotubes

In the early 1990s, scientists at the NEC Fundamental Research Laboratory in Tsukuba, Japan, discovered a tiny graphitelike structure with the most beguiling dual identity. Sometimes it's a metal, and sometimes it's a semiconductor. It can serve as a wire, transporting current from one place to another, and it can also serve as a transistor, using changes in current to store information.

This microscopic structure, known as a carbon nanotube (Fig. 3), could be the secret to extending Moore's Law (which predicts that the number of transistors on the fastest CPUs will double every 18 months) beyond the limits of today's silicon microprocessors. It is also the basic building block for all sorts of future products, from flat-panel displays and long-lasting batteries to fishing poles and satellite cables.

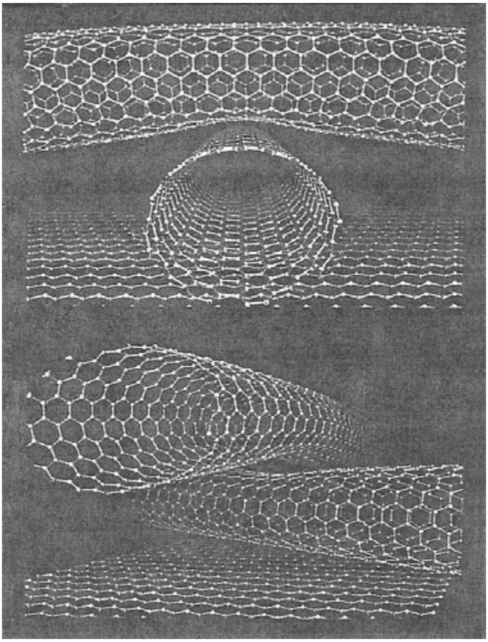

Fig. 3. Carbon nanotubes

Only 1/100,000 the thickness of a human hair yet exceedingly durable, a carbon nanotube is akin to graphite - a sheet of carbon atoms arrangement in a tight honeycomb pattern. Your pencil tip consists of stack after stack of such microscopic sheets. Carbon nanotubes are formed when the sheets of atoms are rolled into cylinders.

When carbon atoms assume a certain arrangement along the length of a tube, the nanotube behaves like a semiconductor. In a different arrangement, it becomes a metal. Semiconductors conduct current at certain voltages but not others. They are used to build transistors, in which processors store information. When one voltage is applied, the current stops, and the transistor turns off. Metals, which conduct at any voltage, are used to build the wires that connect transistors.

In theory, you could build an entire microprocessor from carbon nanotubes. Its parts would be far smaller—and thus far faster—than the copper wires and silicon.

Exercise 3. Using the definitions given below guess the words and cross them out in the word square.

T	I	S	T	R	T	S	C	O
N	M	I	C	U	C	T	E	R
E	I	P	L	E	R	U	S	P
I	C	O	A	N	A	N	S	O
C	R	C	W	O	T	U	O	R
S	O	S	L	A	E	B	R	C
R	A	I	T	U	N	O	B	I
G	P	H	E	D	C	A	R	M

1. A person who is studying or has expert knowledge of one or more of the natural or physical sciences.
2. A cylindrical molecule of a fullerene.
3. A grey crystalline allotropic form of carbon which occurs as a mineral in some rocks and can be made from coke; used as a solid lubricant, in pencils, and as a moderator in nuclear reactors.
4. So small as to be visible only with a microscope.
5. An integrated circuit that contains all the functions of a central processing unit of a computer.
6. Something that consists of parts connected together in an ordered way.
7. Consisting of two parts, elements, or aspects.
8. The chemical element of atomic number 6, a non-metal which has two main forms (diamond and graphite) and which also occurs in impure form in charcoal, soot, and coal.
9. A statement of fact, deduced from observation, to the effect that a particular natural or scientific phenomenon always occurs if certain conditions are present.

Exercise 4. Find the English equivalents in B to the Russian words in A.

A	B		
1. хранить	a) determine	b) include	c) store
2. прочный	a) tight	b) durable	c) entire
3. использовать	a) apply	b) conduct	c) turn on
4. расширять	a) achieve	b) extend	c) double
5. похожий	a) akin	b) fast	c) certain
6. предсказывать	a) guess	b) modify	c) predict
7.чрезвычайно	a) exceedingly	b) freely	c) through
8. сходство	a) arrangement	b) current	c) identity
9. кончик	a) tip	b) stack	c) sheet
10. перемещать	a) serve	b) transport	c) build

Exercise 5. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
flat-panel	pattern	медный провод
silicon	identity	грифель
building	cables	дисплей с плоским экраном
copper	battery	двойное сходство
dual	tip	сотовидная модель
long-lasting	structure	стандартный блок
honeycomb	display	кабельное телевидение
satellite	microprocessor	графитоподобная структура
graphitelike	block	долговечный аккумулятор
pencil	wire	кремниевый микропроцессор

Exercise 6. Unjumble the letters to make the words from the text.

