**МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ**

**ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ОБРАЗОВАНИЮ**

САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ, МЕХАНИКИ И ОПТИКИ

ПРИОРИТЕТНЫЕ НАЦИОНАЛЬНЫЕ ПРОЕКТЫ «Образование»

ПОБЕДИТЕЛЬ КОНКУРСА ИННОВАЦИОННЫХ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ ВУЗОВ

**Л.П. Маркушевская, Л.И. Буханова, Г.С. Германчук,**
**Н.В. Ермошина, Т.Г. Некрасова**

# IN THE WORLD OF LASERS…
## (В МИРЕ ЛАЗЕРОВ…)

**Учебное пособие для студентов**
**инженерно-физического факультета**

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Пособие состоит из четырех глав, в которых представлены оригинальные тексты, знакомящие студентов с историей развития и применения лазеров, волоконной оптики в различных сферах человеческой деятельности. Четвертая глава содержит рекомендации по составлению аннотаций и рефератов по прочитанной оригинальной литературе по специальности, а также подборку текстов, при работе с которыми студенты приобретают навыки лексико-семантического анализа текста, конспектирования и компрессии прочитанного материала, составления тезисов.
К учебному пособию прилагается электронная версия с дальнейшим использованием компьютера.
Пособие также включает в себя три приложения и терминологический словарь. Каждый урок снабжен лексико-грамматическими упражнениями по изучаемой тематике.

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ПРИОРИТЕТНЫЕ НАЦИОНАЛЬНЫЕ ПРОЕКТЫ «Образование»

В 2007 году СПбГУ ИТМО стал победителем конкурса инновационных образовательных программ вузов России на 2007–2008 годы. Реализация инновационной образовательной программы «Инновационная система подготовки специалистов нового поколения в области информационных и оптических технологий» позволит выйти на качественно новый уровень подготовки выпускников и удовлетворить возрастающий спрос на специалистов в информационной, оптической и других высокотехнологичных отраслях экономики.

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# Chapter I
# Maser-Laser History

## Unit 1
## Masers

**WORD-STUDY**

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
*Nouns*
amplifier, characteristic, concept, frequency, microwave, molecule, process, radar, spectroscopy, technique, width.
*Adjectives*
molecular, operable, quantitative, relevant.

**Exercise 2.** ***Read the given collocations and find their Russian equivalents:***
a) to make use of microwave amplifier, to study molecular structure of a material, to make the process more easy, to determine quantitative characteristics, to construct an operable laser, to select the relevant optical frequency, to determine a distance by means of a radar, to propose a new concept, to use molecular beams in microwave spectroscopy;

b) выбрать нужную оптическую частоту, определить количественные характеристики, использовать молекулярный пучок в микроволновой спектроскопии, создать готовый к работе лазер, воспользоваться микроволновыми усилителями, предложить новую концепцию, изучать молекулярную структуру материала, сделать процесс более легким, определить расстояние с помощью радара.

**Exercise 3.** ***Make nouns from the following verbs according to the model and translate them.***
1. *Model: verb + -tion (-ation):* generate – generation;
invent, construct, applicate, calculate, operate, produce, explore, continue, stimulate, radiate.

2. *Model: verb +(-ion) -sion (-ssion):* emit – emission;
extend, convert, process, invert, expand, discuss, transmit, progress.

## UNDERSTANDING A PRINTED TEXT

**List of Terms:**

amplifier – усилитель
radiation – излучение, радиация
stimulated emission of radiation – вынужденное излучение радиации (эмиссия)
wavelength – длина волны
beam – пучок (лучей)
line-width – ширина линии (спектра)
cavity – резонатор
high resolution – высокое разрешение (разрешающая способность)
stable oscillator – стабильный (устойчивый) генератор
radar receiver – радиолокатор (радиолокационный приемник)
optical frequency range – оптический частотный диапазон

### *Reading for discussion*

The devices known as masers and lasers serve as amplifiers and generators of radiation. Their common characteristic is that they make use of the conversion of atomic or molecular energy to electromagnetic radiation by means of the process known as stimulated emission of radiation. When the wavelength of the emitted radiation is in the vicinity of 1 cm we speak of microwave amplifiers or masers. Instruments which generate or amplify visible or nearly visible radiation are called optical masers or lasers.

The history of the invention or the evolution of these devices may be divided into the following periods.

The relevant phase of the premaser period started with the discovery of the existence of the stimulated emission process and ended with the recognition by many physicists of the possibility that this process might lead to a radiation amplifier. This period extends from 1916 to 1953. In 1917, it was Albert Einstein* who was the first to recognize the existence of stimulated emission, but not until the 1950s when the first device was demonstrated.

The maser period begins with the publication of an article by Basov and Prokhorov and the construction of the first operating maser by Townes, Gordon, Zeiger. Basov and Prokhorov gave a detailed theoretical exploration of the use of molecular beams in microwave spectroscopy. The article of Basov and Prokhorov contained detailed calculations pertaining to the role of the relevant physical parameters, the effects of line-width, cavity dimensions, and the like. Thus the quantitative conditions for the operation of a microwave amplifier and generator were found.

In 1954 at Columbia University Charles Townes and two of his students announced the construction and operation of a device that may be used as a high-resolution microwave spectrometer, a microwave amplifier, or a very stable oscillator. They named the device **a "maser" – an acronym for microwave amplification by stimulated emission of radiation.**

From 1958 on, many masers were constructed for applications in radio astronomy and as components of radar receivers. These masers were mostly of the ruby type. Their design became a part of the engineering art and research interest turned toward the extension of stimulated emission techniques in the visible and infrared regions.

Arthur Schawlow of Bell Laboratories and Townes proposed extending the maser concept to the optical frequency range in 1958. Born in Greenville, South Carolina, Townes joined the technical staff of Bell Telephone Laboratories Inc. and worked on radar bombing systems during World War II. In 1948 he joined the faculty of Columbia University and three years later had the idea that resulted in the construction of the maser. From 1959 to 1961 Townes served as a vice president and a director of research of the Institute for Defense Analysis in Washington, D.C*. He then was appointed the professor of physics at Massachusetts Institute of Technology (MIT)*.

The maser period extends from 1954 to 1960.

***References***

*To know more about great scientists read attentively **APPENDIX III.**

*D.C. - District of Columbia

*MIT - Massachussetts Institute of Technology

**COMPREHENSION CHECK**

**Exercise 1.** ***Answer the following questions.***

1. What is the common characteristic of masers and lasers?
2. Who was the first to recognize the existence of stimulated emission? When did it take place?
3. When did the maser period begin?
4. What did Basov and Prokhorov work out?
5. Who was the first to announce the construction and operation of a maser?
6. What does the word "maser" stand for?
7. Where were masers mainly applied?

**Exercise 2.** ***Choose the correct word (words) to complete the sentences.***

1. It was … who first recognized the existence of stimulated emission.

a) Charles Townes

b) Albert Einstein

c) Basov and Prokhorov

2. Instruments which generate or amplify … radiation are called optical masers or lasers.
a) low-energy
b) visible
c) potential

3. In 1954 Townes and two of his students announced the construction and operation of a new device, they named it a "…".
a) laser
b) diode
c) maser

4. The common characteristic of masers and lasers is that they make use of the … of atomic or molecular energy.
a) conversion
b) generation
c) emission

5. Basov and Prokhorov gave a detailed theoretical exploration of the use of … beams in microwave spectroscopy.
a) atomic
b) molecular
c) electronic

**Exercise 3.** ***Topics for discussion.***
1. What have you learnt about the history and application of a maser?
2. Name scientists taking part in the creation of a maser.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the synonyms.***

*Nouns*

| 1 | 2 |
|---|---|
| 1) device | a) development |
| 2) recognition | b) use |
| 3) design | c) apparatus |
| 4) application | d) research |
| 5) evolution | e) discovery |
| 6) exploration | f) adoption |
| 7) invention | g) project |
| | h) process |
| | i) emission |

*Verbs*

| 1 | 2 |
|---|---|
| 1) pertain | a) produce |
| 2) generate | b) conduct |
| 3) lead | c) begin |
| 4) turn (toward) | d) connect |
| 5) start | e) address (to) |
| | f) contain |
| | g) extend |

## LANGUAGE ACTIVITY

**Exercise 1.** ***Give the plural form of the following nouns.***
Device, discovery, process, possibility, datum, amplifier, component, parameter, dimension, beam, receiver, frequency, phenomenon, calculation, cavity.

**Exercise 2.** ***State the part of speech of the following words and determine their meaning without using a dictionary.***
1. Character, characteristic, characterize.
2. Frequently, frequent, frequency.
3. Amplify, amplifier, amplification.
4. Consider, considerable, considerably, consideration.
5. Emission, emit, emitter.
6. Radiator, radiate, radiation, radiative.

**Exercise 3.** ***Translate the following word combinations.***
Various scientific problems, extremely high power, atomic structures, entirely new source, the same wavelength, cavity dimensions, high-frequency radio-like signal, radar receivers, stimulated emission techniques.

**Exercise 4.** ***Fill in the blanks with suitable articles.***
1. The subject matter of physics is usually divided into … number of branches: mechanics, sound, heat, electricity and magnetism, etc.
2. We can illustrate the existence of energy by … following example.
3. … body can do work at the expense of its internal energy which then diminishes.
4. Our scientists solve … lot of complicated problems.
5. On … basis of the experimental facts it is possible to formulate laws.
6. This device may be used as … microwave amplifier.
7. Our researchers have made … detailed theoretical analysis of this phenomenon.
8. The name of the new instrument is a maser, … acronym for microwave amplification by stimulated emission of radiation.

**Exercise 5.** ***Read the following figures, dates, numerals, etc.***

a) 35; 700; 268; 40931; 1175;

b) 1954; 1961; *с* 1954 *по* 1960; 1812; 2005;

c) 1/4; 3/7; 2,58; 0,005; $3^7$; $5^{-10}$;

d) 90%; 1 см; 140 км/ч; 25°C.

**Exercise 6.** ***Choose the correct pronoun.***

1. Townes and two of (his, him) students announced the construction of a new device. 2. (They, their) design became a part of engineering art. 3. The existence of stimulated emission was recognized by (his, him) in 1917. 4. The device was given (it, its) new name. 5. The article of (us, our) scientists contained detailed calculations. 6. The Nobel Prize in physics was awarded to (they, them) in 1964. 7. The conductivity of a conductor decreases as (it, its) temperature increases.

## Unit 2
# Lasers

## WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
*Nouns*
acronym, helium, light, mixture, neodymium, neon, ruby, technology, variety.
*Verbs*
convert, patent, require.
*Adjectives*
dynamic, notable, simultaneous.

**Exercise 2.** ***Read and translate the following international words and explain them.***
Fundamental, radiation, recombination, emission, intensity, technology, experimentation, monochromatic.

**Exercise 3.**
***a) Make adjectives from the following verbs according to the model.***
*Model: verb + -able:* compare - comparable;
operate, change, solve, reason, vary, convert, note, use, extend, control, recognize.

***b) And now make negative forms of these adjectives and translate them.***
*Model: un- + adjective*: comfortable - uncomfortable.

**Exercise 4.** ***Match the equivalents of the given collocations:***
a) conventional light sources, gas-dynamic laser, worldwide recognition, light emitting material, free electron laser, molecular systems, semiconductor laser, narrow spectral regions, quantum electronics, monochromatic radiation;

b) светоизлучающий материал, молекулярные системы, газодинамический лазер, лазер на свободных электронах, полупроводниковый лазер, мировое признание, монохроматическое излучение, узкие спектральные области (излучения), обычные (общепринятые) источники света, квантовая электроника.

## UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

operable laser – действующий лазер
pink ruby medium – лазерная активная среда на розовом рубине
continuously operating laser – лазер, генерирующий излучение в непрерывном режиме

neodymium-doped glass laser – лазер на стекле с неодимом (Nd)
semiconductor – полупроводник
semiconductor junction laser – диодный полупроводниковый лазер
population inversion – инверсия населенности
free electron laser – лазер на свободных электронах
light source – источник света
narrow spectral region – узкий спектральный диапазон

The laser period opens with the achievement of the ruby laser. The acronym **l.a.s.e.r.** stands for **light amplification by stimulated emission of radiation.**

Physicist Theodore Harold Maiman invented the first operable laser. While employed at Hughes Research Laboratories as a section head in 1960, he developed, demonstrated, and patented a laser using a pink ruby medium, for which he gained worldwide recognition. Born in Los Angeles, California, Maiman, in his teens earned college money by repairing electrical appliances and radios. He attended the University of Colorado and received a B.S.* in engineering physics in 1949, then went on to do graduate work at Stanford University, where he received an M.S.* in electrical engineering in 1951 and a Ph.D.* in physics in 1955. In 1962 Maiman founded his own company, Korad Corporation, devoted to the research, development, and manufacture of lasers.

Early in 1961 the first continuously operating laser was announced by Ali Javan and coworkers at Bell Laboratories. This laser was the first to use a gas, a mixture of helium and neon, for the light emitting material. At the same years scientists from American Optical Company made the first neodymium-doped glass laser. In 1962 scientists at General Electric and International Business Machines (IBM) almost simultaneously demonstrated the first semiconductor junction laser.

In 1962 Basov and Oraevskii proposed that rapid cooling could produce population inversions in molecular systems. And in 1966, the first gas-dynamic laser was successfully operated at the Avco Everett Research Lab.

Many new laser types were discovered, most notable among these are the semiconductor lasers. In these lasers electrical energy is converted directly into highly monochromatic radiation.

The 1970s years became the time of discovery of a free electron laser.

Laser applications have also increased in variety. Clearly, most optical experiments can be done at least as well with lasers as with conventional light sources and many can be done much better. Experiments requiring really high intensities in narrow spectral regions can only be made with lasers. Outside the field of scientific experimentation many applications were found in medicine, communications, geophysical and space exploration, military and metals technology. The potential importance of these applications continues to stimulate new developments in the laser field.

The 1964 Nobel Prize in physics was awarded to Charles Townes and to the Russian scientists Nikolai Basov and Alexander Prokhorov for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle.

***References***

*B.S. (B. Sc.) – Bachelor of Science; the first university undergraduate degree
*M.S. (M. Sc.) – Master of Science; the first university graduate degree
*Ph.D. – Doctor of Philosophy; a high rank university degree granted for some research
*in his teens – when he was between 13 and 19 years old

## COMPREHENSION CHECK

**Exercise 1.** ***Look at these two similar sentences. Which one is true?***

| | |
|---|---|
| 1. Ali Javan invented the first laser using a pink ruby medium. | 1. Physicist Mainman invented the first laser using a pink ruby medium. |
| 2. The first gas laser used helium and neon as the light emitting material. | 2. The first gas laser used helium as the light emitting material. |
| 3. The first semiconductor junction laser was demonstrated almost simultaneously by two companies. | 3. The first semiconductor junction laser was demonstrated by IBM corporation. |
| 4. Experiments requiring high intensities in narrow spectral regions can be made as well with lasers as with conventional light sources. | 4. Experiments requiring high intensities in narrow spectral regions can only be made with lasers. |

**Exercise 2.** ***Complete the sentences.***

1. The laser period opens with … .
a) the achievement of gas laser
b) the achievement of molecular laser
c) the achievement of ruby laser

2. It was … who invented the first operable laser.
a) Basov
b) Townes
c) Maiman

3. A laser invented by Ali Javan used … for the light emitting material.
a) ruby medium
b) a mixture of helium and nitrogen
c) a mixture of helium and neon

4. In semiconductor lasers electrical energy … into highly monochromatic radiation.
a) is induced
b) is converted
c) is excited

5. The 1964 Nobel Prize was awarded to Townes, Basov and Prokhorov for fundamental work in the field of … .
a) radioactivity
b) quantum electronics
c) wave optics

**Exercise 3.** ***Topics for discussion.***
1. What do you know about the development of lasers and their fields of application?
2. Could you make your suppositions about future applications of lasers?

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the synonyms.***

*Nouns*

| 1 | 2 |
|---|---|
| 1) head | a) significance |
| 2) coworker | b) creation |
| 3) discovery | c) chief |
| 4) importance | d) progress |
| 5) achievement | e) invention |
| | f) mixture |
| | g) colleague |

*Verbs*

| 1 | 2 |
|---|---|
| 1) require | a) show |
| 2) convert | b) invent |
| 3) demonstrate | c) turn into |
| 4) gain | d) demand |
| 5) suggest | e) declare |
| 6) announce | f) propose |
| | g) operate |
| | h) receive |

## LANGUAGE ACTIVITY

**Exercise 1.** ***State the part of speech of the following words and determine their meaning without using a dictionary.***
Recognition, demonstrate, mixture, molecular, continuously, exploration, spectral, amplifier, inversion, conventional, technology, successfully, conductor, importance, development.

**Exercise 2.** ***Find in the text of Unit 2 adjectives and adverbs (not mentioned in the previous exercise) and write down their degrees of comparison.***

**Exercise 3.** ***Give the three forms of the following verbs.***
Operate, lead, convert, do, amplify, emit, find, found, get, become, increase, employ, make, award.

**Exercise 4.** ***Fill in the blanks with*** **/ some / any / no / not any.**
1. … of these devices are based on the maser-laser principle. 2. I could not find … journal on my research work. 3. Will they have … lectures in physics next week? – No, they have … . 4. They carried out… experiments last month. 5. Do you know … other applications of lasers? 6. … effects of this phenomenon have been investigated. 7. There aren't … problems to be discussed at today's meeting.

**Exercise 5.** ***Translate the following sentences into Russian paying attention to the different meanings of "for".***
1. For a long time people did not know what substances consisted of. 2. The first manned space flight lasted for 108 minutes. 3. In semiconductors of p-type carriers act like positive charges, for the "hole" travels in a direction opposite to that of the electron filling it. 4. Super precise generators are of the greatest importance, for spaceships, for an example, cannot be guided accurately to other planets without such generators. 5. The considerable increase in sensitivity of radio receivers opens up great possibilities for radar, radio navigation, radio astronomy and other fields of science and technology.

**Exercise 6.**
***a) Study using "make" and "do".***
"Make" or "do"? In some contexts these two words have a similar meaning. However, there is a rule which says that "make" usually carries the idea of creation, construction.
*Example:* – Marry made this dress herself.
– This device was made by two students in one of the laboratories of the University.
– Second-year students will make experiments next year.

As for “do”, it is usually associated with work, particular activity.

*Example:* – Have you done your homework?
– We don’t do aerobics this year.
– He plans to do business.

However, there are many exceptions to these rules and specific uses of these verbs:
– to make a decision
– to make a mistake
– to make entry
– to make a device

but:
– to do a service
– to do subjects
– to do a favour
– to do without
– to do one’s best

***b) Now cross out incorrect variant:***

1. My mother doesn’t do/make housework.
2. Did he do/make many mistakes?
3. Every child must do/make his room.
4. Will you do/make a cup of coffee?
5. I will do/make all my best to help you.
6. I’d like to do/make you an offer.
7. Will you do/make me a favour and pass the bread.
8. My mother is going to do/make a cake for your birthday.
9. Now I can’t do/make without my computer.

***c) Analyze the usage of "make" or "do" in the text “Maser-Laser History”.***

## Unit 3

# Fundamental Principles

### WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

phenomenon, temperature, source, color, influence, avalanche, component.

*Verbs*

derive, excite, burn, trigger, evaporate, augment, multiply.

*Adjectives*

intense, pure, fundamental, light, sufficient, coherent, incandescent, equal, tremendous, identical.

**Exercise 2.** ***Read the given collocations and find their Russian equivalents:***

**I.**

a) high energy level, ordinary light source, stimulated emission, unstable atoms, heat-resistant material, energy state, wholly coherent light, incandescent lamp, resulting beam, powerful energy, electromagnetic avalanche;

b) components are in step with each other, to excite molecules, to reach high temperature;

**II.**

a) лампа накаливания, нестабильные атомы, энергетическое состояние, высокий энергетический уровень, мощная энергия, тугоплавкий материал, обычный источник света, электромагнитная лавина, вынужденное излучение, полностью когерентный свет, полученный пучок света;

b) возбуждать (накачивать молекулы), достигать высокой температуры, компоненты совпадают по фазе.

**Exercise 3.**

***a) Make adverbs from the following adjectives according to the model and translate them.***

*Model: adjective + -ly;*

usual, sufficient, tremendous, simple, exact, high, fundamental, independent, simultaneous, direct, real, whole.

***b) Pay special attention to the following prepositions after the given verbs (postpositions) and translate them. Make sentences of your own.***

To give up, to give off, to result in, to result from, to turn to, to turn over, to agree with, to agree to, to agree on (upon), to work in, to work at, to work on.

## UNDERSTANDING A PRINTED TEXT

**List of Terms:**

single color – одноцветный
evaporate – испарять(ся), выпаривать(ся)
heat-resistant material – тугоплавкий материал
coherent light – когерентный свет
resulting beam – полученный пучок света
electromagnetic avalanche – электромагнитная лавина
incandescent lamp – лампа накаливания

***Reading for precise information***

1. Any of a class of devices that produces an intense beam of light of a very pure single colour is called laser. This light beam may be intense enough to evaporate the hardest and the most heat-resistant material. Such light amplification by stimulated emission of radiation explains laser's fundamental principles.

2. Atom and molecules exist at low and high energy levels. Those at low levels can be excited to higher levels, usually by heat. After reaching the higher levels, they give off light when they return to a lower level. In ordinary light sources many excited atoms or molecules emit light independently and in many different colors (according to wavelengths). If, however, during the brief instant when an atom is excited, light of a certain wavelength influences it, the atom can be stimulated to emit radiation that is in phase (in step) with the wave that stimulated it. The new emission thus augments or amplifies the passing wave; if the phenomenon can be multiplied sufficiently, the resulting beam, made up of wholly coherent light (i.e., light of a single frequency or colour in which all the components are in step with each other) will be tremendously powerful.

3. Masers and lasers operate due to the way atoms within them absorb and release energy. Atoms can't take any amount of energy, they hold it only in fixed amount. So they absorb and emit only radio waves or light whose energy is exactly equal to the difference between any two of these fixed energy states.

4. By handling the atoms in just the right way, it is possible to "pump" the same amount of energy into a large number of them at once. But these "excited" atoms are highly unstable. When light of just the right energy passes through the excited gas, each photon can force an atom to give up its energy in the form of an identical photon. The two photons trigger other atoms, and an electromagnetic avalanche is under way. The resulting light can be millions of times brighter than an incandescent lamp burning at the same temperature.

5. The most essential property of the maser is that it can be an extremely low-noise device both as an amplifier and as an oscillator. It is therefore capable of amplifying signals at extremely low levels, and when used as an oscillator, it is capable of generating monochromatic radiation of extreme frequency stability.

6. When certain molecules are excited by electromagnetic radiations, they change energy levels. When they drop back to their previous levels, they give up energy. This is the basis for masers, lasers.

## COMPREHENSION CHECK

### Exercise 1. *Paragraph Study.*

***Paragraph 1.***

1. Identify the sentence which serves as an introduction to the text below.
2. Give a Russian equivalent of "the hardest and the most heat-resistant material".

***Paragraph 2.***

1. State the subject of the paragraph.
2. What energy levels do exist?
3. Find words or word combinations to Russian equivalents: различные цвета, длина волны, влиять, усиливать, достаточно, частота, составляющие (компоненты), мощный.

***Paragraph 3.***

1. State the main idea of the paragraph.
2. What is the principle of maser-laser operation?

***Paragraph 4.***

Identify the topic sentence and state which of the ideas of paragraph 3 is developed in this paragraph.

***Paragraph 5.***

1. State the subject of the paragraph.
2. Give Russian equivalents to: "low-noise device", "extremely low levels", "monochromatic radiation", "extreme frequency stability".

***Paragraph 6.***

State the main idea of the paragraph.