1. orcanb	c__________
2. riew	w_________
3. bacle	c__________
4. rnarmneaget	a__________
5. nyrcledi	c__________
6. tnhegl	l__________
7. pyalp	a__________
8. inioslc	s__________

Exercise 7. Say if the following sentences are true or false. Correct the false ones.

1.Scientists from Japan discovered a huge graphitelike structure with the most beguiling dual identity in the late 1990s.

2. In fact, carbon nanotube is a microscopic structure.

3. Moore's Law predicts that the number of transistors on the fastest CPUs will triple every 18 months.

4. Carbon nanotube is the basic building block for satellite cables, flat-panel displays, long-lasting batteries etc.

5. A pencil tip consists of stack after stack of microscopic sheets.

6. Semiconductors are not able to conduct current at certain voltages.

7. The sheets of atoms are rolled into cylinders and so carbon nanotubes are formed.

8. Metals, which conduct at certain voltage, are used to build the wires that connect transistors.

Exercise 8. Make up the summary of the text in Exercise 2.

The text is under the headline … .
The main idea of the text is…
The author starts telling the readers about (that)…
It is pointed out that … .
Much attention is given to … .
I think this text is … .

Exercise 9. Think of questions using the following sentences.

1. In the early 1990s, scientists at the NEC Fundamental Research Laboratory in Japan, discovered a tiny graphitelike structure.

When ____?
Who ____ ?
What ____?

2. Carbon nanotubes are formed when the sheets of atoms are rolled into cylinders.

How ____ ?
What ____?

3. Semiconductors conduct current at certain voltages but not others.

What kind of voltages ____?

Do ____?

4. Metals, which conduct at any voltage, are used to build the wires that connect transistors.

What purpose ____?

What metals ____?

Exercise 10. Cross out the odd word. All the words in the line should belong to one part of speech.

1. Voltage, conductance, power, chip, resist.
2. Serve, achieve, predict, radiation, build.
3. Exceedingly, essentially, typically, tightly, efficiency.
4. Join, roll, copper, extend, perform.
5. It, one, she, you, they.
6. Transmit, reflect, transistor, emit, absorb.
7. Structure, number, active, conductor, battery.
8. Microprocessor, semiconductor, transistor, nanotube, reflect.
9. Dual, entire, flat, tiny, circuit.
10. Thickness, structure, visible, length, width.

Exercise 11. Divide the words into five columns according to their part of speech.

Noun	Adjective	Pronoun	Adverb	Conjunction

Wire, early, and, dual, identity, slowly, or, sometimes, another, this, secret, double, also, carbon, limit, all, that, thickness, yet, tight, but, it, quickly, processor, entire, they, exceedingly.

Exercise 12. Restore the original sentences and translate them into Russian.

1. As, can, transistor, it, a, serve, also.
2. Structure, nanotube, this, a, microscopic, is, carbon, as, known.
3. Japan, graphitelike, scientists, in, tiny, discovered, a, structure.

4. Building, future, the, it, basic, for, products, is, block, all.

5. Current, voltages, semiconductors, at, certain, conduct.

6. Is, voltage, stops, one, current, when, the, applied.

7. Nanotubes, build, microprocessor, you, an, from, could, carbon, entire

8. Tight, atoms, arrange, a, in, pattern, of, a, honeycomb, sheet, carbon.

Exercise 13. Translate the following sentences paying attention to the Absolute Participial Construction.

1. Carbon nanotubes being exceedingly durable, scientists will use them as building blocks for all sorts of future products.

2. With carbon atoms arranged in a certain order, the nanotube behaves like a semiconductor.

3. A carbon nanotube is akin to graphite, its atoms being arranged in a honeycomb pattern.

4. Silver being very expensive, we rarely use it as a conductor.

5. Carbon nanotubes look like hollow cigars, with the sheets of carbon atoms rolled into cylinders.

6. Scientists being unable to shrink silicon transistors any further, they may abandon silicon altogether and move on to completely new materials.

Exercise 14. Translate the following text into Russian in writing.

Nanotechnologies

Our modern technology builds on an ancient tradition. Thirty thousand years ago, chipping flint was the high technology of the day. Our ancestors grasped stones containing trillions of trillions of atoms and removed chips containing billions of trillions of atoms to make their ax heads; they made fine work with skills difficult to imitate today. They also made patterns on cave walls in France with sprayed paint, using their hands as stencils. Later they made pots by baking clay, then bronze by cooking rocks. They shaped bronze by pounding it. They made iron, then steel, and shaped it by heating, pounding, and removing chips.

We now cook up pure ceramics and stronger steels, but we still shape them by pounding, chipping, and so forth. We cook up pure silicon, saw it into slices, and make patterns on its surface using tiny stencils and sprays of light. We call the products ‘chips’ and we consider them exquisitely small, at least in comparison to ax heads.

Our microelectronic technology has managed to stuff machines as powerful as the room-sized computers of the early 1950s onto a few silicon chips in a pocket-sized computer. Engineers are now making ever smaller devices, slinging herds of atoms at a crystal surface to build up wires and components one tenth the width of a fine hair.

These microcircuits may be small by the standards of flint chippers, but each transistor still holds trillions of atoms, and so-called ‘microcomputers’ are still visible to the naked eye. By the standards of a newer, more powerful technology they will seem gargantuan.

The ancient style of technology that led from flint chips to silicon chips handles atoms and molecules in bulk; call it bulk technology. The new technology will handle individual atoms and molecules with control and precision; call it molecular technology. It will change our world in more ways than we can imagine.

Microcircuits have parts measured in micrometers – that is, in millionths of a meter – but molecules are measured in nanometers (a thousand times smaller). We can use the terms ‘nanotechnology’ and ‘molecular technology’ interchangeably to describe the new style of technology. The engineers of the new technology will build both nanocircuits and nanomachines.

SUPPLEMENTARY TEXTS FOR READING AND TRANSLATING

How Semiconductors Work

Operationally, transistors and vacuum tubes have similar functions; they both control the flow of current.

In order to understand how a semiconductor operates, consider a glass container filled with pure water. If a pair of conductive probes are immersed in the water and a DC voltage (below the electrolysis point i.e. breakdown point for water) is applied between them, theoretically no current would flow because the water has no charge carriers. In reality water undergoes self-ionization which introduces charge carriers allowing a very small current to flow. Dissolve a pinch of table salt in the water and conduction begins, because mobile carriers (ions) have been released. Increasing the salt concentration increases the conduction, but not very much. A dry lump of salt is non-conductive, because the charge carriers are immobile.

An absolutely pure silicon crystal is also an insulator, but when an impurity e. g. arsenic is added (called doping) in quantities minute enough not to completely disrupt the regularity of the crystal lattice, it donates free electrons and enables conduction. This is because arsenic atoms have five electrons in their outer shells while silicon atoms have only four. Conduction is possible because a mobile carrier of charge has been introduced, in this case creating n-type silicon ('n' for negative. The electron has a negative charge).

Alternatively, silicon can be doped with boron to make p-type silicon which also conducts. Because boron has only three electrons in its outer shell another kind of charge carrier, called a 'hole', is formed in the silicon crystal lattice.

In a vacuum tube, on the other hand, the charge carriers (electrons) are emitted by thermionic emission from a cathode heated by a wire filament. Therefore, vacuum tubes cannot generate holes (positive charge carriers).

Note that charge carriers of the same polarity repel one another so that, in the absence of any force, they are distributed evenly throughout the semiconductor material. However, in an impowered bipolar transistor (or junction diode) the charge carriers tend to migrate towards a P/N junction, being attracted by their opposite charge carriers on the other side of the junction.

Increasing the doping level increases the semiconductor conductivity, providing that the crystal lattice, overall, remains intact. In a bipolar transistor the emitter has a higher doping level than the base. The ratio of emitter/base doping levels is one of the main factors that dictates the junction transistor's current gain.

The level of doping is extremely low: in the order of parts per one hundred million, and this is the key to semiconductor operation. In metals, the carrier population is extremely high; one charge-carrier per atom. In metals, in order to convert a significant volume of the material into an insulator, the charge carriers must be swept out by applying a voltage. In metals this value of voltage is astronomical; more than enough to destroy the metal before it converts to an insulator. But in lightly doped semiconductors there is only one mobile charge carrier per million or more atoms. The level of voltage required to sweep so few charge-carriers out of a significant volume of the material is easily reached. In other words, the electricity in metals is incompressible, like a fluid, while in semiconductors behaves as a compressible gas. Doped semiconductors can be rapidly changed into insulators, while metals cannot.

The above explains conduction in a semiconductor by charge carriers, either electrons or holes, but the essence of bipolar transistor action is the way that electrons/holes seemingly make a prohibited leap across the insulating depletion zone in the reverse-biased base/collector junction under control of the base/emitter voltage. Although a transistor may seem like two interconnected diodes, a bipolar transistor cannot be made simply by connecting two discrete junction diodes together. To produce bipolar transistor action they need to be fabricated on the same crystal, and physically sharing a common and extremely thin base region.

Doping of Semiconductors

One of the main reasons that semiconductors are useful in electronics is that their electronic properties can be greatly altered in a controllable way by adding small amounts of impurities. These impurities are called dopants.

Heavily doping a semiconductor can increase its conductivity by a factor greater than a billion. In modern integrated circuits, for instance, heavily-doped polycrystalline silicon is often used as a replacement for metals.