### Exercise 2. *Complete the sentences.*

| | |
|---|---|
| 1. Laser may be termed as … | a) a light of a single frequency or color. |
| 2. Coherent light is … | b) microwave amplification by stimulated emission of radiation. |
| 3. The word maser is an acronym for … | c) having one color. |
| 4. "Monochromatic" can be defined as … | d) a light amplification by stimulated emission of radiation. |

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match Russian and English.***

*Nouns*

| 1 | 2 |
|---|---|
| 1) device | a) состояние |
| 2) source | b) пучок |
| 3) state | c) устройство |
| 4) amount | d) стекло |
| 5) level | e) источник |
| 6) beam | f) количество |
| 7) phenomenon | g) уровень |
| | h) явление |
| | i) усилитель |

*Verbs*

| 1 | 2 |
|---|---|
| 1) resist | a) высвобождать |
| 2) influence | b) поглощать |
| 3) excite | c) достигать |
| 4) absorb | d) сопротивляться |
| 5) reach | e) расширять |
| 6) release | f) возбуждать |
| | g) влиять |
| | h) требовать |

## LANGUAGE ACTIVITY

**Exercise 1.** ***Translate the following sentences paying attention to "due to" and "is due to".***

Compare: due to – благодаря, вследствие, из-за;
is (are, was, were) due to – обусловлен

1. The first space flight became possible due to the efforts of many scientists. 2. Due to the phenomenon of stimulated emission and to the feedback mechanism laser radiation has special characteristics. 3. There is a theory that magnetism is due to electric currents which flow around the Earth. 4. Due to external energy affecting enough atoms, their internal energy can be triggered. 5. Due to the failure with the new device further development of the project was stopped.

**Exercise 2.** ***Translate the following sentences:***

a) 1. The studies of the radio waves from some stars in galaxy resulted in the discovery of the stellar water maser. 2. Some natural bodies give off light in a dark room. 3. The success with the development of masers and lasers resulted in new discoveries in the physics of atom. 4. The scientists of the Institute of Physics were working at the concept of information transmission by means of laser beams. 5. In many laboratories scientists turned to other promising laser uses.

b) 1. The problem the scientists are working on is connected with a new source of radiation. 2. The laboratory they are working in is large. 3. The results you are speaking about were obtained in our laboratory. 4. The elements water consists of are hydrogen and oxygen. 5. In electron tubes the secondary electrons may be attracted back to the electrode they come from.

**Exercise 3.** ***From the sentences given below form interrogative sentences; for doing that:***

a) put general question to each sentence;
b) put special questions to underlined words.

1. <u>Lasers</u> are successfully used <u>in technology</u>.
2. The new electronic device has many applications <u>in space communications</u>.
3. <u>In the XX century</u> chemists discovered <u>new elements</u>.
4. <u>As the equipment was repaired</u> <u>we</u> could continue our work.
5. <u>The quantum theory</u> became <u>the basis for the development of lasers and masers</u>.
6. Two laser beams <u>were acting</u> <u>simultaneously.</u>

**Exercise 4.** ***Confirm the expression using Tag Questions.***

1. We use electricity to produce heat, … ?
2. This student made a report at the conference, … ?
3. The scientists were astonished to discover masers in the galaxy space, … ?
4. You were not ready to continue this work, … ?
5. Many laser physicists have been awarded a Nobel Prize, … ?
6. The experimentalists couldn't obtain wholly coherent beams of light, … ?

**Exercise 5.** ***Put the verbs of the sentences into negative form.***

1. Quantum electronics includes a group of new devices.
2. We could make use of this new method.
3. Optical electronics has opened the way to further inventions.
4. We have possibility to study the works of our colleagues.
5. Thompson helped develop a new research laboratory at Cambridge.
6. Light wave technology may be used in communication.
7. Atoms travelling through precisely controlled laser beam lose speed and energy.
8. The group of researchers demonstrates their optical quantum generator.

**Exercise 6.** ***In the texts about lasers you have come across such adverbs as "considerably", "frequently", "continuously" etc. Let's recollect what an adverb is.***

These are words which inform us about:

1) how something is done (quickly, slowly, carefully, on foot, by bus, etc.). These are adverbs and adverbial phrases of manner;
2) where something is done (there, at home, in England, on Web, at work, etc.). These are adverbs and adverbial phrases of place;
3) when something is done (yesterday, today, next week, at 5 o'clock, etc.). These are adverbs and adverbial phrases of time.

Now, you should remember the order of these words in a sentence: it is "manner-place-time".

*Example:* Our students made this experiment successfully last week.

However this order changes as soon as we meet "movement verbs". Then the order is: "place-manner-time".

*Example:* We went to the Computing laboratory quickly after classes.

Try this exercise:

1. I worked (at the office, hard, today).
2. I'm travelling (every summer, by bicycle, to my native village).
3. He studied (last year, a lot, at university).
4. I drive (every morning, to work).
5. The friend walked (through the park, home, this afternoon).
6. The orchestra performed (at the concert, magnificently, last night).
7. She translated the text (quickly, yesterday, at the lesson).
8. The engineers return (by plane, to France, every weekend).

**Exercise 7.** ***Read and give Russian equivalents to the adverbs with two forms and differences in meaning.***

| | | | |
|---|---|---|---|
| deep = a long way down | full = exactly, very | late = not early | wide = fully; off target |
| deeply = greatly | fully = completely | lately = recently | widely = to a large extent |
| direct = by the shortest route | hard = intently: with effort | near = close | wrong = incorrectly |
| directly = immediately | hardly = scarcely | nearly = almost | wrongly = incorrectly; unjustly |
| easy = gently and slowly | high = at/to a high level | short = suddenly; off target | |
| easily = without difficulty | highly = very much | shortly = soon | |
| free = without cost | last = after all others | sure = certainly | |
| freely = willingly | lastly = finally | surely = without doubt | |

**Exercise 8.** ***Fill in: hard, hardly, hardly ever / anyone / anything.***

All that day, I'd been thinking **1) *...hard...*** to myself about whether or not to go to Jane's party. I **2)** ................ go to parties, but this time I thought I'd make an effort. I worked **3)** ............... all day so that I could leave early and get ready. When I got home, I looked for something nice to wear, and eventually decided on the red dress that I had **4)** ............... worn and **5)** ............... had seen me in before. Unfortunately, I got caught in the rain and when I eventually arrived there was **6)** ............... left, just a couple of Jane's friends. I had **7)** ............... talked to them before so making conversation was very **8)** .............. . As I had eaten **9)** .............. all day, I spent the rest of the party in the kitchen alone!

**Exercise 9.** ***Underline the correct item, then explain the difference in meaning.***

1. The soldier **near / <u>nearly</u>** died as a result of being hit **<u>full</u> / fully** in the chest by a bullet, which penetrated **<u>deep</u> / deeply** inside him.
2. Simon told everyone he would pass the exam **easy / easily**, so he was **deep / deeply** embarrassed when he came **last / lastly** in the class, with 20%.
3. "I **sure / surely** am happy to meet you," said the reporter to the **high / highly** respected singer."
4. When he was almost **full / fully** recovered from his illness the doctor told him to take it **easy / easily** and said that he would be able to return to work **short / shortly.**
5. As he was found **near / nearly** the scene of the murder with a knife in his hand, it is **hard/ hardly** surprising that he was **wrong / wrongly** accused.
6. **Sure / Surely** you can't have answered every question **wrong / wrongly.**
7. Rob was a very poor archer. His first arrow fell **short / shortly** of the target, his second flew about 10 metres **wide / widely** and the third flew **high / highly** into the air and landed behind him.
8. Although he arrived an hour **late / lately**, he started work **direct / directly** and tried **hard / hardly** to make up for lost time.
9. **Lately / Late** she has been getting all her clothes **freely / free** from the fashion company, so I can't understand why she doesn't dress more **prettily / pretty.**
10. It is **wide / widely** believed that there is a bus that goes **direct / directly** from here to the airport, but it's not true.
11. **Last / Lastly**, I would like to say that I would **free / freely** give my life for the cause of world peace.

**Exercise 10.** ***Using the rule of the word order arrange the given group of words to make a right (correct) English sentence.***

1. To, new, began, we, develop, devices.
2. Application, light, in, the, has, century, last, found, new, the.
3. Physicist, theory, the, famous, formulated, quantum, Plank, the.
4. Physical, students, year, not, last, optics, did, study.
5. The basis, lasers, quantum, is, for, the, of, theory, masers, development, the, and.
6. New, the week, carefully, examine, the, apparatus, experts, this, all, laboratory, our, in.

**Exercise 11.** ***Put the words given below into the comparative and superlative degrees:***

a) intense, pure, light, sufficient, simple, hard, high, relevant, real, easy, good, bright, bad;
b) exactly, sufficiently, highly, quickly, well, badly, often.

**Exercise 12.** ***Translate into Russian, paying attention to the degrees of comparison of adjectives.***

1. Laser beam is much brighter than any ordinary light beam.
2. The subject of geometrical optics is not so difficult to study as the subject of physical optics.
3. You have chosen for our meeting the least suitable moment.
4. The more you learn, the more you understand that you know so little yet.
5. Stars are still being formed in the nearest region of the galaxy.
6. Some elements emit the least intense radiation of all the Universe molecules.
7. We cannot work further without any rest.
8. Usually administration wants employee to do more work for less money.
9. The report was as long as it was not interesting.
10. The more I worked with this device, the less satisfactory the results were.

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 13.** ***Translate the text using the words given below.***

1) super high frequency range
2) stimulated emission
3) on the other hand
4) may be considered
5) high frequency electromagnetic energy
6) as a rule
7) for a short period of time
8) branch

Появление лазеров было результатом работ по созданию генераторов СВЧ-диапазона (1) (мазеров). Обычно лазер определяют как генератор электромагнитного излучения оптического диапазона, основанный на использовании вынужденного излучения (2). С другой стороны (3) квантовый генератор (лазер) может рассматриваться (4) как техническое устройство для преобразования энергии в электромагнитную энергию высокой частоты (5) (как правило (6), видимой или инфракрасной). Изобретение лазеров является одним из наиболее выдающихся достижений науки и техники XX века. Первый лазер появился в 1960-ом году. С тех пор происходит интенсивное развитие лазерной техники. В короткое время (7) были созданы разнообразные типы лазеров и лазерных устройств для решения конкретных научных и технических задач. Лазерная техника сравнительно молода, однако, лазеры уже широко применяются во многих отраслях (8) народного хозяйства и в промышленности.

## Unit 4

### WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

hydrogen, nebula, colleague, evidence, diameter, fuel, oxygen, galaxy.

*Verbs*

dub, vibrate, function, collapse, identify.

*Adjectives*

variable, giant, wrong, nuclear, circumstellar, bright, primary.

**Exercise 2.** ***Translate the following international words.***

Recombination (n), photon (n), phonon (n), radiation (n), spectral (a), emission (n), discrete (a), vibration (n), monochromaticity (n), material (n), lens (n), optical (a), economical (a), diode (n), communication (n), position (n), object (n).

**Exercise 3.** ***Match the Russian equivalents to the given collocations:***

a) significant stage of the lasers development; to emit the brightest radiation; the nebula in the nearest region of the galaxy; infrared light; interstellar gas masers; to use a nuclear fuel; to study oxygen and hydrogen molecules;

b) знаменательный этап в развитии лазеров; использовать ядерное топливо; инфракрасное излучение; туманность в ближайшем регионе галактики; космические газовые мазеры; излучать самую яркую радиацию; изучать молекулы кислорода и водорода.

### UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

hydroxide (OH) – окись водорода
Universe molecules – молекулы Вселенной
Orion Nebula – туманность Ориона
line intensity – интенсивность спектральной линии
interstellar OH maser – космический мазер на окиси водорода
nuclear fuel – ядерное топливо
oxygen –кислород
hydrogen – водород
hydroxyl - гидроксильный
circumstellar shell – околозвездная оболочка
molecular energy level – энергетический уровень молекул
silicon monoxide – окись кремния

*Reading and entitling the text*

1. Significant stage in the study of masers became 1963 when Harold Weaver and his radio astronomers at Berkeley were studying the radio waves emitted by hydroxide (OH)* groups in the Orion Nebula, the nearest region in the galaxy where stars are still being formed. Hydroxide emits some of the brightest radiation of all Universe molecules.

2. Weaver and his colleagues were astonished to find that one part of the nebula showed an unusual emission spectrum. Its line intensities were all wrong, and one was so strong that Weaver suspected it of belonging to a different molecule. They dubbed it Mysterium*.

3. Before long, however, the evidence was clear: Mysterium was simply OH. But the OH had formed a natural maser. The molecules were being pumped by infrared light from nearby gas clouds that were collapsing to form stars. Since then, hundreds of interstellar OH masers have been discovered.

4. In 1968 radio astronomers at MIT discovered a second type of OH maser, invariable red giant stars. With diameters several hundred times that of the sun, these stars have burned their primary nuclear fuels and are gradually dying. As they tremble and vibrate, they eject gas that forms a shell around the star. When this cools to a few hundred degrees Kelvin, it forms molecules that can function as masers.

5. The next year brought the discovery of the stellar water maser. Soon after came the strangest one of all: the silicon monoxide (SiO) maser. Unlike the abundant oxygen and hydrogen of hydroxyl and water masers, silicon is relatively rare. Stranger still, when astronomers identified the exact molecular energy levels in these masers, the SiO molecules proved to be between two highly excited states. Such stellar masers can exist only in regions of the circumstellar shell that are at about 1,000 degrees Kelvin.

***References***

*for reading chemical formulas study Appendix I.

* Mysterium - (Latin) is said about something that is impossible to understand or explain.

**COMPREHENSION CHECK**

**Exercise 1.** ***Choose the suitable headlines for each paragraph of the text.***

1. a) The prehistory of the interstellar masers discovery.
   b) The results of the interstellar masers discovery.
   c) The reason of the interstellar masers discovery.

2. a) The influence of Mysterium on the discovery of interstellar masers.
   b) The discovery of an unusual emission spectrum.
   c) An unusual emission of Mysterium.

3. a) The discovery of the method of molecules' pumping.
   b) The discovery of hundreds of natural masers.
   c) The discovery of infrared light in interstellar space.

4. a) The second type of OH masers discovered by MIT astronomers.
   b) Red giant stars discovered by astronomer at Berkeley.
   c) Nuclear fuels as the essential source of natural masers.

5. a) Oxygen and hydrogen as the main building materials for water and silicon lasers.
   b) Identification of the molecular energy level in natural masers.
   c) The stellar water and silicon dioxide masers' discovery.

**Exercise 2.** ***Give your own title to the whole text.***

**Exercise 3.** ***Join suitable parts.***

| | |
|---|---|
| 1. Hydroxide emits some of … | a) the circumstellar shell that are at about 1,000 degrees Kelvin. |
| 2. The diameters of red giant stars are … | b) the brightest radiation of all Universe molecules. |
| 3. Such stellar masers can exist only in the regions of … | c) an unusual emission spectrum. |
| 4. Hundreds of interstellar OH masers … | d) several hundred times that of the Sun. |
| 5. One part of the nebula showed … | e) have been discovered. |

**Exercise 4.** ***Arrange the sentences in their logical order.***
1. Mysterium was a OH molecule that had formed a natural maser.
2. After this discovery hundreds of interstellar OH masers have been discovered.
3. They found an unusual emission spectrum of a molecule that they dubbed Mysterium.
4. The discovery of interstellar masers started when Harold Weaver and his colleagues were studying the radio waves emitted by hydroxide (OH) groups in the nearest region of the galaxy.
5. OH molecules were being pumped by infrared light from nearby gas clouds that were collapsing to form stars.

## INCREASE YOUR VOCABULARY

**Exercise 1.**
***a) Match the synonyms.***

| 1 | 2 |
|---|---|
| 1. to eject | a) to reach |
| 2. to collapse | b) to be a member of |
| 3. to give off | c) to manipulate |
| 4. to augment | d) to break to pieces |
| 5. to handle | e) to release |
| 6. to achieve | f) to expel |
| 7. to belong | g) to increase |
| | h) to suspect |
| | i) to exist |

***b) Find Russian equivalents to English adjectives.***

| 1 | 2 |
|---|---|
| 1. evident | a) яркий |
| 2. nearby | b) точный |
| 3. rare | c) равный |
| 4. significant | d) мощный |
| 5. equal | e) очевидный |
| 6. bright | f) определенный |
| 7. powerful | g) ближайший |
| 8. certain | h) важный |
| 9. exact | i) редкий |
| | j) видимый |
| | k) незначительный |

## LANGUAGE ACTIVITY

**Exercise 1.** ***State the part of speech of the following words and determine their meaning without using a dictionary:***
1) approximate, to approximate, approximation, approximative, approximately;
2) most deficient, deficiency;
3) to emit, emitter, emission, emissive, emissivity;
4) use, to use, user, using, usage, useless, useful, usefulness.

**Exercise 2.**
***a) Make up singular-plural pairs.***
Phenomenon, spectra, index, spectrum, radius, indices, phenomena, radii.

**Exercise 3.** ***Divide the following sentence into three simple sentences.***
The first such laser was described by Giftan and co-workers, who operated a ruby laser 6 cm long and 0.6 cm in diameter, with an input energy of only 150 joules, which was only a small fraction of the energy required for the same ruby in the helical configuration.

**Exercise 4.**
***a) Choose the correct modal verb.***
Можно передать / (must, may, can) be transferred
Нельзя собрать / (must not, cannot, may not) be collected
Нужно придать параллельность / (must, may, can) be collimated
Нельзя обеспечить / (must, can, cannot) be provided
Можно возобновить / (must, can, cannot;) be resumed
Нужно получить / (must, can, cannot) be obtained

***b) Translate from English into Russian, paying attention to modal verbs.***
1. The diode radiation can be collected by a simple lens. 2. Illumination of a semiconductor may be followed by various consequences, electron conductivity, "intrinsic" photoconductivity, impurity or defect photoconduction. 3. A conductor and an insulator must be distinguished by their extreme values of electrical conductivity.

## REVIEW OF CHAPTER I

**Exercise 1.** ***Write a brief summary of the texts.***
Define the main problems dealt with in the texts. Try to use the following words and expressions in your summary: the article covers the period (periods), special attention is given to, thus, hence, that's why.

**Exercise 2.** ***Topics for discussion on the material of Chapter I.***
1. How many stages in maser-laser history can you find?
2. Who contributed much to the development of masers and lasers?

# Chapter II
# Lasers

## Unit 5
## Types of Lasers

### WORD STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

species, ion, scheme, threshold, garnet, target, consequence, designator, ruby.

*Verbs*

yield, broaden, vibrate, summarize, require.

**Exercise 2.** ***Make nouns from the following verbs according to the models and translate them.***

*Verb + ing*

advert, process, tabulate, hold, reason, begin.

*Verb + er/or*

use, develop, design, manufacture, assemble, program, invent, perform, collect.

*Verb + ment*

develop, improve, advertise, equip, require, advance, move, announce, disappoint, govern.

### UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

active species – активные частицы
transition element – переходный элемент
decay time – время распада (затухания)
rangefinder – дальномер
strained crystal – деформированный кристалл
target designator – распознаватель цели
cw laser (continuous wave) – лазер непрерывного действия
Q-switched operation – режим модуляции добротности
low repetition rate – низкая скорость повторения
population inversion – инверсия населённости
cavity – резонатор
material processing – обработка материалов
solid-state laser – твёрдотельный лазер
rod – стержень

tunable radiation – перестраиваемое излучение
unfilled shells – незаполненные оболочки
electric dipole interaction – электродипольное взаимодействие
medium – среда
impurity - примесь

### *Comprehensive reading*

Here we'll consider the main types of lasers: (1) solid-state (crystal or glass) lasers, (2) gas lasers, (3) dye lasers, (4) chemical lasers, (5) semiconductor lasers, (6) color center lasers, (7) free-electron lasers and (8) X-ray lasers.

#### Solid-State Lasers

The term "solid-state laser" is usually reserved for those lasers that have as their active medium either an insulating crystal or a glass. Solid-state lasers often use as their active species impurity ions introduced into an ionic crystal. Usually the ion belongs to one of the series of transition elements in the Periodic Table.

The transitions used for laser action involve states arising from the inner unfilled shells. These transitions are therefore not strongly influenced by the crystal field. Furthermore, these transitions are forbidden by electric dipole interaction so that the spontaneous decay time falls in the millisecond rather than in the nanosecond range as for electric dipole allowed transitions.

#### The Ruby Laser

This type of laser was the first to be made to operate (T.H. Maiman, June 1960) and still continues to be used. Ruby, which has been known for hundreds of years as a naturally occurring precious stone, is a crystal of corundum in which some of the $Al^{3+}$ ions are replaced by $Cr^{3+}$ ions.

Ruby lasers, once very popular, are now less widely used, since they have been replaced by competitors, such as Nd:YAG or Nd:glass lasers. Ruby lasers are, however, still commonly used for a number of scientific and technical applications where the shorter wavelength of ruby compared to Nd:YAG represents a considerable advantage (such as pulsed holography, where Nd:YAG cannot be used owing to the lack of response of the photographic films at the longer wavelength of the Nd:YAG laser). Ruby lasers were extensively used in the past for military rangefinders, an application in which this laser is now completely replaced by Nd:YAG or Nd:glass lasers.

#### Neodymium Lasers

Neodymium lasers are the most popular type of solid-state laser. The laser medium is commonly called YAG (an acronym for *yttrium aluminum garnet*). Nd:YAG lasers can operate either cw (*continuous wave* ) or pulsed.

Nd:YAG lasers are widely used in a variety of applications, among which we mention (1) ranging (most military laser rangefinders and target designators now use Nd:YAG lasers); (2) scientific applications (Q-switched lasers); (3) material processing (cutting, drilling, and welding etc.); (4) medical applications (photocoagulation).

### Nd:Glass Lasers

From an engineering viewpoint, i.e., in terms of pumping configurations and rod dimensions, the most commonly used Nd:glass lasers do not differ greatly from those used for Nd:YAG lasers. Nd:glass lasers are often used in applications where a pulsed laser of low repetition rate is required. This is the case for some military rangefinders and for some scientific Nd:glass lasers. A very important application of Nd:glass is as laser amplifiers in the very high energy systems used in laser-driven fusion experiments.

### Alexandrite Laser

This laser may be considered as the representative of a large class of solid-state lasers. Alexandrite lasers are similar to Nd:YAG lasers and their better performance is obtained at increased temperatures. These lasers are often operated at ~ $100^0$ C. Alexandrite lasers are useful when high average power is needed where tunable radiation is required.

## COMPREHENSION CHECK

**Exercise 1.** ***Answer the questions using the information from the text.***

1. What types of lasers are called solid-state ones?
2. What kind of these lasers was the first to start operating?
3. Ruby lasers are still widely used in pulsed holography, for example. Why?
4. What kind of solid-state lasers is the most popular? How can it operate?
5. Where are Nd:YAG lasers used?

**Exercise 2.** ***Say what you have learnt about solid-state lasers. Begin your story with the phrases listed below:***

After that …

Now it's widely known that …

Solid-state lasers are divided into …

**Exercise 3.** ***Join suitable parts.***

1. Solid-state lasers use as their active medium…

a) insulating crystals

b) neutral atoms in gaseous form

c) transitions between vibrational levels

d) solutions of certain organic dye compounds.

2. The most popular types of solid-state lasers are …

a) ruby lasers

b) Alexandrite lasers
c) Neodymium lasers
d) Nd:glass lasers.

3. Ruby lasers were extensively used in the past for military rangefinders. Now they are completely replaced by…
a) Neodymium lasers
b) Nd:YAG lasers
c) Alexandrite lasers
d) ion lasers

4. The ruby laser was put into operation in…
a) 1930
b) 1965
c) 1950
d) 1960

5. What kinds of lasers can operate either cw or pulsed?
a) ruby lasers
b) Alexandrite lasers
c) Nd:YAG lasers
d) Nd:Glass lasers

## INCREASE YOUR VOCABULARY

**Exercise 1. Match the synonyms.**

*Verbs*

| 1 | 2 |
|---|---|
| 1. influence | a. demand |
| 2. allow | b. think |
| 3. occur | c. permit |
| 4. require | d. decompose |
| 5. consider | e. affect |
| 6. decay | f. happen |
| 7. broaden | g. expand |
| | h. involve |
| | i. provide |
| | j. offer |

*Nouns*

| 1 | 2 |
|---|---|
| 1. use | a. purpose |

| | |
|---|---|
| 2. dimension | b. application |
| 3. form | c. work |
| 4. aim | d. size |
| 5. operation | e. synthesis |
| 6. efficiency | f. configuration |
| 7. fusion | g. transition |
| | h. coefficient |
| | i. interaction |
| | j. difference |

*Collocations*

| 1 | 2 |
|---|---|
| 1. in the same manner | a. thanks to |
| 2. in addition to | b. it's important |
| 3. in terms of | c. besides |
| 4. owing to | d. is substituted |
| 5. it's worth | e. similarly |
| 6. is completely replaced | f. from a viewpoint |
| 7. in a variety of | g. furthermore |
| | h. in a great number |
| | i. usually |
| | j. in fact |

**Exercise 2.** ***Translate the following word combinations knowing that the reference word is the last one.***
*Example:* electron current flow – течение электронного тока.

Semiconductor lasers, solid-state lasers, impurity ions, electric dipole interaction, spontaneous decay time, crystal growth, green and violet absorptions bands, three-level scheme, required threshold pump energy, typical doping levels, peak emission cross section.

**Exercise 3.** ***Give explanation of these terms in English.***
Solid-state lasers, rangefinder, YAG, cw laser.

**Exercise 4.** ***Translate the following sentences paying attention to noun word-groups.***

1. A certain equilibrium state between the opposite processes exists at every temperature.
2. A simplified energy-level scheme of this laser will be discussed later.
3. A very important application of Nd : glass is as laser amplifiers in the very high energy systems used in laser-driven fusion experiments.

4. Since the laser bandwidth is very large, the peak emission cross section is nearly 60 times smaller than that of Nd : YAG.
5. For a given discharge current, these various processes of excitation and deexcitation lead eventually to some equilibrium distribution of population among the energy levels.
6. Metal vapor lasers also constitute a large class of lasers.

**Exercise 5.** ***Choose English equivalents of the Russian words and word combinations from the list given below. Translate the sentences into Russian.***

1. Laser action is obtained from transitions of the neon atom, (в то время как) helium is added to the gas mixture to greatly facilitate the pumping process.
2. (По этой причине [Для этого]) commercially available He-Ne lasers are provided with a power supply.
3. In the case of an ionized atom, the scale of energy levels is expanded (по сравнению с) neutral atoms.
4. Ruby lasers are, however, still commonly used for (множества) scientific and technical applications.

Since, in comparison with, results in, while, the same, a number of, in terms of, for this reason, in addition to, in accordance with.

**LANGUAGE ACTIVITY**

**Exercise 1.** ***Choose the correct degree of comparison.***

1. In vibrational excitation the atoms of the molecule vibrate in relation to each other. This kind of excitation requires (less, the least) energy than electronic excitation.
2. It must be remembered that the normal eye is far (more, the most) sensitive to the visible spectrum than (more, the most) delicate bolometers.
3. A population inversion is then created by electromagnetic waves with energies (greater, the greatest) than the gap between the valence and conduction bands.
4. The doping levels used in Nd:glass are somewhat (higher, the highest) than the value for Nd:YAG.

**Exercise 2. State different meanings of "*that (those)*":**

a. тот, этот
b. что
c. который
d. заменитель существительного (that of)
e. то есть [that is = i.e. ( id est - лат.)]
f. именно, только лишь (it is …that – усилительный оборот)
g. то, что

1. It is also worth pointing out *that* ruby lasers were extensively used in the past for military rangefinders.

2. Gas lasers are usually excited by electrical means, *i.e.,* pumping is achieved by passing a sufficiently large current through the gas.
3. One of the most characteristic features of the He-Ne laser is *that* the output power does not increase monotonically with discharged current but reaches a maximum and thereafter decreases.
4. Since these pure rotational lasers are relatively less important than the other categories, we shall not discuss them further in the sections *that* follow.
5. *That* metals are good conductors of electricity is known to everybody.
6. *It was* the nature of p-n junction *that* happened to be one of the most difficult things for scientists.
7. At *that* time the engineers were testing a new semiconductor for the application in industry.
8. Semiconductor is a material having an electrical conductivity intermediate between *that* of metals and insulators.
9. Output energy and peak power in Q-switched operation are comparable to *those* obtainable with a Nd:YAG rod of comparable dimensions.
10. This was the laser scheme *that* was proposed in the original paper of Schawlow and Townes.

**Exercise 3.** ***Put the verbs in brackets into the correct tense form according to the Sequence of Tences rule.***

1. It is apparent that fiber optics steadily (to replace) copper wire as an appropriate means of communication signal transmission.
2. He said that fiber optics (to use) light pulses to transmit information.
3. The students were told that today more than 80 percent of the world's long-distance traffic (to be carried) over optical fiber cables.
4. They knew that lenses (to date back) to the burning glasses of antiquity.
5. The Danish astronomer Olaf Roemer calculated that the light (travel) a distance equal to the diameter of the Earth's orbit around the Sun for about 22 minutes.
6. In the $19^{th}$ century none could predict that it (to be possible) to produce images of high-speed events.

**Exercise 4.** ***Summarize your knowledge of the Sequence of Tenses and the Reported Speech, and put the verbs in brackets into right form.***

1. The librarian says that she (to work) at a primary school in Seattle.
2. The teacher said that her pupil (to be) a very smart boy.
3. We know that experts (to elaborate) new data transmitting technologies.
4. Alexander Graham Bell declared that he (to work out) an optical telephone system.
5. The Corporation sells its transmitters and receivers on the terms it previously (to insist on).
6. It is known that Robert Maurer, Donald Keck and Peter Schultz (to invent) fiber optic wire.

**Exercise 5.** ***Translate from Russian into English.***

1. В этом тексте даётся описание твёрдотельного лазера. 2. Первый рубиновый лазер был создан в 1960 году. 3. Обычно лазер используется как источник излучения. 4. Основные свойства лазерного излучения – высокая интенсивность, узкая полоса частот, направленность и когерентность. 5. Резонатор лазера состоит из двух параллельных зеркал. 6. Твёрдотельные лазеры, как правило, работают в импульсном режиме.

## Unit 6

# Gas Lasers

## WORD STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

dye, scintillator, curve, dimmer, angle, vibration, vapor, collision, pulse, circumstance, significance, nitrogen, oxygen.

*Adjectives*

dynamic, radial, longitudinal, visual, creative, comparable, intermediate, spontaneous.

**Exercise 2.** ***Make different parts of speech from the following words according to the models.***

*Noun + ive = adjective*

effect, act, excess, success.

*Adjective + ly = adverb*

sufficient, special, notable, rotational, vibrational, intermediate, spontaneous, optic.

*Noun + less = adjective*

use, increase, help, shape, color.

*Noun + ic = adjective*

ion, electron, atom, base.

**Exercise 3.** ***Read and translate the words paying attention to the meaning of the prefix " semi".***

Semiconductor, semi-conductive, semi-conductivity, semiautomatic, semicircle, semifinal, semi-period, semi-terminating, semi-reflecting.

## UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

line-broadening mechanism – механизм уширения линии
ground state – основное состояние
peak spectral wavelength – длина волны в максимуме спектра
optical power output – оптическая мощность на выходе
pulsed operation = pulsed regime (condition) – импульсный режим
continuous operation – непрерывное действие
excitation rate – скорость возбуждения
stimulated emission – вынужденное излучение
noble gas – благородный газ

metal vapor laser – лазер на парах металла
optical pumping – оптическая накачка
vibrational level – колебательный уровень
lower(free) state – свободное состояние
rotational laser – лазер на вращательных переходах
gold vapor laser – лазер на парах золота
vibronic laser – лазер на колебательных переходах
vibrational-rotational lasers – лазеры на колебательно-вращательных переходах
character reading – считывание (распознавание) символов
alignment – настройка, выравнивание
deexcitation – снятие возбуждения
discharge current – разрядный ток
distribution of population – распределение населённости
self-terminating transition – самоограниченный переход
output power - выходная мощность
UV source - источник ультрафиолетового света

***Reading for precise information***

In general, for gases, the broadening of the energy levels is rather small since the line-broadening mechanisms are weaker than in solids. The importance of these lasers lie more in its historical significance since it was the laser scheme that was proposed in the original paper of Schawlow and Townes. Gas lasers are usually excited by electrical means, i.e., pumping is achieved by passing a sufficiently large current (which may be continuous or pulsed) through the gas.

Once a given species is in its excited state, it can decay to lower states, including the ground state, by four different processes: (1) collisions between an electron and the excited species; (2) collisions between atoms; (3) collisions with the walls of the container; and (4) spontaneous emission. These various processes of excitation and deexcitation lead eventually to some equilibrium distribution of population among the energy levels. A population inversion in a gas is a more complicated process than in a solid-state laser, owing to the large number of phenomena involved. We can say that a population inversion between two given levels will take place when either (or both) of the following circumstances occur: (1) the excitation rate is greater for the upper laser level than that for the lower laser level, and (2) the decay of the upper laser level is slower than that of the lower laser level. The latter is a necessary condition for cw operation. If this condition is not satisfied, however, laser action can still occur under pulsed operation provided condition (1) is fulfilled (self-terminating lasers).

## Molecular Gas Lasers

These lasers exploit transitions between the energy levels of a molecule. Depending on the type of transition involved, molecular gas lasers can be placed in one of the three following categories: (1) Vibrational-rotational lasers. These lasers use transitions between vibrational levels of the same electronic state (the ground state). (2) Vibronic lasers which use transitions between vibrational levels of different electronic states. The most notable example of this category of laser is the nitrogen laser. A special class of laser, which can perhaps be included within the vibronic lasers, is the excimer laser. (3) Pure rotational lasers, which use transitions between different rotational levels of the same vibrational state.

**Neutral Atom Lasers**

Neutral atom lasers make use of neutral atoms in either gaseous or vapor form. Neutral atom gas lasers constitute a large class of lasers and include in particular most of the noble gases (He, Ne*). Metal vapor lasers also constitute a large class of lasers, including, for example, Pb, Cu*. All metal vapor lasers are self-terminating and are therefore operated in a pulsed regime.

**Helium-Neon Lasers**

The He-Ne laser is certainly the most important of the noble gas lasers. One of the most characteristic features of the He-Ne laser is that the output power does not increase monotonically with discharge current but reaches a maximum and thereafter decreases. For this reason commercially available He-Ne lasers are provided with a power supply designed to give only the optimum current.

He-Ne lasers oscillating on the red transition are widely used for many applications where a low-power visible beam is needed (e. g., alignment, character reading, metrology, holography, video disk memories).

Copper vapor lasers are used for many scientific applications and for some industrial applications (such as high-speed photography). Gold vapor lasers are increasingly used for photodynamic therapy of tumors.

**Ion lasers**

Ion lasers typically operate in the visible or ultraviolet regions. As in the case of neutral atom lasers, ion lasers can be divided into two categories; (1) ion gas lasers; (2) metal vapor lasers, the most notable example of them is the He-Cd laser.

He-Cd* lasers are attractive for many applications where a blue or UV* beam of moderate power is of interest (e.g., high-speed laser printers, holography).

**Excimer Lasers**

Excimer lasers represent an interesting and important class of molecular lasers involving transitions between different electronic states. This type of laser has two peculiar but important properties, both due to the fact that the ground state is repulsive. (1) Once the molecule, after undergoing the laser transition, reaches the ground state, it immediately dissociates. This means that the lower laser level will always be empty. (2) No well-defined rotational-vibrational transitions exist, and the transition is relatively broad-band.

Excimer lasers are used to ablate very accurately defined regions of various materials in applications related to electronic printed circuits and also for ablating biomedical material. Excimer lasers are also widely used in scientific research and find numerous applications in which a strong and efficient UV source is required (such as in the field of photochemistry).

## COMPREHENSION CHECK

**Exercise 1.** ***True or false? Find phrases in the text that support your point of view.***

1. Molecular gas lasers exploit transitions between the energy levels of a molecule.
2. Vibrational-rotational lasers use transitions between vibrational levels of different electronic states.
3. All metal vapor lasers are not self-terminating ones.
4. The He-Ne laser is the most important of the noble gas lasers.
5. Ion laser operate in the visible or ultraviolet regions.
6. Two peculiar properties of excimer lasers are explained by the fact that the ground state is repulsive.

**Exercise 2.** ***Try to give your explanation of the following terms.***

Chemical efficiency; bound-bound transition; excimer laser; molecular gas laser.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the antonyms.***

*Adjectives*

| 1 | 2 |
|---|---|
| 1. narrow | a. liquid |
| 2. quiet | b. pulsed |
| 3. light | c. noisy |
| 4. solid | d. simple |
| 5. continuous | e. considerable |
| 6. space | f. wide |
| 7. complicated | g. ground |
| | h. dark |
| | i. complex |
| | j. large |

*Nouns*

| 1 | 2 |
|---|---|
| 1. difference | a. stagnation |
| 2. emission | b. increase |
| 3. decrease | c. similarity |
| 4. development | d. absorption |
| 5. excitation | e. element |

| | |
|---|---|
| 6. compound | f. relaxation |
| | g. mixture |
| | h. vibration |

**LANGUAGE ACTIVITY**

**Exercise 1.** ***State the function and translate the verb*** *"to be"* ***according to the list given below:***

a. смысловой глагол
b. вспомогательный глагол, образующий страдательный залог
c. входит в состав общепринятых выражений и не переводится
d. глагол-связка
e. that is = то есть
f. вспомогательный глагол, образующий группу продолженных времён
g. to be to = must

1. The working element of the ruby laser *is* a cylinder of pink ruby containing 0.05 per cent chromium.
2. In the commonly used laser configuration a ruby rod *is surrounded* by the coils of a helical flashlamp operated usually for a few milliseconds with an input energy of 1000 to 2000 joules.
3. The narrowing of the linewidth *is due to* effect of the resonant cavity formed by the mirror.
4. Why *is it difficult* for scientists to compare performance of different kinds of lasers?
5. One of the most characteristic features of the He-Ne laser *is* that the output power does not increase monotonically with discharge current but reaches a maximum and thereafter decreases.
6. This occurs when an impurity atom has acceptor properties, *that is,* can attract electrons.
7. Powder metallurgy *is finding* new applications in various industries – in electronics, aviation, machine-building, etc.

**Exercise 2.** ***Pay attention to the different usage of the verb*** *"to have"****:***

a. смысловой глагол
b. вспомогательный глагол, образующий перфектную группу времён
c. have to = must

1. Commercial applications for gas-dynamic laser *have not yet been found*.
2. Our brief mention made here *has been* to estimate the conceptual interest of creating a population inversion by a gas-dynamic expansion.
3. Excimer laser *has* two peculiar but important properties.
4. The ordinary F-centers *have* a very low fluorescence quantum efficiency.

5. Let us indicate the difficulties that *have to be overcome* to obtain X-ray laser operation.

**Exercise 3.** ***Translate the sentences paying attention to the voice of the predicates.***

1. Semiconductor lasers *will be considered* in a separate section.
2. Some of the properties we now *associate* with semiconductors *have been known* for a century or more.
3. Molecular lasers *are* the most high powered and most efficient type of gas laser.
4. In the type of molecular laser flowing nitrogen *is excited* by electrical discharge.
5. Two, three and four tubes placed parallel to each other and optically coupled *have been used* in some carbon dioxide lasers.
6. Gases *offer* interesting possibility as laser materials because their atoms *are* more suitable for excitation.
7. A simplified diagram of this laser *will be given* later.

**Exercise 4.** ***Read the sentences, state the function of*** *provided* ***and translate these sentences.***

a) при условии, если (что); b) давать, обеспечивать.

1. If this condition is not satisfied, however, laser action can still occur under pulsed operation *provided* condition mentioned above is fulfilled.
2. Copper vapor lasers *provide* the most efficient (~ 1%) green laser source so far available.
3. Polymethine dyes *provide* laser oscillation in the red or near infrared region.
4. Chemical lasers *provide* an interesting example of direct conversion of chemical energy into electromagnetic energy.
5. They are potentially able *to provide* either large output power or large output energy.
6. A resonator *provides for* a stronger coupling between the radiation and the excited atoms.
7. The elliptic cylinder is made of highly reflective material and *is provided* with reflective end plates.
8. The discharge *is provided* by radio-frequency generator which is usually operated on the 25-to-30 nm region.
9. *Provided* the temperature is changed, the force attracting electrons to atoms is also changed.

**Exercise 5.** ***Summarize your knowledge of the Sequence of Tenses. Translate the sentences into Russian.***

1. It is clear that the newest devices of today will become obsolete tomorrow.
2. The engineers asked if the work could be compressed into 6 days.
3. We finally realized that we had chosen the worst possible moment to visit the company.
4. We were told that the Earth revolves round the Sun.
5. He said that for many years he had been making sacrifices for what he believes in.

6. He considered that this problem would be solved in the near future.
7. I was not sure whether this theory could account for these phenomena.
8. It is known that magnifying power of microscopes is being increased from year to year.

**Exercise 6. *Convert the sentences into the Reported Speech.***

1. – Are you ill? – mother asked.
   – No, I'm just tired, - I answered.
2. The teacher said: "The pupil will come tomorrow".
3. My friend said: "I'm working at the state library now".
4. The boy said: "I did this work yesterday".
5. The freshman asked: "Can I help in the laboratory?"
6. The young scientist said: "I've worked in this laboratory for two years".

**Exercise 7. *Translate from Russian into English.***

1. В этом тексте описывается газовый лазер.
2. В газовом лазере применяется смесь гелия и неона.
3. Для создания электрического разряда в газе используется радио-частотный генератор.
4. Возбуждённые атомы гелия сталкиваются с атомами неона.
5. Луч отражается от зеркал, и его интенсивность возрастает с каждым проходом.
6. Первый газовый лазер был изготовлен в 1960 году.

## Unit 7

# Liquid Lasers (Dye Lasers) and Chemical Lasers

## WORD STUDY

**Exercise 1.** ***Find transcription of the words listed below in the dictionary and read them.***

*Nouns*

solution, molecule, coverage, spectroscopy, therapy, combustion, compound.

**Exercise 2.** ***Make up nouns from the following adjectives using suffixes*** **-ty; -cy** ***according to the model.***

*Adjective + ty/cy = noun.*

Accurate, efficient, capable, resistive, possible, monochromatic, frequent, intensive.

## UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

liquid laser – жидкостной лазер
organic compound – органическое соединение
conjugated double bonds – сопряжённые сдвоенные связи
polymethine dyes – полиметиновые красители
wavelength tunability – возможность перестроиться по длине волны
upper state population – заселённость более высокого уровня
frequency-domain spectroscopy – спектроскопия в частотной области
chemical laser – химический лазер
combustion reaction – реакция горения
output energy – выходная энергия
HF type = high frequency type – высокочастотный тип
chemical efficiency – химическая эффективность
organic dye compounds - соединения органических красителей

***Scan-reading***

### Liquid Lasers (Dye Lasers)

The liquid lasers are those in which the active medium consists of solutions of certain organic dye compounds in liquid solvents such as ethyl alcohol, methyl alcohol or water. Organic dyes constitute a large class of polyatomic molecules containing conjugated double bonds.

Due to their wavelength tunability, wide spectral coverage, and the possibility of generating very short pulses, organic dye lasers have found an important role in various fields. In particular, these lasers are widely used in scientific applications, either as a cw narrow band, down to single mode, tunable source of radiation for high-resolution frequency-domain spectroscopy, or as short-pulse lasers for high resolution time domain spectroscopy. Other applications include the biometrical field (e.g., retinal treatment or photodynamic therapy) and applications in the field of laser photochemistry.

## Chemical Lasers

A chemical laser is usually defined as one in which the population inversion is "directly" produced by a chemical reaction. According to this definition, the gas-dynamic $CO_2$ should not be regarded as a chemical laser even though the upper state population arises ultimately from a combustion reaction (e.g., combustion of CO with $O_2$ ). Chemical lasers usually involve a chemical reaction between gaseous elements, and often involve either an associative or a dissociative exothermal chemical reaction.

Chemical lasers are interesting for two main reasons: (1) They provide an interesting example of direct conversion of chemical energy into electromagnetic energy. (2) They are potentially able to provide either large output power (in cw operation) or large output energy ( in pulsed operation). This is because the amount of energy available in an exothermal chemical reaction is usually quite large.

Chemical lasers of the HF type can give large output powers (or energies) with good chemical efficiency. The most important area of these lasers seems to be for high-power military applications.

## COMPREHENSION CHECK

**Exercise 1.** ***Complete the sentences.***

1. In practice a laser is used as …
   a) … an amplifier of current.
   b) … source of radiation.
   c) … a frequency converter.
   d) … generator of energy

2. The intensity of the laser radiation …
   a) … is equal to that of the spontaneous radiation.
   b) … is smaller than that of the spontaneous radiation.
   c) … exceeds that of the spontaneous radiation.
   d) … is almost the same as the spontaneous radiation.

3. The liquid lasers use as their active medium …
   a) … solutions of certain organic dye compounds.
   b) … an insulating crystal or a glass.
   c) … transitions between different electronic states of special molecules.
   d) … a sufficiently large current passing through the gas.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Find the equivalents.***

| | |
|---|---|
| 1. electrical discharge | a. энергетический уровень |
| 2. conventional tube | b. процесс столкновений |
| 3. energy level | c. инфракрасный свет |
| 4. collision process | d. электрический разряд |
| 5. infrared light | e. упрощённая диаграмма |
| 6. simplified diagram | f. обычная трубка |
| 7. experimental conditions | g. внутренний разряд |
| | h. экспериментальные условия |
| | i. ультрафиолетовый свет |

## LANGUAGE ACTIVITY

**Exercise 1.** ***Fill in the gaps with prepositions:***
a) to; b) by; c) of; d) in; e) after; f) out; g) for.

1. This type … laser has two important properties.
2. Once the molecule, … undergoing the laser transition, reaches the ground state, it immediately dissociates.
3. The laser dyes usually belong … one of the following states.
4. … virtue of their wavelength tunability organic dye lasers have found an important role in various fields.
5. … particular, these lasers are widely used in a number of fields.
6. According … this definition, the gas-dynamic $CO_2$ laser should not be regarded as a chemical laser.
7. Chemical lasers are interesting … two main reasons.
8. These transitions are not strongly influenced … the crystal field.
9. It is also worth pointing … that ruby lasers were extensively used in the past.
10. Glass, because … its lower melting temperature and noncrystalline structure, can be grown much more easily than YAG.

**Exercise 2.** ***Summarize your knowledge on the Conditional Sentences. Translate the sentences into Russian.***

1. Should it be desirable to divide the powder of two substances, several ways were possible.
2. If your work meets these conditions, it will be of great service to our industry.
3. Unless the cathode C is water cooled, it will overheat and emit gases.
4. Had it not been for a large size of this body, we should have already weighed it on our pan.
5. But for space meteorological stations we would not be able to observe the formation of hurricanes.
6. Provided one knows the rate of the emission, one can determine the range of the particles.
7. If the results of their molecular weight determination had been accredited, the concept of giant molecular structures might have been established long before the 1930s.
8. Were it not for the horrid humid climate on Venus, we should probably feel ourselves quite at home.
9. If atomic nuclei contained electrons, their charges should be always whole multiples of the electronic charge.
10. Had this warning been heeded, the reaction might have taken quite a different turn.