Intrinsic and Extrinsic Semiconductors

An intrinsic semiconductor is a semiconductor which is pure enough that the impurities in it do not appreciably affect its electrical behavior. In this case, all carriers are created by thermally or optically excited electrons from the full valence band into the empty conduction band. Thus equal numbers of electrons and holes are present in an intrinsic semiconductor. Electrons and holes flow in opposite directions in an electric field, though they contribute to current in the same direction since they are oppositely charged. Hole current and electron current are not necessarily equal in an intrinsic semiconductor, however, because electrons and holes have different effective masses (crystalline analogues to free inertial masses).

The concentration of carriers in an intrinsic semiconductor is strongly dependent on the temperature. At low temperatures, the valence band is completely full, making the material an insulator. Increasing the temperature leads to an increase in the number of carriers and a corresponding increase in conductivity. This principle is used in thermistors. This behavior contrasts sharply with that of most metals, which tend to become less conductive at higher temperatures due to increased phonon scattering.

An extrinsic semiconductor is a semiconductor that has been doped with impurities to modify the number and type of free charge carriers present.

A semiconductor which is doped to such high levels that the dopant atoms are an appreciable fraction of the semiconductor atoms is called degenerate. A degenerate semiconductor acts more like a conductor than a semiconductor.

N-type Doping

The purpose of n-type doping is to produce an abundance of mobile or 'carrier' electrons in the material. To help understand how n-type doping is accomplished, consider the case of silicon (Si). Si atoms have four valence electrons, each of which is covalently bonded with one of four adjacent Si atoms. If an atom with five valence electrons, such as those from group 15 (a.k.a. group V) of the periodic table (e.g. phosphorus (P), arsenic (As), or antimony (Sb)), is incorporated into the crystal lattice in place of a Si atom, then that atom will have four covalent bonds and one unbonded electron. This extra electron is only weakly bound to the atom and can easily be excited into the conduction band. At room temperatures, virtually all such electrons are excited into the conduction band. Since excitation of these weakly bound electrons does not result in the formation of a hole, the number of electrons in such a material far exceeds the number of thermally generated holes. In this case the electrons are the majority carriers and the holes are the minority carriers. Because the five-electron atoms have an extra electron to 'donate', they are called donor atoms. Note that each movable electron within the semiconductor is never far from an immobile positive dopant ion, and the n-doped material normally has a net electric charge of zero.

P-type Doping

The purpose of p-type doping is to create an abundance of holes. In the case of silicon, a trivalent atom (such as boron) is substituted into the crystal lattice. The result is that one electron is missing from one of the four covalent bonds normal for the silicon lattice. Thus the dopant atom can accept an electron from a neighboring atom's covalent bond to complete the fourth bond. Such dopants are called acceptors. The dopant atom accepts an electron, causing the loss of one bond from the neighboring atom and resulting in the formation of a 'hole'. Each hole is associated with a nearby negative-charged dopant ion, and the semiconductor remains electrically neutral as a whole. However, once each hole has wandered away into the lattice, one proton in the atom at the hole's location will be 'exposed' and no longer cancelled by an electron. For this reason a hole behaves as a quantity of positive charge. When a sufficiently large number of acceptor atoms are added, the holes greatly outnumber the thermally-excited electrons. Thus, the holes are the majority carriers, while electrons are the minority carriers in p-type materials. Blue diamonds (Type IIb), which contain boron (B) impurities, are an example of a naturally occurring p-type semiconductor.

Optical Metrology for LEDs and Solid State Lighting

There have been significant advancements in light-emitting diodes (LEDs) in recent years. High brightness LEDs are now available in many colours and their efficiency has recently been greatly improved. LEDs are being utilized in many single-colour applications at a great pace, such as traffic lights, emergency lights, automotive lights, aviation lights, outdoor colour displays, and niche lighting applications. White LEDs are also now available, and their performance is improving year by year. White LEDs are produced by mixture of multi-colour LEDs (e. g., RGB combination), by use of a phosphor excited by blue LED emission, or by multiple phosphors excited by UV LEDs emission. White LEDs are already being introduced into niche lighting applications, and as their performance improves, they are highly expected for use in general lighting due to their potential high efficiency. Solid state lighting is promising because it has theoretically a very high luminous efficacy (theoretical limit of white LEDs light ~ 400 lm/W). Many of white LEDs currently commercially available have a luminous efficacy of ~ 30lm/W, already higher than incandescent lamps. Nearly 100 lm/W has been achieved on laboratory prototypes, which is the level of the current high-efficiency fluorescent lamps. Solid state lighting (SSL) will have great impact for the potential of huge energy savings. In the United States, lighting consumes 22 % of electricity and 8 % of total energy. The U. S. Department of Energy expects that solid state lighting will reduce the energy consumption by lighting to a half of the current level by 2025. This will also lead to 10 % reduction in greenhouse gas emissions. The goal of SSL industry in a shorter term is to achieve 150 lm/W white LED lamps by 2012.