**Exercise 3.** ***Put the verbs in brackets into the correct form of Subjunctive Mood I.***
1. You (to speak) better if you (to be) more attentive. 2. If he (to understand) the situation, he (to act) differently. 3. He (to catch) the train if he (to hurry). 4. If I (to be) you, I (to consider) the matter settled, 5. If only he (to be) here, he (can) tell you, 6. If I (to be) in your place, I (to think) as you do. 7. He not (to do) it if you not (to help) him. 8. If he (to be) present, he (may) object. 9. She (to come) to see you if she not (to be tired). 10. If I (to get) the tickets before twelve o'clock, I (to come) straight home.

**Exercise 4.** ***Put the verbs in brackets into the correct form of Subjunctive*** **Mood *II.***
1. I think that if we (to take shelter) under these trees, we not (to get wet). 2. If I (to hesitate) much longer before getting into the water, he not (to let) me swim at all today. 3. If she (to come) earlier, she (to have been able) to see him before he went out 4. He (to go) for a ride with you, if he (to repair) his bicycle. 5. If a year ago the sailors (to be told) they were to undertake a trip of this sort, they (to be surprised). 6. If he (to be) present, this not (to occur). 7. If the storm not (to rage), the ship (to leave) the harbour last night. 8. If our telephone not (to be) out of order, I (to ring) you up this morning. 9. If you (to come) between two and three yesterday, you (to find) me at home. 10. If I (to have) to carry that heavy box, I (to be) obliged to drop it after five minutes. 11. I not (to go) to sleep over that book if it not (to be) so dull. 12. If I (to know) you (to come), I of course (to stay) at home. 13. If anyone (to say) such

a thing to me, I (to feel) hurt. 14. We never (to solve) the riddle, if you not (to put) us on the track.

**Exercise 5.** ***Complete the sentences.***

1. If I were a genius …
2. If my father was a tycoon of computer industry …
3. If my girlfriend were a hacker …
4. If I had $1000000 to spend in three days …
5. If somebody stole my computer …

**Exercise 6.** ***Give a brief summary of all the texts using the following words and expressions.***

These texts deal with …
The four main types of lasers …
It's known …
Nevertheless …
Therefore …
Just for that …
It's not by chance …
They are widely used …

# Unit 8
# Semiconductor Lasers

## WORD-STUDY

**Exercise 1. *Check the transcription in a dictionary and read the words listed below.***

*Nouns*

function, semiconductor, photon, population, valence, bulk, diode, current, junction.

*Verbs*

assume, suppose, use, fulfill, produce.

*Adjectives*

full, suitable, individual, auxiliary, simultaneous.

*Collocations*

to be associated with, to belong to, no longer, relating to.

*Noun – adjective pairs of words:*

atom – atomic
molecule – molecular
electron – electronic
energy – energetic
system – systematic
bulk – bulky
period – periodic

**Exercise 2. *Fix your attention on the prefix "re" – meaning "again". Translate these verbs:***

read – reread
write – rewrite
make – remake
combine – recombine
design – redesign

## UNDERSTANDING A PRINTED TEXT

**<u>List of terms:</u>**

energy level – энергетический уровень
wave function – волновая функция
valence band – валентная зона (заполненная энергетическая полоса)
conduction band – зона проводимости (свободная зона)
recombination radiation – рекомбинационное излучение

laser oscillation – генерация лазера
energy gap = band gap – энергетический промежуток, запрещенная зона
threshold condition – пороговый режим или пороговый параметр
junction – переход, стык, соединение
hole – дырка (“+” - носитель заряда, квази-частица)
wiggly motion - покачивание

***Reading and translating***

**Semiconductor Lasers**

We have discussed atomic and molecular systems, whose energy levels are associated with localized wave functions, i.e., belong to single atoms or molecules. We'll now consider the case of semiconductors, in which a wave function relates to the crystal as a whole.

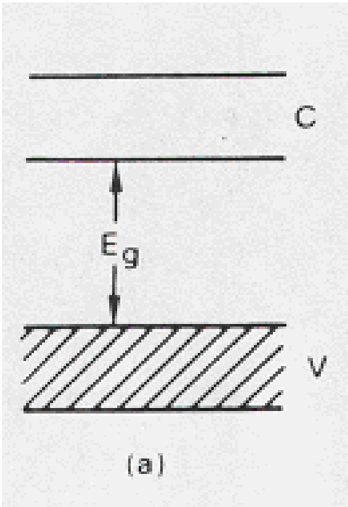



*Fig.1. Principle of operation of a semiconductor laser*

The principle of operation of a semiconductor laser can be followed with the help of Fig.1, where the semiconductor valence band, *V*, and conduction band, *C*, separated by the energy gap, $E_g$, are indicated. If, for simplicity, we assume that the semiconductor is at T = 0 K, then the valence band will be completely filled with electrons while the conduction band will be completely empty. Then electrons are raised from the valence band to the conduction band. After a very short time the electrons in the conduction band will have dropped to the lowest levels in that band, and any electron near the top of the valence band will also have dropped to the lowest unoccupied levels, thus leaving the top of the valence band full of “holes”. This means that there is then a population inversion between the valence and conduction bands (Fig.1(a)).

The electrons in the conduction band fall back into the valence band (i.e., they recombine with holes), emitting a photon in the process (recombination radiation). The process of stimulated emission of recombination radiation will produce laser oscillation when the semiconductor is placed in a suitable resonator and the appropriate threshold conditions are fulfilled. Laser action by stimulated emission of recombination radiation from semiconductor *p-n* junctions was observed in 1962 by four groups, three of which were using GaAs.

Semiconductor lasers now have a number of important applications that cover different fields. The first mass application has been as the optical reading head in a compact disk system. The same kind of application is now being extended to optical disks used as permanent or write-once memories. For these applications GaAs lasers are currently used, but considerable efforts are being made to develop visible-light semiconductor lasers. A second major area of application is in the field of optical fiber communications, where, again, GaAs is used at present while the quarternary InGaAsP laser seems to offer a better choice for the future. In communication applications any component must last for at least $\sim 10^5$ h (i.e., more than 10 years). The lifetime of commercial devices is currently $10^4$ h and that of experimental devices$\sim 5 \times 10^5$ h.

## COMPREHENSION CHECK

**Exercise 1.** ***Answer the questions.***

1. What are energy levels associated with in the case of semiconductors?
2. How is a population inversion between the valence and conduction bands produced?
3. What is emitted in the process of recombination radiation?
4. Which process produces laser oscillation?

**Exercise 2.** ***Using the text explain what is*** **the process of recombination.**

**Exercise 3.** ***Look at two similar sentences. Which one is true? What makes the other sentence false?***

1. a) It is the energy levels of individual atoms which are dealt with in the case of semiconductors.
   b) It is the energy level of the crystal as a whole which is dealt with in the case of semiconductor.
2. a) The conduction and valence bands of a semiconductor are separated by the energy gap.
   b) The conduction and valence bands of a semiconductor are separated by the energy level.
3. a) The electrons recombine with holes in the conduction band emitting a photon.
   b) The electrons recombine with holes in the valence band emitting a photon.
4. a) A suitable resonator is needed to produce laser oscillation.
   b) A suitable ray-tube is needed to produce laser oscillation.

## INCREASE YOUR VOCABULARY

**Exercise 1. *Match the synonyms.***

*Adjectives*

| 1 | 2 |
|---|---|
| 1. single | a) usual |
| 2. convenient | b) energetic |
| 3. typical | c) various |
| 4. synchronous | d) suitable |
| 5. different | e) individual |
| 6. active | f) actual |
| 7. near | g) similar |
| 8. same | h) simultaneous |
| | i) close |
| | j) auxiliary |
| | k) some |
| | l) passive |

**Exercise 2. *Find the equivalents.***

1. so far — a) до сих пор; b) только что; c) давно.
2. no longer — a) как только; b) больше не; c) недавно.
3.instead of — a) из-за; b) вместо; c) благодаря.
4. either…or — a) ни…ни; b) ли…или нет; c) или…или.

## LANGUAGE ACTIVITY

**Exercise 1. *Summarize your knowledge of the Infinitive, translate the sentences into Russian.***

1. The beam of another laser was used to excite the bulk semiconductor.
2. The most convenient way of excitation is to use the semiconductor in the form of a diode.
3. To provide feedback for laser action two end faces are made parallel.
4. A complicating feature of color-center lasers is the need to keep the laser crystal at cryogenic temperatures (T = 77K).
5. To prepare laser crystals on color centres requires considerable care and skill.

**Exercise 2. *Summarize your knowledge of the types of Subordinate Clauses. Form one sentence out of two using conjunctions given in brackets and translate it.***

1. I don’t remember the day. They left for London. (when)

2. We went across the fields. There stood Anne's cottage. (where)
3. I asked him. He wanted of me. (what)
4. I thought. He was a good actor. (that)
5. He managed to get such books. He did not tell me about it. (how)
6. I couldn't come to see you. I was unwell. (because)
7. Wait for me a little. You are not in a hurry. (if)
8. I met them. They arrived from London. (as soon as)
9. I leave Stratford. I'll let you know. (before)
10. The reason is not clear. Many students were absent at the lecture. (why)

**Exercise 3.** ***Translate into English using conjunctions*** *"which", "when", "if", "as", "where", "that", "till".*

1. Школа, в которой (где) я учился, находится в центре города.
2. Вот книга, которую вы хотели прочитать.
3. Преподаватель сказал, что я должен много работать над произношением английских слов.
4. Когда мы вернулись, было уже темно.
5. Я буду ждать до тех пор, пока вы не позвоните.
6. Мы не могли вас навестить, так как только вчера прибыли из Лондона.
7. Если дождь не прекратится, мы не пойдем гулять.

**Exercise 4.** ***Cross out*** *"that", "who", "which", "when"* ***if one can manage without them.***

1. This is the house that Jack built.
2. He only likes people who like him.
3. He only talks to people who/whom he likes.
4. He told me an anecdote which I remember for a long time.
5. The newspaper gives the facts which speak for themselves.
6. I think Mary is a person who forgets nothing.
7. Jim is the person that everyone is talking about.
8. He said he was sorry and the question which he had asked meant nothing bad and that was true.
9. What's the time when the bus comes?

**Exercise 5.** ***Translate the sentences into Russian. Point out the Complex Subject.***

1. The free-electron laser is said to operate in the Raman regime.
2. An electron beam is supposed to move at a speed close to the speed of light.
3. In a FEL an electron beam is known to pass through the magnetic field.
4. The question of efficiency is believed to be the most important issue for a FEL.
5. Demonstrations of FEL operation are reported to have been made on several devices around the world.
6. Free electron lasers are known to be inherently large and expensive machines.
7. Because of low values of electron energy, free electron lasers were found to oscillate in the millimeter wave region.

8. Interest in the FEL applications is likely to be the strongest in the frequency ranges where more conventional lasers are not available.
9.The potential high power capability of a FEL is sure to be used in military applications.
10. Free electron lasers are unlikely to be widely used due to their limited efficiency.
11. Injected along the periodic structure, the electrons seem to acquire a wiggly motion.
12. The resulting electron acceleration seems to produce a longitudinal emission of radiation.

## Unit 9

# The Homojunction Laser

## WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

homojunction, heterojunction, advantage, donor, acceptor, configuration, coating, surface, interface.

*Verbs*

distinguish, achieve, extend, absorb.

*Adjectives*

perpendicular, transverse, cryogenic, refractive, fundamental.

*Collocations*

to be based on, at the room temperature, because of, to provide feedback.

**Exercise 2.** ***Make adverbs from the following adjectives according to the model and translate them.***

*Adjective + ly*

usual, sufficient, significant, considerable, strong, rapid.

## UNDERSTANDING A PRINTED TEXT

**<u>List of terms:</u>**

homojunction laser – гомолазер, лазер на гомопереходе
double heterojunction – двойной гетеропереход
end face –торцевая поверхность
reflecting coating –отражающий слой (покрытие)

### *Reading for precise information*

Two basic types of semiconductor laser diode can be distinguished, namely, the homojunction and the double heterojunction (DH) lasers. The importance of the homojunction laser is based mostly on its historical significance.

In the homojunction laser, the pumping process is achieved in a *p-n* junction where both *p*-type and *n*-type regions are made of the same semiconductor material (e.g., GaAs).

Figure 1 shows a typical configuration of a *p-n* junction laser, the shaded region being the active layer. It is seen that the diode has small dimensions. To provide feedback for laser action, two end faces are made parallel. Often the two surfaces are not provided with reflecting coatings.

Note that, the thickness of the active region in the direction perpendicular to the junction is ~1 μm. Because of diffraction, however, the transverse dimension of the laser beam in this direction is significantly larger than the active region (~5 μm). The laser beam therefore extends quite considerably into the p and n regions, where it is strongly absorbed. This is the fundamental reason why the room-temperature current density for a homojunction laser is high.

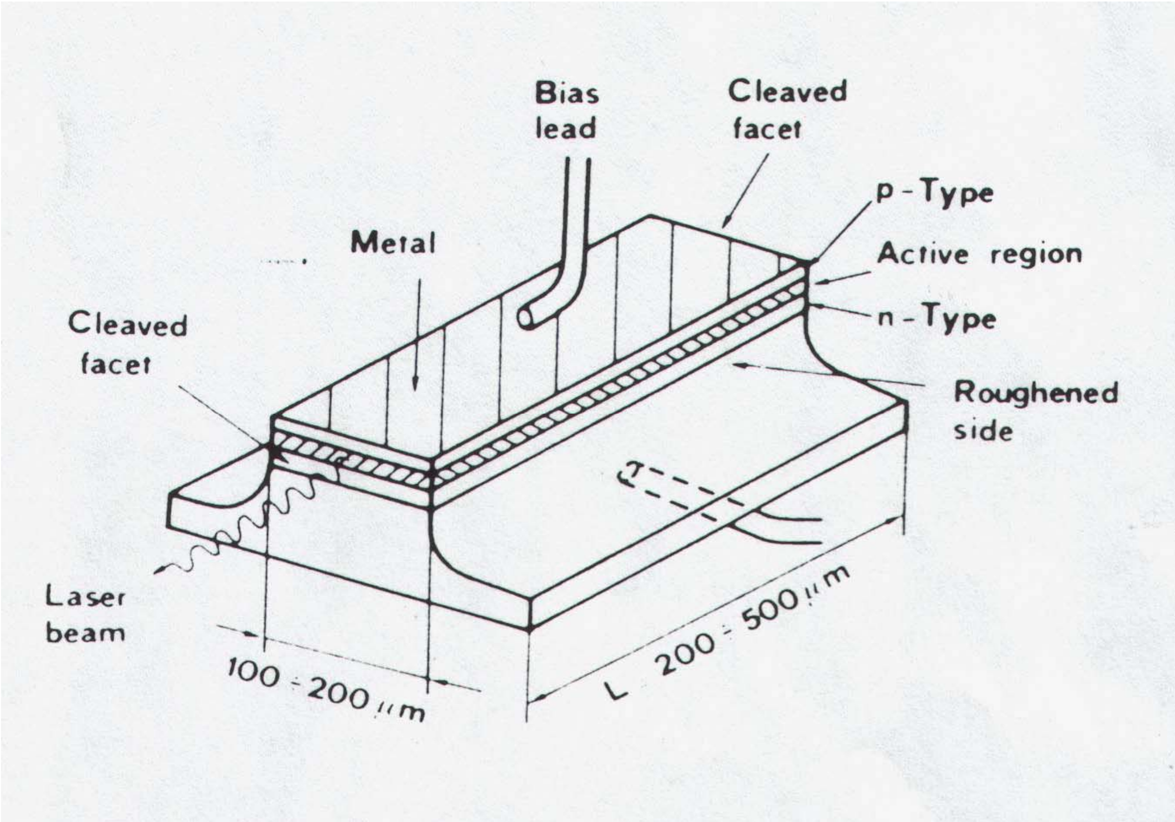



*Fig.1. Typical broad-area p-n homojunction laser made of GaAs*

## COMPREHENSION CHECK

**Exercise 1. E*xplain using the text:***
- the term "homojunction";
- the importance of homojunction lasers.

**Exercise 2.** ***Complete the sentences.***

1. The importance of the homojunction laser is based mostly on
   a) its practical importance.
   b) its historical significance.
   c) its theoretical simplicity.

2. To provide feedback for laser action
   a) two end faces of the diode are made parallel.

b) two end faces of the diode are made rough.
c) two end faces of the diode are made smooth.

3. The laser beam extends into the *p* and *n* regions
a) where it is simply dispersed.
b) where it is disseminated.
c) where it is strongly absorbed.

## INCREASE YOUR VOCABULARY

**Exercise 1. Match the antonyms.**

*Verbs*

| 1 | 2 |
|---|---|
| 1. to increase | a) to help |
| 2. to raise | b) to agree |
| 3. to prevent | c) to drop |
| 4. to reject | d) to object |
| 5. to emit | e) to decrease |
| | f) to release |
| | g) to allow |
| | h) to absorb |
| | j) to adopt |

**Exercise 2.** ***Match the synonyms.***

*Verbs*

| 1 | 2 |
|---|---|
| 1. decrease | a) emphasize |
| 2. underline | b) note |
| 3. trap | c) supply |
| 4. indicate | d) reduce |
| 5. provide | e) capture |
| 6. show | f) present |
| 7. achieve | g) nominate |
| | h) illustrate |
| | i) reach |

## LANGUAGE ACTIVITY

**Exercise 1.** ***Transform the following sentences into one with the Complex Subject Structure as shown below.***

*Model:* We assume that Equation 4 is used for simplicity.
Equation 4 is assumed to be used for simplicity.

1. We suppose that electrons are raised from the valence band to the conduction band.
2. We consider that semiconductors deal with a wave function relating to the crystal as a whole.
3. We know that laser action was first observed in 1962 using GaAs.
4. They say that semiconductor-laser pumping has been achieved in a number of ways.
5. We believe that atomic and molecular systems energy levels belong to single atoms or molecules.
6. We see that population inversion is achieved in a narrow stripe between the *p* and *n* sides of the junction.
7. We found that some color-center lasers have been mode-locked.
8. It is reported that mode-locked color-center lasers generate very short pulses in single-mode fibers.

**Exercise2.** ***Translate into Russian paying attention to the Complex Object Structure.***

1.Computer people know the number of viruses to be rapidly growing.

2.The researchers expected the combined effect of a few factors to reduce the threshold current density.

3.She doesn’t want her washing-machine to have been broken down again.

4.Such a diode structure of the GaAs laser allows the current density to be reduced.

5.To make a computer collect data is much better than to pay a person to do the same work.

6.Going from the green to the soft X-ray region we see wavelength decrease by a factor of 50.

7.They assumed the energy barriers to have confined injected holes and electrons within the active region.

8.We believe other types of double-heterojunction lasers to be vigorously developed.

9.We expect the web to provide distant students with full university level courses.

10.The mass-media report the environment to have been heavily polluted due to the man’s irresponsible activity.

11.By means of a special program the experimenter made the robot obey his commands.

## Unit 10

# The Double-Heterojunction Laser

## WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
*Nouns*
variety, layer, gain, barrier, profile, fiber.
*Collocations*
order of magnitude, compared with, is due to.

**Exercise 2.** ***Make nouns from the following adjectives according to the model.***
*Adjective + ness*
thick, useful, red, great, empty, full, complete.

## UNDERSTANDING A PRINTED TEXT

**List of terms:**

active region – активная область
refractive index – показатель преломления
current (threshold) density – плотность порогового тока
order of magnitude – порядок величины
gain – усиление
band gap – запрещенная зона
energy barrier – энергетический барьер
optically guiding structure – оптический волновод
tails – шлейф (сигнала), "крылья", "хвосты"
threshold current density - пороговая плотность тока

***Comprehensive reading***

It was in fact after the invention of the heterojunction laser in 1969 that it became possible to operate semiconductor lasers cw at the room temperature, thus opening up the great variety of applications in which these lasers are nowadays used.

To illustrate its features, Fig.1 shows an example of a double-heterojunction GaAs laser structure. In this diode there are two junctions between different materials. The active region consists of a thin layer of GaAs. With such a diode structure, the threshold current density for room-temperature operation can be reduced by about two orders of magnitude compared with the homojunction device. Thus cw operation at room temperature is made possible.

The reduction of threshold current density is due to the combined effect of three circumstances: (1) The refractive index of GaAs ($n_1 = 3.6$) is significantly large, thus providing an optically guiding structure. (2) The band gap of GaAs (~ 1.5 eV) is significantly small. Energy barriers confine injected holes and electrons within the active layer. Thus the concentration of holes and electrons in the active layer is increased and therefore the gain is also increased. (3) The laser beam is less strongly absorbed. Therefore, the tails of the transverse beam profile which extend into both the *p* and *n* regions are not so strongly absorbed there.

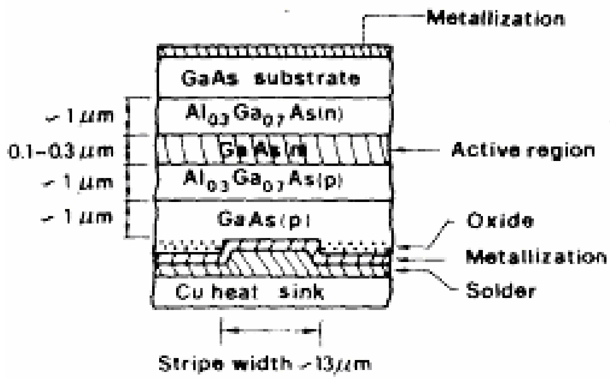



*Fig.1. Schematic diagram of a double-heterojunction semiconductor laser. The active region consists of the GaAs (n) layer (hatched area)*

Double-heterojunction lasers operating at either λ ≅ 1.3 μm or λ ≅ 1.6 μm, are now being vigorously developed.

## COMPREHENSION CHECK

**Exercise 1.** ***Find in section B answers to questions in section A.***

**A.**

1. When did it become possible to operate semiconductor lasers cw at room temperature?
2. What is a double – heterojunction GaAs laser structure?
3. What does the active region of a double – heterojunction laser consist of?
4. What factors influence (affect) the threshold current density?
5. Why is the gain in the active layer of the DH lasers increased?

**B.**

a) There are two junctions between different materials in a double – heterojunction GaAs laser.
b) The active region of a double – heterojunction laser consists of a thin layer of GaAs.
c) The gain in the active layer of DH lasers is increased with the increase of the concentration of holes and electrons in it.
d) It became possible to operate semiconductor laser cw at room temperature after the invention of the heterojunction laser in 1969.

e) The threshold current density is mostly affected by the combined effect of the GaAs large refractive index, its small band gap and less absorption of the laser beam.

**Exercise 2.** ***Find in the text phrases from which we can understand the meaning of the terms:***
a) double – heterojunction laser;
b) the active region.

**Exercise 3.** ***Look at two similar sentences. Which one is true?***
1. a) The single – heterojunction laser is most widely used.
   b) The double – heterojunction laser is the only one that is commonly used.
2. a) After the invention of the heterojunction diode, semiconductor lasers could operate cw at room temperature.
   b) From the very beginning semiconductor lasers could operate cw at the room temperature.
3. a) The active region consists of a thin layer of GaAs.
   b) The active region consists of a thick layer of GaAs.
4. a) The refractive index of GaAs is significantly large.
   b) The refractive index of GaAs is significantly small.
5. a) Energy barriers prevent injection of holes and electrons into the active layer.
   b) Energy barriers confine injected holes and electrons within the active layer.