Such a goal for SSL is a great challenge. There are many technical hurdles to overcome for SSL to be able to substantially penetrate into general lighting market. For example, much improvement is needed for the internal quantum efficiency (Q.E.) of LEDs. The yellow-green region (~540 to ~570 nm, called the ‘green hole’) suffers from very low efficiency (less than 10 % Q.E.) while red LEDs already achieve more than 80 % Q.E. and blue LEDs have Q.E. of ~50 %. The green region is important for multi-chip white LEDs to produce good colour rendering. Light extraction efficiency is also a difficulty. About 50 % of the light from the chip is trapped inside the encapsulation and lost. Phosphor type white LEDs suffer from the loss of quantum efficiency of phosphors (currently about 70 %). Flux per chip is very important for real application of LEDs for lighting, as lighting requires a large amount of luminous flux. Finally, cost is probably the largest hurdle for penetration into lighting market. The price per kilo lumen of white LEDs is currently two orders of magnitude higher than traditional lamps.

Atomic Force Microscopy in Nanomedicine

Atomic force microscopy (AFM) is a type of scanning probe microscopy (SPM) technique developed by G. Binnig, C.F. Quate and C. Gerber in 1986. It is one of the most important tools in nanoscience and technology to visualize, manipulate and modify single biomolecules at their near native environment. Considerable advances in biomedical research were gained through structural biology studies using electron microscopy, X-ray diffraction, nuclear magnetic resonance etc. However, their main limitations being extensive sample preparations, crystallization problems, size limitations and most importantly their non-physiological imaging environments doesn't provide any functional information of the samples analyzed. On the other hand, AFM doesn't require such elaborate sample preparations; it allows examining the samples at their physiological conditions thus permit functional and dynamic studies under noninvasive conditions. Most importantly, it allows easy integration of other complementary modalities like fluorescence microscopy (including widefield, confocal, TIRF, FRET, etc.), electrophysiology, optical tweezers, microfluidics, etc., thus providing a powerful platform to obtain structure-function data at single molecular level.

In its simplest form, AFM has a cantilever with a sharp probe at its tip to scan the sample surface. When the tip is drawn close to a surface, depending upon the surface characteristics, the tip experiences a variety of force interactions that deflects the cantilever which is detected by a laser spot (most commonly) on a quadrant photodiode. A feedback control maintains the tip-sample separation via cantilever deflection to maintain the constant force experienced by the tip. In certain configurations, the sample is mounted on a X, Y, Z piezoelectric tube that can move the sample in z axis to maintain the same force experienced by the tip and move the sample in X, Y to enable raster scan across the sample. By doing so, it captures the topography of the sample down to molecular/atomic resolutions (0.1 nm in Z and 1 nm in X, Y) (Fig. 4).

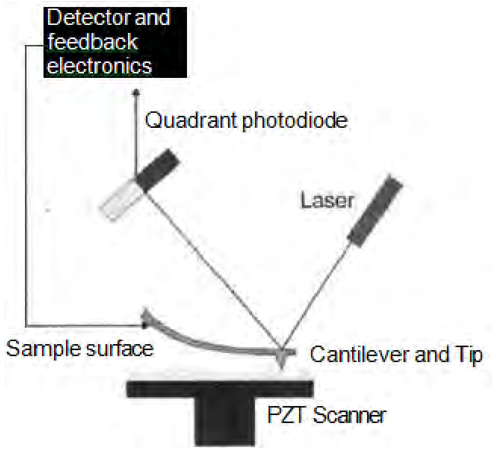

Fig. 4. Schematic of the operating principle of AFM

There are two main imaging modes of AFM:

1) contact mode, in which an electronic feedback circuit maintains a constant deflection, ensuring a constant force of interaction between tip and sample. The amount of 'z' variation needed to maintain the constant interaction force is plotted versus the x and y coordinates, producing a topographic image and

2) tapping mode, in which the amplitude of vibration of an oscillating cantilever is maintained constant during scanning. In the tapping mode, the phase lag between the driving circuit and the actual tip vibration is also measured. The deflection of the cantilever in the contact mode and the damping of vibration amplitude in tapping mode are caused by a sum of attractive and repulsive forces.

The dominant repulsive force sensed by the AFM cantilever results from the overlapping of electron orbitals between the atoms of the tip and of the sample. The dominant attractive force is Van der Waals interaction, which is primarily due to non localized dipole-dipole interactions. Another strong attractive force component that exists while imaging in air is the meniscus-surface force due to adsorbed water layers. In fluids, consideration should be given to electrostatic interactions between charges and the sample and tip, and structural forces, and adhesion forces. In the tapping mode, conductive/magnetically coated cantilevers can sense electrostatic and magnetic forces, and image for instance magnetic domains, surface charge distributions, local surface capacitance and local conductance. These forces can be used to generate images that provide valuable information on the differences in local surface chemistry, like separate lipid and protein clusters in a membrane, and as such can be used as effective sensors of energy and the functional states of a specimen.