**Exercise 4.** ***Translate into English.***
1. В гетеродиоде есть два перехода между разными полупроводниковыми материалами.
2. Активная зона представляет собой тонкий слой арсенида галлия.
3. Пороговая плотность тока для генерации при комнатной температуре должна быть очень маленькой.
4. Показатель преломления GaAs очень велик, а энергетический промежуток очень мал.
5. При таких условиях концентрация дырок и электронов в активном слое увеличивается.
6. В такой структуре диода лазерный луч (пучок) поглощается слабее.
7. Шлейф поперечного профиля лазерного луча проникает как в *p*- так и в *n*-области перехода.
8. Сейчас усиленно разрабатываются другие типы гетеролазеров.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the synonyms.***
*Adjectives*

| 1 | 2 |
|---|---|
| 1. different | a) active |

| | |
|---|---|
| 2. significant | b) various |
| 3. vigorous | c) potential |
| 4. great | d) brushed |
| 5. possible | e) important |
| 6. shaded | f) energetic |
| | g) large |
| | h) another |
| | j) hatched |
| | k) desirable |

**Exercise 2.** ***Match the antonyms.***

*Adjectives*

| 1 | 2 |
|---|---|
| 1. empty | a) historical |
| 2. small | b) complete |
| 3. short | c) philosophical |
| 4. practical | d) large |
| 5. active | e) longitudinal |
| 6. transverse | f) long |
| | g) useful |
| | h) theoretical |
| | i) full |
| | j) inert |

**LANGUAGE ACTIVITY**

**Exercise 1.** ***Define the form and the function of the Participle in the sentences given below. Translate the sentences into Russian.***

1.The refractive index of GaAs is significantly large, thus providing an optically guiding structure.

2.Having dropped to the lowest unoccupied levels, the electrons leave the top of the valence band full of “holes”.

3.The electrons fall back into the valence band, emitting a photon in the process.

4.The negative consequences of technological progress being discussed ought not to be neglected.

5.Being used in plural the word “brains” denote the ability to think clearly and learn quickly.

6.When operating a computer you must have regular breaks.

7.This is the geometry of a soft X-ray laser using the exploding-foil technique.

8.Being pumped by another laser the color-center laser can successfully operate in the near infrared.

9.Currently, there are plenty of companies developing agent software.

10.When injected along periodic structure, the electrons acquire a wiggle motion.

11.In this section, a wave function relating to the crystal as a whole, is dealt with.

**Exercise 2.** ***Revise your knowledge of the Absolute Participle Construction. Translate the sentences given below into Russian.***

1. There are single and double-heterojunctions, the latter type of junction being the one practically used.
2. Energy barriers are formed at the two junctions, with the injected holes and electrons being confined within the active layer.
3. With the laser beam being less strongly absorbed, the tails of the transverse beam profile extend into both *p* and *n* regions.
4. The donor and acceptor concentrations being very large in a homojunction diode, both p and n regions are in the form of a degenerate semiconductor.
5. Fig.1 shows a typical configuration of a *p-n* junction laser, the shaded region being the active layer.
6. A double-heterojunction laser contains two junctions between different materials, with the active region being a thin layer of GaAs.
7. There are semiconductor diodes with single and double heterojunction, the latter type of junction being the only one which is commonly used.
8. With the concentration of holes and electrons in the active layer being increased, the gain is also increased.
9. The refractive index of GaAs is large, the energy gap of GaAs being significantly small.
10. The electrons in the conduction band fall back into the valence band and recombine with holes, a photon being emitted in the process.

11 There being a population inversion between conduction and valence bands, the process of stimulated emission of recombination radiation will produce laser oscillation.

## Unit 11

# X-Ray Lasers

## WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***

*Nouns*

angström, lithography, resolution, configuration, irradiation, length.

*Verbs*

determine, announce, focus, ionize.

*Adjectives*

coherent, three-dimensional, neutral, particular, nuclear, longitudinal.

**Exercise 2.** ***Make nouns from the following verbs according to the model and translate them.***

*Verb + er/or*

conduct, act, develop, generate, amplify, emit, operate, oscillate.

*Verb + tion*

recombine, conduct, excite, radiate, populate, direct, oscillate, vibrate, rotate.

## UNDERSTANDING A PRINTED TEXT

**List of terms:**

a soft X-ray laser – лазер мягкого рентгеновского излучения
foil – фольга
to explode – взрывать(ся), распадаться
coherent oscillation – когерентные колебания
X-ray region – область рентгеновского излучения (спектральная)
X-ray holography – рентгеновская голография
cell parts – части клетки
three – dimensional pictures – 3-х мерные снимки
resolution – разрешающая способность, разрешение
evaporated stripe - напыленная полоска
ground electronic configuration – основная электронная конфигурация
natural broadening – естественное уширение
Å (angström) – ангстрем
radiative lifetime - продолжительность (длительность) излучения

***Scan-reading***

The achievement of coherent oscillation in the X-ray region has been a dream that is slowly but steadily coming true. The potential applications of X-ray lasers are indeed very important: they include such possibilities as X-ray holography of cells or the cell parts, where three-dimensional pictures with a resolution of a few angströms could be obtained, and X-ray lithography of semiconductor devices, where patterns could be produced with extremely high resolution.

At the higher frequencies corresponding to the X-ray region, the linewidth is determined by natural broadening since the radiative lifetime becomes very short. Thus, if we go, for example, from the green ($\lambda$ = 500 nm) even to the soft X-ray region ($\lambda \cong$ 10 nm) the wavelength decreases by a factor of 50.

The best results achieved so far make use of the powerful second harmonic beam ($\lambda$ = 0.53 μm) of the Novette laser. The beam is focused to a fine line on a thin evaporated stripe (75 nm) of selenium on a 150-nm-thick foil. The foil could be irradiated from one or both sides. Owing to the high intensity of this pump beam the foil explodes and a highly ionized Se plasma is formed with an approximately cylindrical shape of diameter. A particular constituent of this plasma is 24-times ionized Se having the same ground electronic configuration, as neutral Ne (neonlike selenium), and this corresponds to a particularly stable configuration.

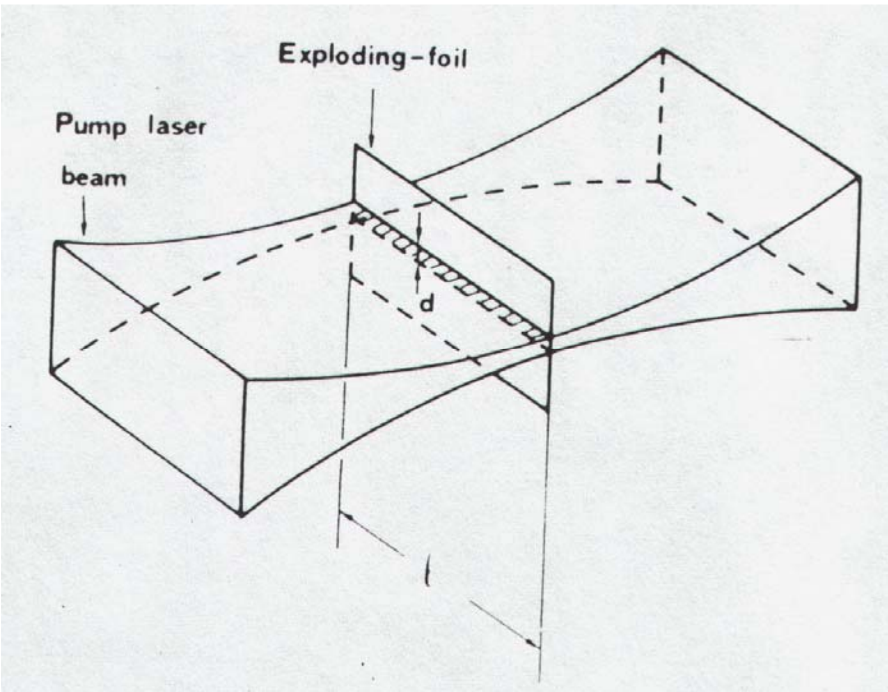



*Fig.1. Transverse irradiation geometry of a soft X-ray laser using the exploding-foil technique*

With a pump configuration as in Fig.1 a strong longitudinal emission of soft X-rays has been observed. The X-ray output energy produced was an extremely small fraction (~ $10^{-10}$) of the pump energy.

Besides the achievement of stimulated emission in the soft X-ray region, stimulated emission in the soft X-ray to X-ray region at $\lambda$ = 14 Å has also been announced. The laser was pumped by the intense X-rays produced by a small nuclear detonation.

## COMPREHENSION CHECK

**Exercise 1.** ***Make your choice answering alternative questions.***

1. Does coherent oscillation in the X-ray region find wide application or it has only a theoretical interest?
2. Is the radiative lifetime long or short in the X- ray region?
3. Is stimulated emission observed in the extreme UV or in the far-infrared?

***Exercise 2. Look at two similar sentences. Which is true and which is false?***

1. a) In the region from the green to the soft X-ray, the wavelength decreased by a factor of 50.
   b) In the region from the green to the soft X-ray, the wavelength slightly decreases.
2. a) To achieve the best results, the use was made of the powerful second harmonic beam of the Novette laser, USA.
   b) To achieve best results, the use was made of the powerful first harmonic beam of the Novette laser, USA.
3. a) Stimulated emission is observed on two lines which fall in the extreme UV to soft X-ray region.
   b) Stimulated emission is observed on two lines which fall in the near green to soft X-ray region.

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 3.** ***Translate into English.***

1. Сейчас стало реальностью получение когерентного колебания в области рентгеновского излучения. Это так называемый разер (т.е. рентгеновский лазер).
2. С помощью рентгеновского лазера возможно получить трехмерные голографические изображения клетки или даже ее частей. Разрешение полученных образцов чрезвычайно велико.
3. Луч накачки очень высокой интенсивности падает на тонкую полоску селена, напыленную на слой фольги толщиной 150 нм. Фольгу облучают с одной или с двух сторон и она распадается под воздействием луча накачки. Таким образом, образуется высоко ионизированная селеновая плазма, которая является источником вынужденного излучения.
4. Выходная энергия полученного рентгеновского излучения составляет очень небольшую долю от энергии накачки.
5. Еще в одном случае лазерная накачка производилась интенсивным рентгеновским излучением, полученном при небольшом ядерном взрыве.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the antonyms.***

*Adjectives*

| 1 | 2 |
|---|---|
| 1. practical | a) large |
| 2. thin | b) theoretical |
| 3. longitudinal | c) hard |
| 4. soft | d) transverse |
| 5. small | e) spontaneous |
| 6. stimulated | f) thick |
| 7. experimental | g) emitted |
| | h) commercial |
| | i) standard |
| | j) neutral |

**Exercise 2.** ***Read and translate the collocations given below:***
extremely high resolution
highly ionized plasma
approximately cylindrical shape
particularly stable configuration
sufficiently high reflectivity
extremely small fraction
possibly the shortest wavelengths.

## LANGUAGE ACTIVITY

**Exercise 1.** ***Summarize your knowledge of emphatic structure "It is (was) … that" and translate the sentences into Russian according to the model.***
*Example:* It was a ruby crystal that was used in the first lasers.
Именно рубиновый кристалл использовался в первых лазерах.
It was after my first accident that I started driving more carefully.
Только после своей первой аварии я стал ездить более осторожно.

1. It was after the invention of the heterojunction laser that it became possible to operate semiconductor laser cw at room temperature.
2. It is the X-holography of cells that resulted in obtaining three dimensional pictures with a resolution of a few angströms.
3. It is due to the irradiation of the foil by the pump beam of high intensity that a highly ionized Se plasma could be formed.
4.It was invention of a floppy disk that resulted in a convenient way to read computer programs.

5.It is because the FELs are so large and expensive, that their application is practically limited by the frequency ranges unavaible for conventional lasers.
6.It is the hacker who cracks computer codes to penetrate into other people's private information.
7.It is due to the Fabry-Perot etalon that the fine tuning can be achieved in color-centers lasers.
8.It was academician Denisyuk's fundamental discovery that paved the way to three-dimensional television.

## Unit 12

# The Free-Electron Laser

## WORD-STUDY

**Exercise 1. C*heck the transcription in a dictionary and read the words listed below.***

*Nouns*

volume, structure, wiggler, expenditure, vacuum, facilities, issue, comment, regime, efficiency, phenomenon.

*Verbs*

conjugate, inject, acquire, derive, oscillate, range, describe.

*Adjectives*

magnetic, periodic, relativistic, effective, orthogonal.

**Exercise 2. *Make adverbs from the following adjectives according to the model and translate them into Russian.***

*Adjective + ly*

previous, recent, spontaneous, transverse, longitudinal, transverse, sufficient, complete.

## UNDERSTANDING A PRINTED TEXT

**<u>List of terms:</u>**

periodic structure –периодическая структура
stimulated process – вынужденный (индуцированный) процесс
e.m. field – электромагнитное поле
spontaneously emitted radiation – спонтанное излучение
orthogonal plane –перпендикулярная, ортогональная плоскость
e-beam accelerator – ускоритель электронных пучков
plasma waves – плазменные волны
undulator } ондулятор
wiggler }
gain curve – амплитудная характеристика
undular - волнообразный

### *Reading for precise information*

In this laser an electron beam moving at a speed close to the speed of light is made to pass through the magnetic field generated by a periodic structure (called the wiggler or the undulator) (Fig.1). The stimulated process comes about through the interaction of the e.m. field of the laser beam with these relativistic electrons moving in the periodic magnetic structure.

To understand how this interaction comes about, we first consider the case of spontaneously emitted radiation, i.e., when no mirrors are used. Once injected along the periodic structure, the electrons acquire a wiggly motion in the plane orthogonal to the magnetic field. The resulting electron acceleration produces a longitudinal emission of radiation.

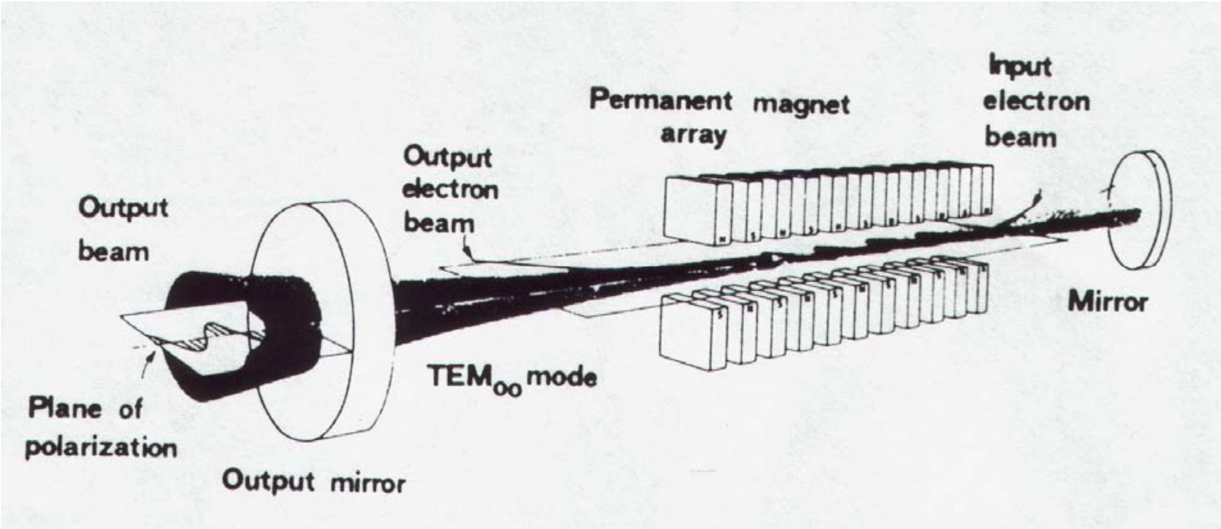



*Fig.1. Basic structure of a free-electron laser*

So far, demonstrations of FEL operation have been made on several devices (more than 10) around the world, with oscillation wavelengths ranging from millimeter waves up to the green region. Many more FELs are now at various stages of planning. All these lasers require large facilities since they must make use of sufficiently large *e*-beam accelerators. One of the most important issues for a FEL is the question of its efficiency. Since the emitted frequency depends on the electron energy the maximum energy that can be extracted from the electron is that which shifts its energy so that the corresponding operating frequency falls outside the gain curve. This means that the efficiency in such a device is rather limited.

Free electron lasers using *e*-beams of low energy and much higher currents have also been made to operate. The electron-electron interaction becomes so strong in this case that collective oscillatory motions (plasma waves) are induced in the *e*-beam when interacting with the e.m. wave in the wiggler.

The most attractive properties of a FEL are (1) Wide tunability; (2) excellent beam quality, close to the diffraction limit; and, potentially, (3) very high efficiency, and thus very high laser power about 200 kW. Free electron lasers are inherently large and expensive machines, and interest in their applications is the strongest in the frequency ranges where more conventional lasers are not so readily available. The potential high power capability of FEL has resulted in considerable expenditure aimed at military applications.

## COMPREHENSION CHECK

**Exercise 1.** ***Find correct answers to the questions in section A.***

**A.**

1. Which medium is an electron beam passing through in the FEL?
2. What produces the stimulated process in the FEL?
3. Where do the electrons acquire a wiggly motion?
4. Does the resulting electron acceleration produce longitudinal or transverse emission?
5. What is the range of the oscillation wavelengths in FELs?
6. Why do FELs require large facilities?
7. Is the efficiency of FELs large?

**B.**

a) The resulting electron acceleration produces a longitudinal emission.
b) The stimulated process is produced by the interaction of the e.m. field of the laser beam with the electrons moving in the periodic magnetic structure.
c) An electron beam is passing through the magnetic field generated by the wiggler.
d) The efficiency of FELs is rather limited.
e) The electrons acquire a wiggly motion in the plane orthogonal to the magnetic field.
f) FELs require large facilities since they must make use of sufficiency large e-beam accelerators.
g) The oscillation wavelengths in the FELs ranges from millimeter waves up to the green region.

**Exercise 2.** ***Explain using the text:***

- the term “wiggler”;
- the term “plasma waves”.

**Exercise 3.** ***Look at two similar sentences. Which one is true?***

1. a) Wiggler is a periodic structure which generates the magnetic field.
   b) Wiggler is a periodic structure which generates the synchrotron type radiation.
2. a) The electrons movement is produced by the field of the wiggler magnet.
   b) The electrons movement is influenced by the field of the wiggler magnet.
3. a) The electrons acquire a wiggly motion in the plane tangential to the magnetic field.
   b) The electrons acquire a wiggly motion in the plane orthogonal to the magnetic field.
4. a) All these lasers must make use of sufficiently large e-beam accelerators.
   b) All these lasers must make use of sufficiently large heavy particle accelerators.
5. a) The oscillation wavelengths range from millimeter waves to the far-infrared region.
   b) The oscillation wavelengths range from millimeter waves to the green region.

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 4.** ***Translate into English.***

1. В лазерах на красителе электрон свободно движется вдоль цепочки атомов в молекуле, соединенной двойной связью.
2. В полупроводниковом лазере электрон свободно движется через весь объем кристалла.
3. В лазере на свободных электронах, электронный луч движется со скоростью близкой к скорости света. В таком лазере электрон “свободен” в том смысле, что он не привязан ни к одному атому, ни к группе атомов.
4. Для получения лазерного эффекта в лазерах на свободных электронах используются мощные электронные ускорители.
5. Эффективность лазеров на свободных электронах довольно ограничена.
6. Продольная скорость электрона почти равна скорости света в вакууме.
7. Как только электроны врываются в циклическую структуру, они приобретают колебательное движение в плоскости ортогональной магнитному полю.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the synonyms.***

*Verbs*

| 1 | 2 |
|---|---|
| 1. bind | a) produce |
| 2. note | b) radiate |
| 3. generate | c) bond |
| 4. move | d) occur |
| 5. come about | e) point out |
| 6. emit | f) operate |
| 7. derive | g) travel |
| | h) oscillate |
| | i) deduce |
| | j) induce |
| | k) reflect |

*Nouns*

| 1 | 2 |
|---|---|
| 1. speed | a) undulator |
| 2. devices | b) emission |

| | |
|---|---|
| 3. wiggler | c) generator |
| 4. radiation | d) velocity |
| 5. issue | e) facilities |
| 6. oscillator | f) machines |
| | g) question |
| | h) frequency |
| | i) meter |
| | j) reflection |

**LANGUAGE ACTIVITY**

**Exercise 1.** ***Translate the sentences paying special attention to the Passive Voice Constructions.***

1. In such cases electrons are bound to a single atom or a molecule.
2. The movement of electrons is influenced by the field of the wiggler magnet.
3. So far, different types of semiconductor lasers have been considered.
4. These quantities can be derived from Eq 3.
5. Many more FELs are being developed now.
6. A number of types of color – center lasers are now being used.
7. Pulses as short as 5 ps have been obtained in this way.
8. Mode-locked color-center lasers have been used to generate very short pulses in single mode fibers.
9. At T = 0 K the valence band will be completely filled with electrons.
10. Semiconductor laser pumping can in principle be achieved, and indeed has been achieved, by using either an auxiliary electron beam or the beam of another laser.
11. Laser action by stimulated emission of recombination radiation from semiconductor p-n junctions was observed in 1962 by four groups of researchers.

**Exercise2.** ***Define the function of Gerund in the sentences given below. Translate the sentences into Russian.***

1.Preparing laser crystals based on color-centers requires great skill and care.
2.The fine tuning of the color-center laser is achieved by using Fabry-Perot etalons.
3.New types of free-electron lasers are now at different stages of planing.
4.One of the most attractive properties of FEL is achieving very high laser power.
5.They succeeded in having produced software and peripherals compatible with all versions.
6.The wide rage of wavelength over which the laser have been operated is worth mentioning.
7.Upon being placed in a suitable resonator, the semiconductor is capable of producing laser oscillation.
8.The purpose of making two end faces of the diode parallel is providing feedback for laser action.

9.Man couldn't rely so much on computers without making them more user-friendly first.

**Exercise3.** ***Revise your knowledge of the Gerund Constructions. Translate the sentences given below into Russian.***

1.We know of some color-centers having very low fluorescence quantum efficiency.
2.Their having used a dispersive optical device to achieve coarse tuning of the lasers is not strange indeed.
3.Computers were appreciated for their having completely changed many fields of human activity.
4.FELs being large and expensive resulted in their being limited by military application.
5.FELs can't operate without sufficiently large beam –accelerators being used.
6.Some doctors object to children's playing computer games too often.
7.GaAs being widely used for many applications is a well know fact.
8. Now, the semiconductor lasers applications are being extended to their being used in permanent or write –once memories of computing systems.
9. Our having accomplished our work so quickly surprised everyone.
10. Due to it's being strongly absorbed in the p-n junction, the laser beam of the homojunction laser doesn't show sufficient efficiency.

**Revise your knowledge of modal verbs.**

**Exercise 4.** ***Translate these sentences into Russian having in mind the meaning of the modal verb:***
can-ability, may –permission and probability, must-necessity, will-inevitability, would-insistence.

1.The sea can be rough in the harbour.
2.A scientist may freely choose his line of research.
3.Most people can question the uncertain, only few can question the obvious.
4.Good ideas should be written down before they are forgotten.
5.A true scientist will enjoy his work more than anything else.
6.Occasionally a machine will go wrong and it is impossible to find out what the matter is.
7.Two basic types of semiconductor laser diode can be distinguished.
8.Free electrons lasers require large facilities since they must make use of sufficiently large e-beam accelerators.
9.After a very short time the electrons in the conduction band will have dropped to the lowest level in that band.
10.It should be noted that preparation of laser crystals requires considerable care and skill.
11.The foil could be irradiated from one or both sides.

## Unit 13

# Color-Center Lasers

### WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below. Translate them into Russian.***

*Nouns*

variety, anion, vacancy, ion, circle, counterpart, fluorescence, quantum, efficiency, pulse.

*Verbs*

constitute, pump, generate, trap.

*Adjectives*

efficient, foreign, adjacent, similar, continuous, synchronous.

*Collocations*

by virtue of, the same technique, a number of, at present, on a scale of, in their way.

**Exercise 2.** ***Make nouns from the following verbs according the model and translate them.***

*Verb + ing*

to pump, to process, to focus, to lock, to tune, to scatter, to broaden.

*Verb + ion*

to compress, to oscillate, to investigate, to operate, to indicate, to emit, to propagate.

*Verb – noun*

to increase, to decrease, to trap, to center, to focus, to pump, to power, to slope.

### UNDERSTANDING A PRINTED TEXT

**List of terms:**

color-center laser – лазер на центрах окраски
optically pumped laser – лазер с оптической накачкой
near infrared – ближняя инфракрасная область (спектра)
the wavelength range – диапазон длин волн
anion vacancy – анионная вакансия
singly ionized counterpart – эквивалент однократно ионизированный; заменитель
fluorescence quantum efficiency – квантовый выход флуоресценции
broad tunability – возможность перестройки в широком диапазоне
threshold pump power(s) –пороговое значение мощности накачки
pump beam – пучок накачки
mode locked lasers – лазер с синхронизированными модами

laser emission range – область излучения лазера
grating – решетка (дифракционная)
line width – ширина линии
molecular spectroscopy – молекулярная спектроскопия
propagation behavior – характеристика распространения
a birefringent filter – двулучепреломляющий фильтр
a dispersive optical system – диспергирующая оптическая система
coarse tuning – грубая настройка
fine tuning – точная настройка
laser crystal – лазерный кристалл
laser wavelength – длина волны лазерной генерации
pump wavelength – длина волны накачки

***Reading and translating***

A number of different types of color centers are now being used as the basis of efficient, optically pumped lasers with broad tunability in the near infrared. At present color-center lasers allow operation over the wavelength range 0.8-3.3 μm. On a scale of increasing wavelength, these lasers thus take over just where the organic dyes give up.

The ordinary color center laser consists of an electron trapped in an anion vacancy of the crystal.

Not all color centers are good candidates for laser action, however, since some of them have a very low fluorescence quantum efficiency.

It should be noted that the preparation of laser crystals based on different types of color centers requires considerable care and skill.

The laser is longitudinally pumped by another laser in a configuration similar to that used for cw dye lasers. Here the pump beam passes through the input mirror, which has a high reflectivity at the laser wavelength and a high transmission at the pump wavelength. Coarse tuning of the laser is usually achieved by means of a dispersive optical system such as a prism, a grating or a birefringent filter. The fine tuning and selection of a single mode is achieved by using one or more Fabry-Perot etalons in the cavity. A complicating feature of color-center lasers is the need to keep the laser crystal at cryogenic temperatures (usually $T \approx 77$ K).

We note that some color-center lasers have also been mode-locked using the same technique of synchronous pumping as for dye lasers. Pulses as short as 5 ps and tunable over the laser emission range have been obtained in this way.

Due to their broad tunability, their very narrow oscillation linewidth, and their picosecond pulse capabilities, color-center lasers have found applications in areas such as molecular spectroscopy, and investigations of propagation behavior in optical fibers.

## COMPREHENSION CHECK

**Exercise 1.** ***Complete the tag questions and answer them.***

1. Color-center lasers are optically pumped lasers, …?
2. Color-center lasers operate over the wavelength range 0.8-3.3 mm, …?
3. The ordinary F center consists of an electron trapped in an anion vacancy of the crystal, …?
4. Some color-center lasers have been mode-locked, …?
5. The color-center laser is not pumped by another laser, …?
6. The color-center lasers have not found applications in a variety of areas, …?

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 1.** ***Translate into English.***

1. Лазеры на центрах окраски работают в диапазоне длин волны 0.8-3.3 микрометров.
2. Обычный F-центр состоит из электрона, захваченного в анионную вакансию кристалла.
3. Не все F-центры пригодны для получения лазерного эффекта.
4. Подготовка лазерных кристаллов на базе (основе) F-центров требует большой осторожности (внимания) и мастерства.
5. Лазер на центрах окраски подвергается продольной накачке другим лазером.
6. Для таких лазеров пороговые мощности накачки составляют порядка нескольких десятков милливатт.
7. Следует отметить, что существует также лазер на центрах окраски со связанными модами. В них используется такая же методика синхронной накачки как в лазерах на красителе.
8. Лазеры со связанными модами способны испускать очень короткие импульсы в одномодовом оптическом волокне.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match the synonyms.***

*Verbs*

| **1** | **2** |
|---|---|
| 1. indicate | a) be known as |
| 2. require | b) utilize |
| 3. focus | c) obtain |
| 4. trap | d) demand |
| 5. use | e) show |
| 6. illustrate | f) center |
| | g) note |

| | |
|---|---|
| | h) figure |
| | i) generate |
| | j) capture |

**LANGUAGE ACTIVITY**

**Exercise 1.** ***Translate the sentences into Russian paying attention to the structure "is made to do".***

1. In this laser the electron is made to pass through the magnetic field generated by the wiggler.
2. The first FEL was made to operate at λ=3.4 mm using the Standford University linear accelerator.
3. Only two types of color-centres have been made to lase.
4. Mode-locked color-center lasers emitted at λ=1.5 mm have been made to generate very short pulses in single-mode fibers.
5. X-ray lasers are usually made to operate without mirrors.
6. Semiconductor lasers were made to operate cw at room temperature after the invention of the heterojunction laser in 1969.

***Exercise 2.*** **Transform the following sentences using the Complex Object Structure as shown below.**

Model: The Web will provide distant students with full university level course; we expect it.
We expect the Web to provide distant students with full university level course.

1.A wave function relates to the crystal as a whole; we know that.
2.The semiconductor valence and conduction bands are separated by the energy gap; Fig.1 shows this.
3. In semiconductors a lot of new areas of research come into being nowadays; we see it.
4.Semiconductor lasers have already been used in different fields of applications; we believe so.
5.New generations of computers behave more user-friendly; the researchers made so.
6. The transverse dimension of the laser beam greatly exceeds the active region; everybody can see it.
7.The laser beam was strongly absorbed in the *p* and *n* regions; the researchers estimated that.
8.The double-heterojunction laser has opened up the great variety of applications; we think so.
9.Computers are able to do only what they are told; everybody knows that.
10.The scope of research will steadily expand; one can expect this.
11.At present laser action has been produced over the wavelength rage 0.8-3.3 mm; color-center lasers allowed it.

## Unit 14

# Laser Applications

**WORD STUDY**

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
Alignment, geodetic, cauterize, lesions, missile, satellite, isotope, fusion, reduction, ideal.

**Exercise 2.** ***Read and translate the collocations given below.***
To trim microelectronic components, to heat-treat semiconductor chips, to cut fashion patterns, trace substances, tunable dye laser, to vaporize lesions, a small fraction of a second

**UNDERSTANDING A PRINTED TEXT**

**<u>List of Terms</u>**:

cauterize - прижигать
crustal movement – движение земной коры
dye laser – лазер на красителе
exposure time – время экспонирования
frequency shift – сдвиг по частоте
fusion - плавление
heat-treat – подвергать термообработке
high-density information recording – высокая плотность записи информации
lesions - повреждения
low-loss optical fibers – оптические волокна с низкими потерями
to trim – подрезать, формировать
laser-activated switches - переключатели, активируемые лазерным излучением
earthbound communication - наземная связь
vaporize lesions - испарять дефекты

***Reading and discussing***

The use of lasers is restricted only by imagination. Lasers have become valuable tools in industry, scientific research, communication, medicine, military technology, and the arts.

**Industry**

Powerful laser beams can be focused on a small spot with enormous power density. Consequently, the focused beams can readily heat, melt, or vaporize material in a precise manner. Lasers have been used, for example, to drill holes in diamonds, to shape machine tools, to trim microelectronic components, to heat-treat semiconductor chips, to cut fashion patterns, to synthesize new material, and to attempt to induce controlled nuclear fusion. The powerful short pulse produced by a laser also makes possible high-speed photography with an exposure time of several trillionths of a second. Highly directional laser beams are used for alignment in road and building construction.

Lasers are used for monitoring crustal movements and for geodetic surveys. They are also the most effective detectors of certain types of air pollution. In addition, lasers have been used for precise determination of the earth-moon distance and in tests of relativity. Very fast laser-activated switches are being developed for use in particle accelerators, and techniques have been found for using laser beams to trap small numbers of atoms in a vacuum for extremely precise studies of their spectra.

**Scientific Research**

Because laser light is highly directional and monochromatic, extremely small amounts of light scattering or small frequency shifts caused by matter can easily be detected. By measuring such changes, scientists have successfully studied molecular structures. With lasers, the speed of light has been determined to an unprecedented accuracy, chemical reactions can be selectively induced, and the existence of trace substances in samples can be detected.

**Communication**

Laser light can travel a large distance in outer space with little reduction in signal strength. Because of its high frequency, laser light can carry, for example, 1,000 times as many television channels as are now carried by microwaves. Lasers are therefore ideal for space communications. Low-loss optical fibres have been developed to transmit laser light for earthbound communication in telephone and computer systems. Laser techniques have also been used for high-density information recording. For instance, laser light simplifies the recording of a hologram, from which a three-dimensional image can be reconstructed with a laser beam.

**Medicine**

Intense, narrow beams of laser light can cut and cauterize certain tissues in a small fraction of a second without damaging the surrounding healthy tissues. They have been used to "weld" the retina, bore holes in the skull, vaporize lesions, and cauterize blood vessels. Laser techniques have also been developed for lab tests of small biological samples.

**Military Technology**

Laser guidance systems for missiles, aircraft, and satellites are commonplace. The use of laser beams against hostile ballistic missiles has been proposed, as in the defence system urged by US President Ronald Reagan in 1983. The ability of tunable dye lasers to excite selectively an atom or molecule may open up more efficient ways to separate isotopes for construction of nuclear weapons.

**Laser Safety**

Because the eye focuses laser light as it does other light, the chief danger in working with lasers is eye damage. Therefore, laser light should not be viewed, whether it is direct or reflected. Lasers should be used only by trained personnel wearing protective goggles.

## CHECK YOUR UNDERSTANDING

**Exercise 1.** ***Find the suitable endings of the following sentences.***

1. Lasers have become valuable tools in…
2. Powerful laser beam can be focused on…
3. Lasers are also the most effective detectors of…
4. Laser techniques have also been used for…
5. Lasers have been used to…
6. Laser techniques have also been developed for…

a. a small spot with enormous power density.
b. high-density information recording.
c. certain types of air pollution.
d. lab tests of small biological samples.
e. "weld" the retina, bore holes in the skull, vaporize lesions and cauterize blood vessels.
f. industry, scientific research, communication, medicine, military technologies and arts.

**Exercise 2.** ***Translate the passage "Military Technology" and discuss the topics.***

1. What do you think about missile defense systems situation in Russia and the USA?
2. What other (not mentioned in the texts) uses of laser do you know?

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Read English words and collocations and find Russian equivalents to them.***

1. exposure time
2. frequency shift
3. speed of light
4. laser light
5. intensity
6. tunable dye laser
7. damage
8. defence system
9. nuclear weapon
10. nuclear fusion
11. pulse
12. molecular structure

a. импульс
b. система защиты
c. ядерное оружие
d. свет лазера
e. вред
f. структура молекулы
g. лазерный луч
h. защита
i. скорость света
j. интенсивность
k. ядерный (синтез)
l. перестраиваемый лазер на красителе
m. сдвиг по частоте
n. время экспонирования

**Exercise 2.** ***Translate the following word combinations with Participle II as an attribute.***

focused beams
powerful short pulse produced by
very fast laser-activated switches
small frequency shifts caused by
in the defence system urged by
trained personnel

## LANGUAGE ACTIVITY

**Two or more nouns can be combined in several ways.**

1. ‘s possessive (SOL’s owner)
2. one noun used as adjective (office hours)
3. phrases with "of" (independence of mind)
4. compound nouns forming one word (workplace)

**Reread the chapter "Lasers" and write noun combinations under the following four headings:**

| ‘s possessive | one noun used as adjective | phrases with "of" | compound nouns forming one word |
|---|---|---|---|

**Exercise 1.** ***Put the verbs in brackets into the correct form.***

1. If I had known that you were in hospital I (visit) you.2. If I (know) that you were coming I'd have baked a cake. 3. If you (arrive) ten minutes earlier you would have got a seat. 4. You would have seen my garden at its best if you (be) here last week. 5. I wouldn't have believed it if I (not see) it with my own eyes. 6. I (offer) to help him if I had realized that he was ill. 7. If I (realize) what a bad driver you were I

wouldn't have come with you. 8. If he had known that the river was dangerous he (not try) to swim across it.

# SUPPLEMENTERY TASKS

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 1.** ***Translate the text into English using words given below.***

**Пробивка отверстий в часовых камнях**

Одним из первых применений лазеров была пробивка отверстий в часовых камнях. Сверление отверстий всегда было очень трудоемкой операцией. Современная лазерная технология позволяет прошивать отверстия требуемой формы в камнях различных типов с высокой скоростью и качеством.

**Лазерная сварка**

Одним из первых применений лазеров в ювелирной отрасли были операции ремонта различных изделий с помощью лазерной сварки. Примером применения в массовом производстве лазерной сварки является лазерная сварка цепей при их производстве. Особенностью этого процесса является его двухэтапность: сначала формируется цепочка, потом производится ее пайка традиционными методами. Лазерная технология позволяет производить сварку звена цепи при его формировании на одной технической операции и одном и том же оборудовании. Впервые такая технология была разработана для сварки золотых цепочек итальянской фирмой Laservall. Преимущество лазерной сварки – локальность ввода тепла, низкие потери материала при сварке, возможность соединения деталей, практически без нагрева всего изделия целиком.

1. to make a hole
2. to drill
3. labour-consuming
4. jewels (часовые камни)
5. chain
6. manufacture
7. soldering
8. two-step
9. welding
10. chain section
11. jewellery
12. advantages
13. low losses
14. heating.

**Exercise 2.** ***Translate into English using key words given below.***

## Лазеры в медицине

Одним из крупнейших открытий прошлого века являются лазеры.

Лазеры - это квантовые генераторы оптического диапазона или просто генераторы света. Лазеры представляют собой источники света, работающие на базе процесса вынужденного испускания фотонов возбужденными атомами или молекулами под воздействием фотонов излучения, имеющих ту же частоту.

В сравнительно короткое время появились различные типы лазеров и лазерных устройств, предназначенных для решения конкретных научных и технических задач. Принято различать два типа лазеров: усилители и генераторы. Второй подход к классификации лазеров связан с физическим состоянием активного вещества. С этой точки зрения лазеры бывают твёрдотельными, газовыми, жидкостными, полупроводниковыми.

В настоящее время в большинстве стран мира наблюдается интенсивное внедрение лазерного излучения в биологических исследованиях и в практической медицине. Клинические наблюдения показали эффективность лазера ультрафиолетового, видимого и инфракрасного спектров для местного применения на патологический очаг и для воздействия на весь организм. Исключительные свойства лазеров привлекли внимание хирургов. Оказывается, что луч лазера с успехом используется в качестве скальпеля. По сравнению с обычным такой скальпель обладает рядом достоинств: надёжность в работе, абсолютная стерильность, производит почти бескровный разрез и т.д.

Лазерный луч найдёт применение в качестве прижигающего инструмента для обработки кожных новообразований и повреждений.

Другими областями, в которых предложено использовать лазер, являются: лечение зубов путём испарения поражённых кариесом частей зуба, обесцвечивание татуировок и других поглощающих дефектов кожи.

Исследования, демонстрирующие потенциальные возможности применения лазеров в медицине, пока находятся на начальной стадии, и развитие этих областей требует длительных поисков во многих направлениях.

оптический диапазон - optical range
вынужденного - stimulated
в сравнительно короткое время - in rather short time
усилители - amplifiers
физическим состоянием активного вещества - a physical condition of active substance.
в большинстве стран мира - in the majority of the countries of the world
интенсивное внедрение - intensive introduction
свойства - properties
хирург - the surgeon
повреждения - damages
лечение зубов поражённых кариесом частей зуба путём испарения - treatment of teeth by evaporation of the parts, struck with caries.

**Exercise 3.** ***Translate into Russian the following texts in writing. Write down key-words from the texts.***

# How a Laser Works

## The Basics of an Atom

Everything we see within the Universe is made up of an infinitesimally large number of combinations of the 100 different kinds of atoms. The arrangement and bonding of these atoms determines what material/object they constitute.

Atoms are constantly in motion. They continuously vibrate and move. Although all atoms are vibrating to a degree, atoms can be in a different state of excitation (i.e. they can have different levels of energy). If a large degree of energy is applied to an atom then it can leave what is referred to as ground-state energy level and go to an excited level. The level of excitation is proportional to the amount of energy applied.

A simple atom as shown in Figure 1 consists of a nucleus, which consists of protons and neutrons and what is often referred to as an electron cloud. For a simplistic interpretation of the atom model it is easy to think of the electrons within the electron cloud following discrete paths or orbits within the cloud. This analogy suits our purpose as we can then consider these orbits to be the different energy levels that make up the atom. If we add some form of energy to the atom we can assume that electrons from the lower-energy orbitals will transfer to the higher-energy orbitals at a greater distance from the nucleus, resulting in a higher level of excitation.

*Electron Nucleus orbit*

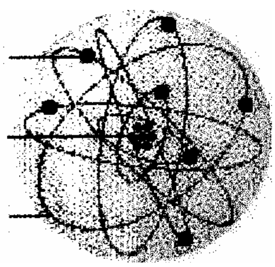


*Fig.1. Simple Atom Model*

When atoms reach a higher-energy orbital they eventually seek to return to the ground-state energy level. Upon returning to the ground-state energy level the excess energy is released in the form of a photon - a particle of light.

## The Connection Between Atoms and Lasers

A laser is a device that controls the way in which energised atoms release photons. There are many different types of laser available; all the different types of laser rely on the same basic elements. In all types of laser there is a lasing medium, which is pumped to get the electrons within the atoms to a higher-energy orbital i.e. to get the atoms excited. Typically, very intense flashes of light or an electrical discharge pump the lasing medium and create a large number of excited-state atoms. This creates a high degree of population inversion (the number of excited state atoms versus the number of atoms at ground-state energy level). At any stage the excited state atoms can release some of the energy and return to a lower-energy orbital. The energy released, which comes in the form of photons, has a very specific wavelength that is dependant on the level of energy of excitation of the electron when the photon is released. Two identical atoms with electrons in identical states will release photons with identical wavelengths. This forms the basis for laser light.

**Laser light has the following properties:**

- Laser light is monochromatic. It contains one specific wavelength of light, which as described earlier is determined by the amount of energy released when the electron drops to a lower-energy orbital.
- Laser light is coherent. Each photon moves in step with the other (i.e. all photons have wave fronts that move in unison).
- Laser light is highly directional (i.e. a laser beam is very tight and concentrated).

Any photon that has been released by an atom, (which therefore has a wavelength, phase and energy level dependant on the difference between the excited atom state and the ground-state energy level) should encounter another atom that has another electron in the same excited state, thus stimulated emission can occur. The first photon can stimulate or induce atomic emission so that the emitted photon vibrates with the same frequency and direction.

## UNDERSTANDING PRINTED TEXTS

**Exercise 5.** ***Read the text and underline the topic sentence.***

### Lasers in Communication

Fiber optic cables are a major mode of communication partly because multiple signals can be sent with high quality and low loss by light propagating along the fibers. The light signals can be modulated with the information to be sent by either light emitting diodes or lasers. The lasers have significant advantages because they are more nearly monochromatic and this allows the pulse shape to be maintained better over long distances. If a better pulse shape can be maintained, then the communication can be sent at higher rates without overlap of the pulses. Telephone fiber drivers may be solid state lasers consuming power of only half a milliwatt. Yet they can sent 50 million pulses per second into an attached telephone fiber and encode over 600 telephone conversations.

**Exercise 6.** ***Translate the text and entitle it.***

Laser cutters are credited with keeping the U.S. garment industry competitive in the world market. The programmed cutter can cut dozens to hundreds of thicknesses of cloth, and can cut every piece of the garment in a single run. The usefulness of the laser for such operations comes from the fact that the beam is highly collimated and can be further focused to a microscopic dot of extremely high energy density for cutting.

**Exercise 7.** ***Read the text given below and answer in what abstract can you find the information about:***

a) holography;
b) using of laser beams in building construction;
c) computing the distance to the Moon.

## Laser uses

1. Eye surgeons can use laser beams to "weld" detached retinas back onto the eyeball without cutting into the eye. The laser beam is directed onto the retina through the pupil of the eye. Scar tissue forms at the impact site of the laser beam and at that point fastens the retina to the inner surface of the eye.

2. Laser beams have been used for industrial purposes. The diamond dies through which extremely thin wire filaments are drawn can be drilled with a laser beam. The already narrow beam of light can be further reduced to a diameter of less than 0.001 inch. The energy concentrated in this tiny beam is known to be sufficient to cut through diamond.

3. Laser beams are sometimes used as reference points in building construction. They accurately mark straight lines along the course of large buildings. A laser beam is used by scientists to detect whether portions of a two-mile-long particle accelerator in Stanford, California, move out of alignment.

4. Three-dimensional images can be produced by laser beams. Holography, or laser photography, relies on the coherent beam of laser light to produce a *hologram,* a three-dimensional information record of an object on photographic film. A portion of a laser beam is reflected off the object and into the path of a reference beam of unreflected laser light. The interaction of the two beams produces a unique interference pattern in the film. When another laser beam is aimed through the hologram's interference "picture," a three-dimensional image of the original object is reconstructed.

5. The distance between the earth and the moon has been measured accurately by means of a laser beam. Scientists recorded the time taken for a laser beam to bounce off a reflector placed by astronauts on the moon. Knowing the speed of light in a given period of time, scientists were able to compute the distance with accuracy.

**Exercise 8.** ***Read and entitle the text.***

To produce laser light it is necessary to have a pair of mirrors at either end of the lasing medium. These mirrors are often known as an optical oscillator due to the process of oscillating photons between the two mirrored surfaces. The mirror positioned at one end of the optical oscillator is half-silvered, therefore it reflects some light and lets some light through. The light that is allowed to pass through is the light that is emitted from the laser. During this process photons are constantly stimulating other electrons to make the downward energy jump, hence causing the emission of more and more photons and an avalanche effect, leading to a large number of photons being emitted of the same wavelength and phase.

Below is a graphical illustration of what has been detailed above. The graphics illustrate how laser light is created using a ruby laser, the first fully functioning laser. Theodore Maiman invented the ruby laser on May 16th 1960 at the Hughes Research Laboratories.

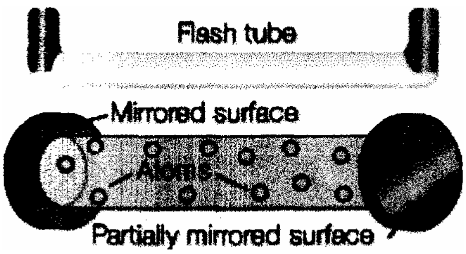



*Fig.1. Schematic of Laser in Non-Lasing State*

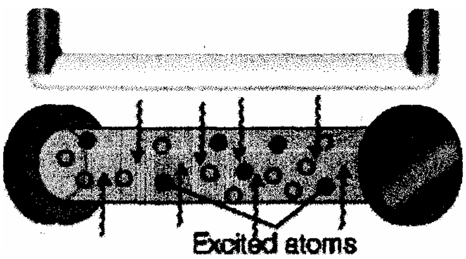



*Fig.2. Schematic Illustrating the Excitation of Atoms Using Light Source*

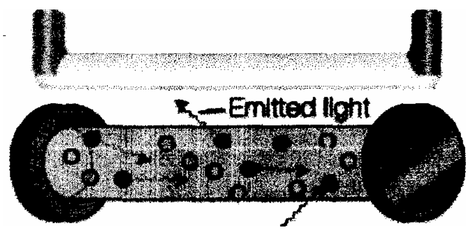



*Fig.3. Schematic Showing Photon Emission*

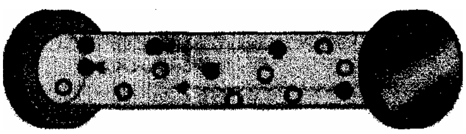


*Fig.4. Schematic Showing the Stimulated Emission of Further Photons*

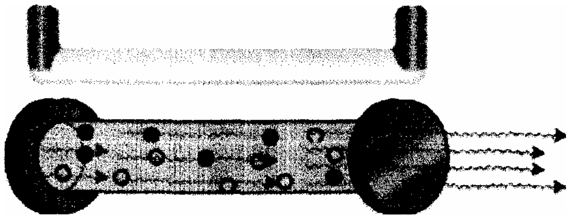


*Fig.5. Schematic Showing Column of Laser Light Leaving Optical Osculate*

# Chapter III
# Fiber Optics

## Unit 15
## The History of Fiber Optics

### WORD STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
*Nouns*
atmosphere, facsimile, fountain, semaphore, spectrum, turbulence.
*Verbs*
confine, illustrate, install, languish, mount.
*Adjectives*
analogous, dielectric, inaccessible, transparent.