Nanomechanical Biosensors: a New Sensing Tool

Biosensors are devices that take advantage of the high specificity of biological reactions for detecting target analytes. They couple a biological recognition element (specific to the target analyte) with a physical transducer that translates the bio-recognition event into a measurable effect, such as an electrical signal, an optical emission or a mechanical motion. In the early 1960s, Clark and Lyons and Updike and Hicks developed the first biosensor, based on the specific catalytic interaction of the glucose oxidase enzyme with glucose. Since then, there has been rapid growth in research activities in this area and the biosensor field has made great advances in developing new sensing devices capable of characterizing and quantifying biomolecules in many fields, such as biomedical, industrial or environmental control.

However, besides the excellent results obtained with existing sensor technologies, we still need biosensors able to detect, in a direct way, very low (picomolar to femtomolar) levels of a great number of chemical and biochemical substances in areas such as environmental monitoring, industrial and food processing, healthcare, biomedical technology, and clinical analysis. Progress in microtechnologies allows development of highly sensitive sensors with the additional advantage of miniaturization. Microbiosensor or nanobiosensor devices based on microelectronics and related micro-electromechanical system (MEMS) technologies provide devices that could easily be integrated into portable 'lab-on chip' platforms to perform 'point-of-care' analysis because, for many applications, portability is a major issue. Additional advantages of this approach to fabrication are robustness, reliability, low energy consumption, and mass production with consequent reduction in costs.

Microcantilever sensors are most promising for microbiosensors and nanobiosensors. This new class of highly sensitive biosensors can perform local, high resolution and label-free molecular recognition measurements. They are derived from the microfabricated cantilevers used in atomic force microscopy (AFM) and are based on the bending induced in the cantilever when, for example, a biomolecular interaction takes place on one of its surfaces. The microcantilevers translate the molecular recognition of biomolecules into nanomechanical motion (from a few nm to hundreds of nm), which is commonly coupled to an optical or piezo-resistive read-out system.

Microcantilevers are typically made of silicon/silicon nitride or polymer materials, with dimensions ranging from tens to hundred of µm long, some tens of µm wide and hundreds of nm thick. Moreover, these devices can be fabricated in arrays comprising 10 to thousands of microcantilevers, so they are a promising alternative to current DNA and protein chips because they could permit parallel, fast, real-time monitoring of thousands of analytes (e.g., proteins, pathogens, and DNA strands) without any need for labeling. When fabricated at the nanoscale (nanocantilevers), the sensitivity goes down and expected limits of detection (LODs) are in the femtomole (fmol) to attomole (amol) range with the astonishing possibility of detection at the single-molecule level in real time.

Carbon Nanotubes and Nanodevices

Carbon nanotubes, discovered in 1991, are molecular structures which consist of graphene cylinders closed at either end with caps containing pentagonal rings. Carbon nanotubes are produced by vaporizing carbon graphite with an electric arc under an inert atmosphere. The carbon molecules organize a perfect network of hexagonal graphite rolled up onto itself to form a hollow tube. The standard arc evaporation method produces only multilayered tubes, and the single-layer uniform nanotubes. One can fill nanotubes with any media, including biological molecules. The carbon nanotubes can be conducting or insulating medium depending upon their structure. The application of these nanotubes, formed with a few carbon atoms in diameter, provides the possibility to fabricate devices on an atomic and molecular scale. The diameter of nanotube is 100,000 times less that the diameter of the sawing needle. The carbon nanotubes, which are much stronger than steel wire, are the perfect conductor (better than silver), and have thermal conductivity better than diamond. The carbon nanotubes are manufactured using the carbon vapour technology. Single-wall carbon nanotubes are manufactured using laser vaporization, arc technology, vapour growth, as well as other methods.

The carbon nanotubes can be organized as large-scale complex neural networks to perform computing and data storage, sensing and actuation, etc. Metallic solids (conductor, for example, copper, silver and iron) consist of metal atoms. These metallic solids usually have hexagonal, cubic, or body centered cubic close-packed structures. Each atom has 8 or 12 adjacent atoms. The bonding is due to valence electrons that are delocalized thought the entire solid.

MEMS Accelerometers

An accelerometer is an electromechanical device that measures acceleration forces. These forces may be static, like the constant force of gravity pulling at our feet, or they could be dynamic – caused by moving or vibrating the accelerometer. There are many types of accelerometers developed and reported in the literature. The vast majority is based on piezoelectric crystals, but they are too big and too clumsy. People tried to develop something smaller, that could increase applicability and started searching in the field of microelectronics. They developed MEMS (micro electromechanical systems) accelerometers.

The first micro machined accelerometer was designed in 1979 at Stanford University, but it took over 15 years before such devices became accepted mainstream products for large volume applications. In the 1990s MEMS accelerometers revolutionised the automotive airbag system industry. Since then they have enabled unique features and applications ranging from hard disk protection on laptops to game controllers. More recently, the same sensor core technology has become available in fully integrated, full-featured devices suitable for industrial applications.