**Exercise 2.** ***Make adverbs from the following adjectives according to the model and translate them.***
*Adjective + -ly = adverb*

a) careful – carefully
experimental, essential, practical, total, virtual
b) simple – simply
gentle, probable, suitable, terrible
c) easy – easily
lazy, noisy
d) complete – completely
efficient, brilliant, effective, ultimate

*Adjective + -ally = adverb*

e) heroic – heroically
atomic, automatic, tragic, analytic, symbolic

### UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

bandwidth – диапазон
bundle of optical fibres – оптоволоконный кабель
decode – декодировать, расшифровывать
glass-clad fibre – волокно со стеклянным покрытием
fused silica – кварцевое стекло

melting point – точка плавления
one waveguide mode –одноволновая мода колебаний
optical-frequency amplifier – усилитель оптических частот
phenomenon of total internal reflection – эффект полного внутреннего отражения
theoretical specification – теоретические условия (спецификации)
transparent – прозрачный
world's long-distance traffic – международное сообщение
core – сердцевина
hollow pipes - полые трубки
transparent rods - прозрачные стержни
wire - провод, проволока

***Reading and discussing***

Optical communication systems date back more than two centuries to the "optical telegraph" that French engineer Claude Chappe invented in the 1790s. His system was a series of semaphores mounted on towers, where human operators relayed messages from one tower to the next. It reduced the need in hand-carried messages, but by the mid-19th century it was replaced by the electric telegraph.

Alexander Graham Bell patented an optical telephone system, which he called the photophone, in 1880, but his earlier invention, the telephone, proved far more practical. He dreamed of sending signals through the air, but the atmosphere didn't transmit light as reliably as wires carried electricity. In the decades that followed, light was used for a few special applications, such as signalling between ships, but otherwise optical communications, like the experimental photophone Bell donated to the Smithsonian Institution, languished on the shelf.

In the intervening years, a new technology slowly took root that would ultimately solve the problem of optical transmission, although it was a long time before it was adapted for communications. It depended on the phenomenon of total internal reflection, which can confine light in a material surrounded by other materials with lower refractive index, such as glass in air. In the 1840s, Swiss physicist Daniel Collodon and French physicist Jacques Babinet showed that light could be guided along jets of water for fountain displays.

Optical fibres went a step further. They were essentially transparent rods of glass or plastic stretched so they were long and flexible. During the 1920s, John Logie Baird in England and Clarence W. Hansell in the United States patented the idea of using arrays of hollow pipes or transparent rods to transmit images for television or facsimile systems. However, the first person known to have demonstrated image transmission through a bundle of optical fibres was Heinrich Lamm, then a medical student in Munich. His goal was to look inside inaccessible parts of the body. During his experiments, he reported transmitting the image of a light bulb.

By 1960, glass-clad fibres fine for medical imaging were made, but they didn't match communication purposes.

Meanwhile, telecommunications engineers were seeking more transmission bandwidth. Radio and microwave frequencies were in heavy use, so they looked to higher frequencies to carry loads they expected to continue increasing with the growth of television and telephone traffic.

The next step towards optical communications was the invention of laser. The July 22, 1960 issue of "Electronics" magazine introduced its report on Theodore Maiman's demonstration of the first laser by saying "Usable communications channels in the electromagnetic spectrum may be extended by development of an experimental optical-frequency amplifier." But rain, haze, clouds, and atmospheric turbulence limited the reliability of long-distance atmospheric laser links. Optical wave-guides proved to be a problem.

Optical fibres had attracted some attention because they were analogous in theory to plastic dielectric wave-guides used in certain microwave applications. In 1961, Elias Snitzer demonstrated the similarity by drawing fibres with cores so small that they carried light in only one waveguide mode. However virtually everyone considered fibres too lossy for communications.

In 1964, a critical (and theoretical) specification was identified by Dr. C.K. Kao for long-range communication devices, the 10 or 20 decibels of light loss per kilometer standard. Kao also illustrated the need for a purer form of glass to help reduce light loss.

In 1970, one team of researchers began experimenting with fused silica, a material capable of extreme purity with a high melting point and a low refractive index. Corning Glass researchers Robert Maurer, Donald Keck and Peter Schultz invented fiber optic wire or "Optical Waveguide Fibers" capable of carrying 65,000 times more information than copper wire, through which information carried by a pattern of light waves could be decoded at a destination even a thousand miles away. The team had solved the problems presented by Dr. Kao.

The first optical telephone communication system was installed about 1.5 miles under downtown Chicago in 1977, and each optical fiber carried the equivalent of 672 voice channels. Today more than 80 percent of the world's long-distance traffic is carried over optical fiber cables, 25 million kilometers of the cable Maurer, Keck and Schultz designed has been installed worldwide.
Today more than 80 percent of the world's long-distance traffic is carried over optical fiber cables.

## CHECK YOUR UNDERSTANDING

**Exercise 1.** ***Answer the following questions.***

1. What is known about the invention of the optical telegraph?
2. Why didn't Bell's optical telephone system find wide application?
3. How did the invention of laser affect optical communications?
4. What goal did Heinrich Lamm set working on image transmission through optical fibres?
5. What were the results of the experiments with fused silica?

**Exercise 2.** ***Topics for discussion.***

1. Why do you think that the development of fibre optics took such a long time?
2. Why is it possible to call the development of fibre optics a key for world's communications?

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Compare two columns and find Russian equivalents to words or word combinations:***

| 1 | 2 |
|---|---|
| 1) bandwidth | a) показатель преломления |
| 2) bundle of optical fibers | b) прозрачный |
| 3) critical temperature | c) волновод |
| 4) decode | d) диапазон |
| 5) glass-clad fiber | e) выбирать |
| 6) fused silica | f) технические условия |
| 7) melting point | g) передача |
| 8) optical-frequency amplifier | h) оптический телеграф |
| 9) phenomenon of total internal reflection | i) медный провод |
| 10) refractive index | j) теоретические условия (спецификация) |
| 11) theoretical specification | k) кварцевое стекло |
| 12) transparent | l) волокно со стеклянным покрытием |
| 13) waveguide | m) усилитель оптических частот |
| 14) transmission | n) эффект полного внутреннего отражения |
| 15) message | o) оптоволоконный кабель |
| 16) copper wire | p) критическая температура |
| 17) core | q) сердцевина, стержень |
| 18) one waveguide mode | r) точка плавления |
| | s) декодировать, расшифровывать |
| | t) сообщение |
| | u) коэффициент упругости |
| | v) одноволновая мода колебаний |

## LANGUAGE ACTIVITY

**Exercise 1.** ***Insert prepositions:*** *on, in, of, for, to, with, by, from.*

1. Operators of optical telegraph relayed messages … one tower … the next.
2. Bell dreamed … delivering messages through the air.
3. They have already started experiments … germanium.

4. This fiber optic wire was capable … carrying much more information.
5. Fibers with small cores can carry light … only one waveguide mode.
6. The National Geographic issued the report … some new achievements in holography.
7. It took quite a long time before a new technology was adapted … communications.
8. Those fibers were especially fine … medical imaging.
9. The problems presented … Dr. Kao had been successfully solved.

**Exercise 2.** ***Summarize your knowledge of the Conditional Sentences and translate the sentences into Russian.***
1. If I had more time I should complete the experiment.
2. If we had known the dimensions of the body we should have calculated its volume.
3. Had we visited this research institute we should have seen a new model of the system.
4. Semaphores wouldn't have reduced the need in hand-carried messages, if they hadn't been replaced by the electric telegraph.
5. If you carry out this experiment you will learn much useful information.
6. If we didn't raise the temperature, we shouldn't increase the pressure.

**Exercise 3.** ***Complete the sentences given below.***
1. I would have told her the latest news, if I … .
2. They would be very glad, if you … .
3. If I were you, I … .
4. If they came to see us one of these days, we … .
5. If you stayed with us a little longer, you … .
6. Had I met him before, I … .

**Exercise 4.** ***Summarize your knowledge of the Sequence of Tenses and Reported Speech.***
1. I was sure they (need, needed) my help.
2. He was asked when and where he (was born, had been born).
3. We didn't know she (works, was working) as a secretary.
4. I knew the delegation (will arrive, would arrive) the next day.
5. Mr. Burton said it (is, was) the most exciting game he (has ever seen, had ever seen).
6. I was afraid he (failed, would fail) at the forthcoming examinations.

***Exercise 5. Summarize your knowledge of non-Finite forms. Define the form of the underlined words (Infinitive, Participle - I, Participle - II, Gerund). Translate the sentences.***
1. While carrying out his experiment Heinrich Lamm reported about transmitting the image of a light bulb.
2. His goal was to look inside inaccessible parts of the object.

3. The team had solved the problems presented by Dr. Kao.
4. Having been tested, the new apparatus was recommended for work in all the laboratories.
5. The experiments of the physicists resulted in making much more powerful microscopes.
6. The described results of the test depended on the accuracy of the used instrument.
7. Diagrams illustrate two methods of connecting a series of cells.
8. Some of the produced effects are discussed in the following chapter.

## Unit 16
# Fiber Optic Systems

## WORD STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
*Nouns*
contaminant, cladding, interface, abrasion, germanium, utility.
*Verbs*
bounce, shield, channel, convert, tunnel, replace, transmit.

**Exercise 2.** ***Read and translate the following collocations.***
Outer jacket, strength material, coded electronic pulse information, total internal reflection, injection-laser diode.

**Exercise 3.** ***The following groups of words are all related in meaning because they have the same roots. Notice the suffixes indicating nouns.***

| *Verbs* | *Nouns* |
|---|---|
| transmit | transmitter, transmission |
| receive | receiver, receivership |
| inform | informer, information |
| translate | translator, translation |
| reflect | reflector, reflection |
| construct | constructor, construction |
| contribute | contributor, contribution |
| advertise | advertiser, advertisement |
| employ | employer, employment |

## UNDERSTANDING A PRINTED TEXT

**<u>List of Terms:</u>**

abrasion – механические повреждения поверхности, трение
angle of incidence – угол падения
buffer material – буферный материал
critical value – критическое значение
electric utility company – электрическая бытовая компания
extremely reflective surface – поверхность с высоким отражением
injection-laser diode (ILD) – инжекционный лазерный диод
interface – интерфейс, стык
light-emitting diode (LED) – светодиод

optic cladding – оптическое покрытие, оболочка
optic core – сердцевина оптического волокна
outer jacket – внешнее покрытие, внешний слой, кожух
receiver – приемник
solvent – разъедание, коррозия, растворитель
strand – пучок волокон, кабель
terrestrial hardwired systems – наземные электронные системы
transmitter - передатчик
transmission medium – передающая среда

***Scan-reading***

In recent years it has become apparent that fiber optics is steadily replacing copper wire as an appropriate means of communication signal transmission. Fiber optic systems are currently used most extensively as the transmission link between terrestrial hardwired systems. They span the long distances between local phone systems as well as other system users which include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

## Fiber-Optic Technology

A fiber-optic system can generally be seen as a system with three main components: a transmitter, a transmission medium and a receiver. As a model it is similar to the copper wire system that fiber optics is replacing. The difference is that fiber optics uses light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the three main components in the fiber optic chain will give a better understanding of how the system works in conjunction with wire based systems.

At the head end of the chain is the transmitter. This is the place of origin for information coming on to fiber optic lines. The transmitter accepts coded electronic pulse information coming from copper wire. It then processes and translates that information into equivalently coded light pulses. A light-emitting diode (LED) or an injection-laser diode (ILD) can be used for generating the light pulses. Using a lens, the light pulses are tunneled into the fiber-optic medium where they transmit themselves down the line.

Light pulses move easily down the fiber-optic line because of a principle known as total internal reflection. This principle of total internal reflection states that when the angle of incidence exceeds a critical value, light cannot get out of the glass; instead, the light bounces back in. When this principle is applied to the construction of the fiber-optic strand, it is possible to transmit information down fiber lines in the form of light pulses.

There are generally five elements that make up the construction of a fiber-optic strand, or cable: the optic core, optic cladding, a buffer material, a strength material and the outer jacket. The *optic core* is the light carrying element at the center of the optical fiber. It is commonly made from a combination of silica and germanium.

Surrounding the core is the *optic cladding* made of pure silica. It is this combination that makes the principle of total internal reflection possible. The difference in materials used in the making of the core and the cladding creates an extremely reflective surface at the point in which they interface. Light pulses entering the fiber core reflect in the core cladding interface and thus remain within the core as they move down the line.

Surrounding the cladding is a buffer material used to help shield the core and cladding from damage. A strength material surrounds the buffer, preventing stretch problems when the fiber cable is being pulled. The outer jacket is added to protect against abrasion, solvents, and other contaminants.

Once the light pulses reach their destination they are channeled into the optical receiver. The basic purpose of an optical receiver is to detect the received light incident on it and to convert it to an electrical signal containing the information impressed on the light at the transmitting end. In other words the coded light pulse information is translated back into its original state as coded electronic information. The electronic information is then ready for input into electronic based communication devices such as a computer, telephone or TV.

## COMPREHENSION CHECK

**Exercise 1.** ***Answer the following questions.***

1. What is the purpose of fiber optic systems?
2. What are three main components of a fiber optic system?
3. How does a transmitter work?
4. How is a fiber optic cable constructed?
5. What is the purpose of an optical receiver and how does it work?
6. What is fiber optics replacing as a means of signal transmission?

**Exercise 2.** ***Topics for discussion.***

1. Advantages of fiber optic systems.
2. Usage of fiber optic systems.

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Match words and collocations from the left column with words and collocations from the right column.***

| | |
|---|---|
| 1. abrasion<br>2. angle of incidence<br>3. buffer material<br>4. copper wire system<br>5. contaminant<br>6. critical value<br>7. extremely reflective surface | a) механическое повреждение поверхности<br>b) поверхность с высоким отражением<br>c) интерфейс, стык<br>d) сердцевина оптического волокна<br>e) импульс<br>f) угол падения<br>g) связь, осуществляемая по медным |

| | |
|---|---|
| 8. injection-laser diode<br>9. interface<br>10. light-emitting diode<br>11. optic cladding<br>12. optic core<br>13. outer jacket<br>14. pulse<br>15. receiver<br>16. terrestrial hardwired systems<br>17. transmitter<br>18. transmission medium<br>19. to enter<br>20. to exceed | проводам<br>h) приемник<br>i) наземные электронные системы<br>j) буферный материал<br>k) передающая среда<br>l) входить<br>m) вредный фактор<br>n) превосходить<br>o) выходить<br>p) световой диод<br>q) внутреннее покрытие<br>r) предельное значение<br>s) инжекционный лазерный диод<br>t) внешнее покрытие, кожух<br>u) оптическое покрытие<br>v) передатчик<br>w) пластинка |

**Exercise 2.** ***Insert the proper words or collocations: a) optical receiver, b) fiber optics, c) optic core, d) fiber optic strand, e) principle, f) transmitter***

1. A … usually consists of five main elements.
2. The received light is detected and converted into an electrical signal by … .
3. Instead of using electronic pulses to transmit information down copper lines … uses light pulses to transmit information down fiber lines.
4. … accepts coded electronic pulse information coming from copper wire.
5. In a fiber optic line a … known as total internal reflection is used.
6. This is the light carrying element at the center of the optical fiber. It's called …

**Exercise 3.** ***Which of the italicized words in each sentence is the predicate?***

1. Last month our laboratory *developed* a new technique *required* for thermodynamic studies of a two-phase system.
2. The technique *allowed* us to obtain results *predicted* by theory.
3. The results *obtained disagreed* with earlier data *reported* by Dr. Brown.
4. After a *heated* discussion the laboratory *applied* the method *improved* by Dr. Brown.
5. The model *suggested described* adequately the thermodynamic peculiarities *studied* by Dr. Brown.
6. The method *applied increased* the accuracy of the results.
7. The scientist theoretically *predicted complicated* interaction between the components *involved* in the process.
8. The crystal *produced revealed cracked* faces.

**Exercise 4.** ***Translate the sentences paying special attention to Passive Constructions.***

1. Some people *are* easily *influenced* by other people's opinions.

2. The distribution of plants *is* greatly *affected* by local conditions.
3. His lectures *are* always *followed* by heated discussions.
4. The seminar *was attended* by all the participants.
5. In several areas of research the efforts of scientists *are joined* by those of philosophers and sociologists.
6. At the university students are offered a curriculum of study which *is followed* by a test.
7. Scientists *were consulted* prior to their successful operation.

**Exercise 5.** ***Translate the following sentences where the participles are used as the adverbial modifiers.***

1. *Having reported* on the discovery of rays of unknown nature Bequerel excited the curiosity of Marie Curie.
2. *Realizing* the necessity for a different approach the physicists reluctantly abandoned the project.
3. *Confining* his attention to one problem the scientist will surely achieve its solution much sooner.
4. *Recognizing* a problem the scientist makes the first step to its solution.
5. The scientist is often interested in a problem, *disregarding* possible consequences of its solution.
6. *When heated*, magnetized steel will lose its magnetism.

**Exercise 6.** ***Identify the function of the participles in the sentences given below as:***
1) определение; 2) обстоятельство; 3) образует страдательный залог;4) образует группу продолженных времён.

1. Fiber optic systems *are* currently *used* most extensively as the transmission link between terrestrial hardwired systems.
2. As a model a fiber-optic system is similar to the copper wire system that it *is replacing*.
3. The transmitter is the place of origin for information *coming on* to fiber optic lines.
4. *Using* modern installations and techniques the scientists succeeded in working out a complicated engineering problem.
5. A light-emitting diode *can be used* for generating the light pulses.
6. Light pulses move easily down the fiber-optic line because of a principle *known* as total internal reflection.
7. *Having realized* the threat to our environment we made the first step to its preservation.
8. The transmitter accepts *coded* electronic pulse information.

**Exercise 7. While translating the sentences pay attention to the chains of attributes.**

1. The transmitter processes and translates the information into *equivalently coded light pulses.*

2. The optic core is *the light carrying element* at the center of the optical fiber.
3. In other words *the coded light pulse information* is translated back into its original state as *the coded electronic information.*
4. The electronic information is then ready for input into *electronic based communication device,* such as a computer, telephone or TV.
5. When a photon is absorbed by an electron and becomes excited there is a rapid transition into *another long-lived energy state.*
6. The development of a semiconductor laser is one of the most important developments in *the rapidly changing field* of technology.

**Exercise 8. *Give English equivalents of the italicized part of the sentences, using passive structures and the verbs:* to affect, to allow, to attend, to develop, to deal with, to face, to follow, to make use of, to refer to.**

1.*За докладом последовало* бурное обсуждение.

2.*На скорость реакции влияет множество* других *факторов.*

3. *Этот вопрос будет* подробно *рассмотрен* в следующей статье.

4. На этой стадии *мы столкнулись с* новыми *трудностями.*

5. *Ему не дали возможности закончить* эту работу.

6. В последнее время *эта теория* часто *упоминается* во многих статьях.

7. Для того чтобы преодолеть эти недостатки, *использовали* новую *методику,* специально *разработанную* для данного эксперимента.

**Exercise 9. *Summarize your knowledge of the Passive Voice. Translate the sentences into Russian.***

1. This method has been referred to in an earlier paper.
2. I don’t think this instrument can be relied upon.
3. The data cannot be accounted for by the existing theory.
4. The best treatment of this syndrome is generally agreed upon.
5. Such things are not even thought of before the discovery is actually made.
6. The rate of the reflection is affected by the change in such parameters as concentration, temperature and pressure.
7. Solar batteries are dealt with in this new text-book.
8. The properties of these systems were much spoken about.

## Unit 17

## WORD-STUDY

**Exercise 1.** ***Check the transcription in a dictionary and read the words listed below.***
Boundaries, extraneous, coaxial, unique, bandwidth, fidelity, corrode.

**Exercise 2.** ***Read and translate the collocations given below.***
Most responsible for its evolution, basic point-to-point fiber optic transmission system, replica of the original signal, wide range of benefits, virtually all kinds, ground loops, there is no possibility of a spark, outdoor atmospheric conditions, information carrying capacity.

## UNDERSTANDING A PRINTED TEXT

**List of Terms:**

coaxial cable – коаксиальный кабель
corrode – подвергаться действию коррозии
data rate – скорость передачи информации
duct – труба для кабеля, оболочка
extraneous signal pickup – прием постороннего сигнала
fidelity – точность, достоверность
fire hazard – угроза пожара
lash – подсоединять
low-loss glass fiber optic cable – стеклянный оптоволоконный кабель с низкими потерями
monitor – передавать (информацию)
optical receiver – оптический приемник
power line – силовой кабель (линии электропередачи)
point-to-point fiber optic transmission system - волоконная система передачи типа "точка - точка"
solid state laser diode – твердотельный лазерный диод
spark – возгорание, искровой разряд
splice – сплетение (проводов)
tap – подключаться
transmission media – средства передачи информации
ground loop - заземление

***Reading and entitling the text***

Our current "age of technology" is the result of many brilliant inventions and discoveries, but it is our ability to transmit information, and the media we use to do it, that is perhaps most responsible for its evolution. Progressing from the copper wire of a century ago to today's fiber optic cable, our increasing ability to transmit more information, more quickly and over longer distances has expanded the boundaries of our technological development in all areas.

Today's low-loss glass fiber optic cable offers almost unlimited bandwidth and unique advantages over all previously developed transmission media. The basic point-to-point fiber optic transmission system consists of three basic elements: the optical transmitter, the fiber optic cable and the optical receiver.

**THE OPTICAL TRANSMITTER** converts an electrical analog or digital signal into a corresponding optical signal. The source of the optical signal can be either a light emitting diode, or a solid state laser diode. The most popular wavelengths of operation for optical transmitters are 850, 1300, or 1550 nanometers.

**THE FIBER OPTIC CABLE** consists of one or more glass fibers, which act as waveguides for the optical signal. Fiber optic cable is similar to electrical cable in its construction, but provides special protection for the optical fiber within. For systems requiring transmission over distances of many kilometers, or where two or more fiber optic cables must be joined together, an optical splice is commonly used.

**THE OPTICAL RECEIVER** converts the optical signal back into a replica of the original electrical signal.

Fiber optic transmission systems – a fiber optic transmitter and receiver, connected by fiber optic cable – offer a wide range of benefits not offered by traditional copper wire or coaxial cable. These include:

1. The ability to carry much more information and deliver it with greater fidelity than either copper wire or coaxial cable.

2. Fiber optic cable can support much higher data rates, and at greater distances, than coaxial cable, making it ideal for transmission of serial digital data.

3. The fiber is totally immune to virtually all kinds of interference, including lightning, and will not conduct electricity. It can therefore come in direct contact with high voltage electrical equipment and power lines. It will not also create ground loops of any kind.