Micro machined accelerometers are a highly enabling technology with a huge commercial potential. They provide lower power, compact and robust sensing. Multiple sensors are often combined to provide multi-axis sensing and more accurate data.

What could link an inkjet printer head, a video projector DLP system, a disposable bio-analysis chip and an airbag crash sensor – yes, they are all MEMS, but what is MEMS? Micro Electro Mechanical Systems or MEMS is a term coined around 1989 by Prof. R. Howe and others to describe an emerging research field, where mechanical elements, like cantilevers or membranes, had been manufactured at a scale more akin to microelectronics circuit than to lathe machining. It appears that these devices share the presence of features below 100 µm that are not machined using standard machining but using other techniques globally called micro-fabrication technology. Of course, this simple definition would also include microelectronics, but there is a characteristic that electronic circuits do not share with MEMS. While electronic circuits are inherently solid and compact structures, MEMS have holes, cavity, channels, cantilevers, membranes, etc, and, in some way, imitate 'mechanical' parts. The emphasis on MEMS based on silicon is clearly a result of the vast knowledge on silicon material and on silicon based micro-fabrication gained by decades of research in microelectronics. And again, even when MEMS are based on silicon, microelectronics process needs to be adapted to cater for thicker layer deposition, deeper etching and to introduce special steps to free the mechanical structures. MEMS needs a completely different set of mind, where next to electronics, mechanical and material knowledge plays a fundamental role. Then, many more MEMS are not based on silicon and can be manufactured in polymer, in glass, in quartz or even in metals.

The development of a MEMS component has a cost that should not be misevaluated and the technology has the possibility to bring unique benefits. The reasons that prompt the use of MEMS technology are, for example, miniaturization of existing devices, development of new devices based on principles that do not work at larger scale, development of new tools to interact with the microworld. Miniaturization reduces cost by decreasing material consumption. It also increases applicability by reducing mass and size allowing to place the MEMS in places where a traditional system doesn't fit. A typical example is brought by the accelerometer developed as a replacement for traditional airbag triggering sensor also used in digital cameras to help stabilize the image or even in the contactless game controller integrated in the latest handphones. Another advantage that MEMS can bring relates with the system integration. Instead of having a series of external components (sensor, inductor) connected by wire or soldered to a printed circuit board, the MEMS on silicon can be integrated directly with the electronics. These so called smart integrated MEMS already include data acquisition, filtering, data storage, communication, interfacing and networking. As we see, MEMS technology not only makes the things smaller but often makes them better.

MEMS Technology

MEMS is an emerging technology which uses the tools and techniques that were developed for the integrated circuit industry to build microscopic machines. These machines are built on standard silicon wafers.

The real power of this technology is that many machines can be built at the same time across the surface of the wafer, with no assembly required. Since it is a photographic-like process, it is just as easy to build a million machines on the wafer as it would be to build just one.

These tiny machines are becoming ubiquitous, and are quickly finding their way into a variety of commercial and defense applications.

There are several different broad categories of MEMS technologies:

1) Bulk Micromachining

Bulk micromachining is a fabrication technique which builds mechanical elements by starting with a silicon wafer, and then etching away unwanted parts, and being left with useful mechanical devices. Typically, the wafer is photo patterned, leaving a protective layer on the parts of the wafer that you want to keep. The wafer is then submerged into a liquid etchant, like potassium hydroxide, which eats away any exposed silicon. This is a relatively simple and inexpensive fabrication technology, and is well suited for applications which do not require much complexity, and which are price sensitive.

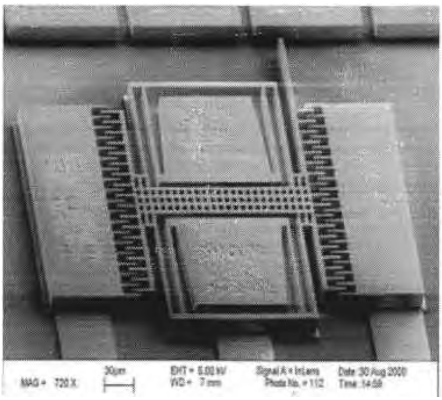

Fig. 5. Pressure sensor for high-reliability avionics and industrial applications

Today, almost all pressure sensors are built with bulk micromachining. Bulk micromachined pressure sensors offer several advantages over traditional pressure sensors. They cost less, are highly reliable, manufacturable, and there is very good repeatability between devices.

All new cars on the market today have several micromachined pressure sensors, typically used to measure manifold pressure in the engine.

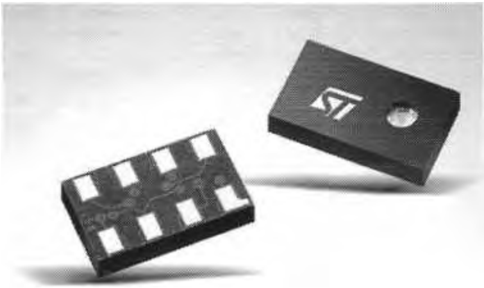

Fig. 6. ST MEMS pressure sensor

The small size and high reliability of micromachined pressure sensors make them ideal for a variety of medical applications as well.

2) Surface Micromachining

While bulk micromachining creates devices by etching into a wafer, surface micromachining builds devices up from the wafer layer-by-layer.

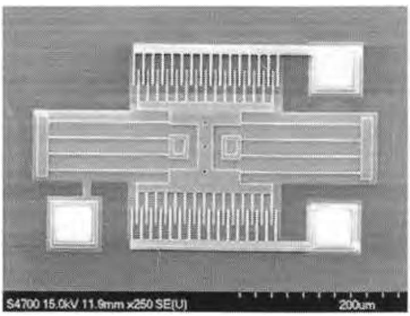

Fig. 7. Polysilicon resonator structure fabricated using a surface micromachining process

A typical surface micromachining process is a repetitive sequence of depositing thin films on a wafer, photo patterning the films, and then etching the patterns into the films. In order to create moving, functioning machines, these layers are alternating thin films of a structural material (typically silicon) and a sacrificial material (typically silicon dioxide). The structural material will form the mechanical elements, and the sacrificial material creates the gaps and spaces between the mechanical elements. At the end of the process, the sacrificial material is removed, and the structural elements are left free to move and function.

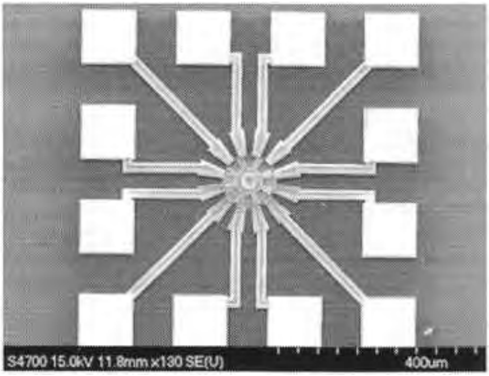

Fig. 8. Polysilicon micromotor fabricated using a surface micromachining process

For the case of the structural level being silicon, and the sacrificial material being silicon dioxide, the final ‘release’ process is performed by placing the wafer in hydrofluoric acid. The hydrofluoric acid quickly etches away the silicon dioxide, while leaving the silicon undisturbed.

The wafers are typically then sawn into individual chips and the chips are packaged in an appropriate manner for the given application.

Surface micromachining requires more fabrication steps than bulk micromachining, and hence is more expensive. It is able to create much more complicated devices, capable of sophisticated functionality. Surface micromachining is suitable for applications requiring more sophisticated mechanical elements.

Appendix

ПРАВИЛА ЧТЕНИЯ НЕКОТОРЫХ МАТЕМАТИЧЕСКИХ СИМВОЛОВ

Простые дроби (Common Fractions)

Числитель выражается количественным, а знаменатель порядковым числительным. Если числитель больше единицы, то знаменатель принимает окончание множественного числа -*s*.

1/2	a half; one half
1/3	a third; one third
1/4	a) a quarter; one quarter
	b) a fourth; one fourth
1/10	a (one) tenth
1/100	a (one) hundredth
1/1234	a (one) thousand two hundred and thirty-fourth
3/4	a) three fourths
	b) three quarters
2 1/2	two and a half
125 3/4	a (one) hundred and twenty-five and three-fourths

Десятичные дроби (Decimal Fractions)

В десятичных дробях целое число отделяется от дроби точкой, называемой **point**. Каждая цифра читается отдельно. «Ноль целых» может совсем не ставиться и не читаться или читаться одним из следующих способов: **o, nought, zero**.

0.1	1) o point one	0.25	1) nought point two five
.1	2) nought point one	.25	2) point two five
	3) zero point one		
	4) point one		
0.01	1) o point o one	2.35	two point three five
.01	2) nought point nought one	45.67	forty five point six seven
	3) zero point zero one		
	4) point nought one		
	5) point zero one		

Отдельные знаки, выражения

+	plus	d^2	1) *d* squared 2) *d* to the second power 3) the square of *d*
–	minus		
±	plus or minus		
· ×	multiplied by; times by	z^{10}	*z* to the tenth power
:	divided by	z^{-10}	*z* to the minus tenth power
=	equals; is equal to	b'	*b* prime
%	per cent	b''	*b* double prime
0 ºC	zero degrees Centigrade (Celsius)	c_1	*c* first
32 ºF	thirty-two degrees Fahrenheit	c_2	*c* second
10″	1) ten seconds 2) ten inches	c_n	*c* n-th
		W^{-1}	watt to the minus first power
√a	the square root of a		

Contents

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