4. As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil or exposed to most corrosive atmospheres in chemical plants without significant concern.

5. Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber. Even in the most explosive of atmospheres, there is no fire hazard, and no danger of electrical shock to personnel repairing broken fibers.

6. Fiber optic cables are virtually unaffected by outdoor atmospheric conditions, allowing them to be lashed directly to telephone poles or existing electrical cables without concern for extraneous signal pickup.

7. A fiber optic cable, even one that contains many fibers, is usually much smaller and lighter in weight than a wire or coaxial cable with similar information

carrying capacity. It is easier to handle and install, and uses less duct space. (It can frequently be installed without ducts.)

8. Fiber optic cable is ideal for secure communications systems because it is very difficult to tap but very easy to monitor. In addition, there is absolutely no electrical radiation from a fiber.

## CHECK YOUR UNDERSTANDING

**Exercise 1.** ***Which title suits the text better?***

1. From the History of Fiber Optics.
2. Advantages of Fiber Optics.
3. Fiber Optic Systems.
4. Future of Fiber Optics.

**Exercise 2.** ***Answer the following questions.***

1. What are the main parts of the basic point-to-point optic transmission system?
2. What is the purpose of an optical transmitter?
3. What kinds of cables are used in fiber optics?
4. What is a fiber optic system?
5. Could you list some of the advantages of fiber optic systems?

## INCREASE YOUR VOCABULARY

**Exercise 1.** ***Read the English nouns and collocations and find the Russian equivalents to them.***

| | |
|---|---|
| 1. fiber optic cable | a. возгорание, искровой разряд |
| 2. light emitting diode | b. оптический передатчик |
| 3. coaxial cable | c. внешние атмосферные условия |
| 4. optical signal | d. угроза пожара |
| 5. optical transmitter | e. светодиод |
| 6. fire hazard | f. оптический сигнал |
| 7. transmission | g. длина волны |
| 8. spark | h оптоволоконный кабель |
| 9. outdoor atmospheric conditions | i. коаксиальный кабель |
| 10. weight | j. отражение |
| 11. copper wire | k. сердцевина оптического волокна |
| 12. advantage | l. вес |
| 13. optical receiver | m. носитель |
| 14. wavelength | n. волновод |
| 15. rate | o. передача |
| 16. carrier | p. оптический приемник |
| 17. radiation | q. излучение |

18. waveguide

r. скорость
s. преимущество
t. медный провод

**Exercise 2.** ***Read the English adjectives and find the Russian equivalents to them.***

1. immune
2. explosive
3. unlimited
4. digital
5. solid-state
6. original

a. первоначальный
b. огнеупорный
c. цифровой
d. твердотельный
e. взрывчатый
f. защищенный, невосприимчивый
g. стеклянный
h. узкий
i. неограниченный

**Exercise 3.** ***Read the English verbs and find the Russian equivalents to them.***

1. tap
2. monitor
3. contain
4. convert
5. conduct
6. provide
7. lash

a. обеспечивать
b. скреплять
c. раскрывать
d. подключаться
e. проводить
f. превращать
g. подсоединять
h. отражать
i. передавать информацию
j. содержать

**Exercise 4.** ***Choose the proper English equivalents to the Russian words:***

излучение – radiate, radiation, radiative, radiated
проводить – conductive, conduct, conductance
приемник – receive, receiver, receiving
обеспечивать – provide, provider, providing
первоначальный – original, origin, originally
передача – transmitter, transmit, transmitting, transmission

## LANGUAGE ACTIVITY

**Exercise 1.** ***Insert prepositions***.

A fiber optic transmitter and receiver are connected … fiber optic cable. The fiber is totally immune … virtually all kinds of interference. The basic fiber is made … glass. Fiber optic cable is ideal … secure communications systems. Fiber can carry much more information and deliver it … great fidelity. The optical transmitter converts an electrical analog or digital signal … a corresponding optical signal.

Progressing … the copper wire to fiber optic cable has promoted technological development in all areas.

**Exercise 2.** ***From the sentences given below choose those with the* Absolute Participle Construction *and translate them.***

1. Some lasers manufactures being not ready to sell their product to hospitals, the use of lasers in medicine is not as common as it could be.
2. A new laser gyroscope completed by "Carl Zeiss" is the world's largest, geodesists planning to use it to measure the rotation of the Earth.
3. Light from Nd:YAG laser passing through a focusing lens is launched into the fiber.
4. Some laser measurements methods requiring electronic equipment at both the laser and target areas, special optical compact system was developed with all equipment at one end.
5. Customers buying lasers for medical applications wanted them delivered with all appliance descriptions.
6. A diagnostic probe for detecting early symptoms of some eye diseases having been developed, the collaborates designed a fiber optic device capable to characterize the nature of crystalline impurities in the lens of the eye.
7. Laser printers being inexpensive and available have been used for structures requiring a small number of pixels.
8. We see the world starting to fabricate micro-components and miniature systems due to lasers and other high technological devices.

**Exercise 3.** ***Transform the sentences using the Absolute Participle Construction.***

1. As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals.
2. When two or more fiber cables of a system must be joined together, an optical splice is commonly used.
3. Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber.
4. Fiber optic cable is ideal for secure communication systems and, in addition, there is absolutely no electrical radiation from it.
5. The source of optical signal can be either a high emitting diode or a solid state laser diode, and the mostly used wavelengths for optical transmitters are from 850 to 1550 nanometers.

**Exercise 4.** ***Summarize your knowledge of the* Gerund *and translate the sentences given below.***

1. In forming holograms two sets of waves are involved.
2. A copper wire was capable of carrying much less information than a fiber wire can do.
3. Laser installation can't be started without having been previously adjusted.
4. Our using the lens to tunnel the light pulses into the fiber-optic medium was accepted by everybody.

5. The new formula of glass is worth considering to reduce light loss.
6. In 1948, Gabor succeeded in producing a two-step imaging process which later was called holography.
7. Using fiber optic cable and advances in optoelectronic devices permitted the scientist and his students to design a system with a diameter less then 1 cm and a length less than 1.3 cm.

**Exercise 5.** ***Translate the sentences paying attention to the*** **Gerund** ***and*** **Participles.**

1. – Applying lasers in medicine becomes more and more frequent in hospitals.
   – Applying lasers surgeons are able to make bloodless operations.
2. – Continuing laser research new scientists will have new ideas and new inventions.
   – Continuing laser research will give rise to new ideas and new inventions
3. – Focusing a laser beam on a small spot with enormous power density makes the materials to heat, melt or vaporize them.
   – Focusing a laser beam on a small spot with enormous power density we can heat, melt or vaporize the material.
4. – On cooling water enters the tube of the device.
   – While cooling water prevents explosion of the device.
5. – The engineers suggested cooling water to prevent explosing of the overheated device.
   – The engineer was guilty of not having cooled water.
6. – Having cooled water we prevented the device from explosion.
   – Water having been cooled, the device could start working.

## Unit 18

# Fiber Optic Applications

## WORD STUDY

**Exercise 1.** ***Read and translate the collocations given below.***
Revenue streams, telecommunication transmission, copper wire system, light impulse, shared program software, optical fiber application, optical bandwidth, fiber/coaxial hybrid, optical receiver, optical converter, commercial installation, trunk line, backbone architecture.

***Exercise 2. Can you think of anything in your country that should be nationalized (e.g. airlines), privatized, standardized, modernized or computerized?***

## UNDERSTANDING A PRINTED TEXT

**List of Terms:**

attenuation – ослабление, затухание
backbone-основная составляющая, структура
database-база данных
delivery-доставка, передача
feasible-годный, подходящий
installation-установка
integrate-объединять, включать
node-узел
trunk line-магистральная линия
power company-энергетическая компания
revenue streams-источники дохода
shared program software-пакетное деление программ
superhighway-супермагистраль
terrestrial-наземный
utilities-предприятия
LAN - Local Area Network – местная сеть

***Scan-reading***

The use of fiber was generally not available until 1970, when Robert Maurer of Corning Glass Works was able to produce a fiber with a loss of 20 dB/km. It was recognized that optical fiber would be feasible for telecommunication transmission only if glass could be developed so pure that attenuation would be 20 dB/km or less. That is 1% of the light would remain after travelling 1 km.

Today's optical fiber attenuation ranges from 0.5 dB/km to 1000 dB/km depending on the optical fiber used

The applications of optical fiber communications have increased at a rapid rate since the first commercial installation of a fiber-optic system in 1977. Telephone companies began early on replacing their old copper wire systems with optical fiber lines. Today's telephone companies use optical fiber throughout their system as the backbone architecture and as the long-distance connection between city phone systems.

Cable television companies have also begun integrating fiber optics into their cable systems. The trunk lines that connect central offices have generally been replaced with optical fiber. Some providers have begun experimenting with fiber to the curb using a fiber/coaxial hybrid. Such a hybrid allows for the integration of fiber and coaxial at a neighborhood location. This location, called a node, would provide the optical receiver that converts the light impulses back to electronic signals. The signals could then be fed to individual homes via coaxial cable.

Local Area Networks (LAN) have also integrated or constructed their systems using optical fiber. A LAN is a collective group of computers, or computer systems, connected to each other allowing for shared program software or databases. Colleges, universities, office buildings, and industrial plants, just to name a few, all make use of optical fiber within their LAN systems.

Power companies are an emerging group that may begin to apply fiber optics as new revenue streams. With declining revenues in the power industry, some utilities are considering entering the telecommunications business as a way to supplement these shrinking revenues.

Based on industry activity, it is evident that fiber optics has become the industry standard for terrestrial transmission of telecommunication information. The choice is not whether to convert to optical fiber, but rather than to convert to optical fiber. The bandwidth needs of the Information Superhighway require a medium, like optical fiber, that can deliver large amounts of information at a fast speed. It will be difficult for copper cable to provide for future bandwidth needs. Satellite and other broadcast media will undoubtedly play a role alongside fiber optics in the new-world telecommunications order. Considering all the services that the telecommunications industries are announcing to be just around the corner, and a modern society that seems to be expecting them, it is evident that fiber optics will continue to be a major player in the delivery of these services.

## COMPREHENSION CHECK

**Exercise 1.** ***Answer the following questions.***

1. Why was the use of fiber optics generally not available until 1970?
2. What could you tell us about the applications of fiber optics by telephone companies?
3. How do different cable television companies and LAN systems use optical fiber communications?

4. Why are some power companies so interested in how to apply fiber optics?

5. Why is it possible to say that fiber optics has become the industry standard for terrestrial transmission of telecommunication information?

**Exercise 2.** ***Complete the sentences given below.***

1. Until 1970 the use of the fiber optics was …
2. The choice is not whether to convert to optical fiber, but …
3. The optical receiver converts the light impulses …

## REWIEW OF THE CHAPTER III

**Exercise 1.** ***Write a brief summary of the texts.***

Define the main problems dealt with in the texts. Try to use the following words and expressions in your summary:

1. As the title implies the text describes … . 2. It is specially noted that … . 3. It is spoken in detail … . 4. The text gives valuable information on .. . 5. … (e.g. some important facts or principles) are considered (mentioned, discussed, stressed). 6. The text may be of interest (great help) to … .

**Exercise 2.** ***Topics for discussion on the material of Chapter III.***

1. Do you consider fiber optics to be really usable communication of nowadays and why?
2. How do you view the future of fiber optics?
3. What could you say about the advantages and disadvantages of fiber optic systems?

# SUPPLEMENTARY TASKS

## IMPROVE YOUR TRANSLATION PRACTICE

**Exercise 1.** ***Translate the text into Russian. Write down key-words from the text.***

### Fiber-Optic Economics

One of the initial economic factors to consider when converting to fiber optics is the cost of replacing wire systems with fiber. Increased demand for optical fiber has brought the prices down within competitive range of copper. However, since transmitters, converters, optical repeaters, and a variety of connecting hardware will be needed, the initial cost of changing over to fiber can be expensive. Increased demand, advances in the technology and competition has brought the prices down somewhat. Short term and long term gains should be considered when updating a communications system. In the short term it is often less expensive to continue using copper cabling for covering expanded communication needs. By simply adding more wire to an existing system, expanded needs can be covered. This avoids the expense of adding the transmitters and receivers needed for integrating optical fiber. Long-term needs, however, may require more expansion in the future.

In the long term it may be more cost effective to invest in conversion to fiber optics. This cost effectiveness is due to the relative ease of upgrading fiber optics to higher speeds and performance. It has already been seen in the industry as communication providers are wiring customers with optical fiber bandwidth that exceed consumer bandwidth needs. This is in anticipation of future bandwidth needs. It is generally accepted that customers will need increased bandwidth as the information highway grows. Replacing copper with fiber today would avoid continued investment in a soon to be outdated copper system.

Television and telephone companies hurry to build systems that will convert television and telephone technology and thus provide a one-server system for their customers. Fiber optics will play a pivotal role in this race since the bandwidth needed for providing an all-in-one service with television, telephone, interactive multimedia, and Internet access is not available in much of the wiring of America. Competition for customers is a strong factor motivating communication networks to convert their systems over to fiber optics.

Competition is not only between users of fiber optics networks. Recent developments and proposed plans in the satellite industry may have an effect on the use of fiber optics as a transmission medium. The satellite industry is proposing, and building, several systems that they say will provide the telecommunication services needed without the need for laying more fiber-lines. Like terrestrial cellular systems, satellites also have an advantage over fiber in that they can provide mobile access to telecommunications services. They can provide a level of global ubiquity that is not possible with fiber optics or with terrestrial cellular. Satellite services could potentially serve rural and undeveloped communities that may never see a fiber optic line come through the part of the world.

None of these satellite systems, however, can provide the bandwidth potential of fiber optics. Fiber optics has the proven ability to deliver more information per second. So, it is no wonder that satellite providers have not announced plans that could effectively provide television, telephone, interactive multimedia, and Internet services into an all-in-one service. Evidently, tomorrow is with fiber optics.

**Exercise 2.** ***Read the following text if necessary using a dictionary. Point out the main idea of paragraphs given below.***

## Optical Transmitters

1. The basic optical transmitter converts electrical input signals into modulated light for transmission over an optical fiber. Depending on the nature of this signal, the resulting modulated light may be turned on and off or may be linearly varied in intensity between two predetermined levels. The most common devices used as the light source in optical transmitters are the *light emitting diode* (LED) and the *laser diode* (LD). In a fiber optic system, these devices are mounted to enable an optical fiber to be placed in very close proximity to the light emitting region in order to couple as much light as possible into the fiber. In some cases, the emitter is even fitted with a tiny spherical lens to collect and focus "every last drop" of light onto the fiber, and in other cases a fiber is connected directly to the actual surface of the emitter.

2. LEDs have relatively large emitting areas and, as a result, are not as good light sources as LDs. However, they are widely used for short to moderate transmission distances because they are much more economical, quite linear in terms of light output versus electrical current input and stable in terms of light output versus ambient operating temperature. LDs, on the other hand, have very small light emitting surfaces and can couple many times more power to the fiber than LEDs. LDs are also linear in terms of light output versus electrical current input, but unlike LEDs they are not stable over wide operating temperature ranges and require more elaborate circuitry to achieve acceptable stability. In addition, their added cost makes them primarily useful for applications that require the transmission of signals over long distances.

3. LEDs and LDs operate in the infrared portion of the electromagnetic spectrum so that their light output is usually invisible to the human eye. Their operating wavelengths are chosen to be compatible with the lowest transmission loss wavelengths of glass fibers and highest sensitivity ranges of photodiodes. The most common wavelengths in use today are 850 nanometers, 1300 nanometers, and 1550 nanometers. Both LEDs and LDs are available in all three wavelengths.

4. LEDs and LDs, as previously stated, are modulated in one of two ways: on and off, or linearly. A transistor is used to switch the LED or LD on and off in step with an input digital signal. This signal can be converted from almost any digital format by the appropriate circuitry, into the correct base drive for the transistor. Overall speed is then determined by the circuitry and the inherent speed of the LED or LD. Used in this manner, speeds of several hundred megahertz are readily

achieved for LEDs and thousands of megahertz for LDs. Temperature stabilization circuitry for the LD has been omitted from this example for simplicity. LEDs do not normally require any temperature stabilization.

5. Linear modulation of an LED or LD is accomplished by the operational amplifier circuit. The inverting input is used to supply the modulating drive to the LED or LD. Once again temperature stabilization circuitry for the LD has been omitted from this example for simplicity.

6. Digital on/off modulation of an LED or LD can take a number of forms. The simplest, as we have already seen, is light-on for a logic "1", and light-off for a logic "0". Two other common forms are pulse width modulation and pulse rate modulation. In the former, a constant stream of pulses is produced with one width signifying a logic "1" and another width, a logic "0". In the latter, the pulses are all of the same width but the pulse rate changes to differentiate between logic "1" and logic "0".

7. Analogue modulation can also take a number of forms. The simplest is intensive modulation where the brightness of an LED is varied in direct step with the variations of the transmitted signal. In other methods, a RF carrier is first frequency modulated with another signal or, in some cases, several RF carriers are separately modulated with separate signals, then all are combined and transmitted as one complex waveform.

8. The equivalent operating frequency of light, which is, after all, electromagnetic radiation, is extremely high – of the order of 1,000,000 GHz. The output bandwidth of the light produced by LEDs and laser diodes is quite wide. Unfortunately, today's technology does not allow this bandwidth to be selectively used in the way that conventional radio frequency transmissions are utilized. Rather, the entire optical bandwidth is turned on and off in the same way that early "spark transmitters" (in the infancy of radio) turned wide portions of the RF spectrum on and off. However, with time, researchers will overcome this obstacle and "coherent transmissions", as they are called, will become the direction in which the fiber optic field progresses.

# APPENDIX I

## Химические формулы

При чтении химических элементов и формул необходимо помнить следующее:

- каждая буква и цифра читается отдельно, например, **NaCL** читается как: n, a, c, l;
- знаки, используемые в такого рода формулах, читаются следующим образом:

+ - plus, together with, added to, combined with;
= - give, form, are equal to
$\rightarrow$ - forms, is formed from;
$\leftarrow$ - give, pass over to, lead to.

Например,

$\mathbf{CO_2+H_2O \rightarrow H_2CO_3}$ – c, o, two plus h, two, o give h, two, c, o, three;

$\mathbf{C+2H_2 \rightarrow CH_4}$ – c plus 2 molecules of h two form c, h, four.

# APPENDIX II

**He** - helium - гелий
**Ne** - neon - неон
**Pb** - plumbum - свинец
**Cd** - cadmium - кадмий
**Nd** - neodymium - неодим
**$CO_2$** - carbon dioxide - двуокись углерода
**Se** - selenium -селен
**GaAs** - gallium arsenide – арсенид галлия
**YAG** - yttrium aluminium garnet – иттрий-алюминиевый гранат
**Cr** - corundum - хром
**Cu** - 1) copper; 2) cuprum - медь

# APPENDIX III

## Albert Einstein

**Albert Einstein** was born in Germany, on March 14, 1879. Later his family moved to Italy and then to Switzerland. In 1896 he entered the Swiss Federal Polytechnic School in Zurich to be trained as a teacher in physics and mathematics. In 1901, the year he gained his diploma, he accepted a position as technical assistant in the Swiss Patent Office. In 1905 he obtained his doctor's degree.

During his stay at the Patent Office, and in his spare time, he produced much of his remarkable work. For his researches in Relativity he was awarded the Nobel Prize in 1921. In 1933 he renounced his citizenship for political reasons and emigrated to America to take the position of Professor of Theoretical Physics at Princeton. He became a United States citizen in 1940 and retired from his post in 1945.

At the start of his scientific work, Einstein realized the inadequacies of Newtonian mechanics and his special theory of relativity stemmed from an attempt to reconcile the laws of mechanics with the laws of the electromagnetic field. He dealt with classical problems of statistical mechanics and problems in which they were merged with quantum theory: this led to an explanation of the Brownian movement of molecules. He investigated the thermal properties of light with a low radiation density and his observations laid the foundation of the photon theory of light.

In his early days, Einstein postulated that the correct interpretation of the special theory of relativity must also furnish a theory of gravitation and in 1916 he published his paper on the general theory of relativity. During this time he also contributed to the problems of the theory of radiation and statistical mechanics.

In the 1920's, Einstein embarked on the construction of unified field theories, although he continued to work on the probabilistic interpretation of quantum theory, and he persevered with this work in America. He contributed to statistical mechanics by his development of the quantum theory of a monatomic gas and he has also accomplished valuable work in connection with atomic transition probabilities and relativistic cosmology.

After his retirement he continued to work towards the unification of the basic concepts of physics, taking the opposite approach, geometrisation, to the majority of physicists.

Einstein's researches are, of course, well chronicled and his more important works include *Special Theory of Relativity* (1905), *Relativity* (English translations, 1920 and 1950), *General Theory of Relativity* (1916), *Investigations on Theory of Brownian Movement* (1926), and *The Evolution of Physics* (1938).

Albert Einstein received honorary doctorate degrees in science, medicine and philosophy from many European and American universities. During the 1920's he lectured in Europe, America and the Far East and he was awarded Fellowships or Memberships of all the leading scientific academies throughout the world. He gained numerous awards in recognition of his work, including the Copley Medal of the Royal Society of London in 1925, and the Franklin Medal of the Franklin Institute in 1935.

## Arthur L. Schawlow

**Arthur L. Schawlow** was born in New York, U.S.A. on May 5, 1921. His father had come from Europe a decade earlier from Riga. His mother was a Canadian and the family moved to Toronto in 1924. Schawlow attended public schools there, and Vaughan Road Collegiate Institute (high school).

As a boy, Schawlow was always interested in scientific things, electrical, mechanical or astronomical, and read nearly everything that the library could provide on these subjects. He intended to try to go to the University of Toronto to study radio engineering. Unfortunately his high school years, 1932 to 1937, were in the deepest part of the great economic depression. His father's salary as one of the many agents for a large insurance company could not cover the cost of a college education for Schawlow.

There were, at that time, no scholarships in engineering, but Schawlow and his sister were both fortunate enough to win scholarships in the faculty of Arts of the University of Toronto. Schawlow's sister was for English literature, and his was for mathematics and physics. Physics seemed pretty close to radio engineering, and so that was what Schawlow pursued. Physics has given him a chance to concentrate on concepts and methods, and he has enjoyed it greatly.

A scientific career was something that few of them even dreamed possible, and nearly all of the entering class expected to teach high school mathematics or physics. In 1945 Schawlow returned to the University. It was by then badly depleted in staff and equipment by the effects of the depression and the war, but it did have a long tradition in optical spectroscopy. There were two highly creative physics professors working on spectroscopy, Malcolm F. Crawford and Harry L. Welsh. Schawlow took courses from both of them, and did his thesis research with Crawford. It was a very rewarding experience, for he gave the students good problems and the freedom to learn by making their own mistakes. Moreover, he was always willing to discuss physics, and even to speculate about where future advances might be found.

A Carbide and Carbon Chemicals postdoctoral fellowship took Schawlow to Columbia University to work with Charles H. Townes. There were no less than eight future Nobel laureates in the physics department during his two years there. Working with Charles Townes was particularly stimulating. Not only was he the leader in research on microwave spectroscopy, but he was extraordinarily effective in getting the best from his students and colleagues.

From 1951 to 1961, A. Schawlow was a physicist at Bell Telephone Laboratories. There his research was mostly on superconductivity, with some studies of nuclear quadruple resonance. On weekends he worked with Charles Townes on their book *Microwave Spectroscopy*, which had been started while he was at Columbia and was published in 1955. In 1957 and 1958, while mainly still continuing experiments on superconductivity, Schawlow worked with Charles Townes to see what would be needed to extend the principles of the maser to much shorter wavelengths, to make an optical maser or, as it is now known, a laser. Thereupon, A. Schawlow began work on optical properties and spectra of solids which might be relevant to laser materials, and then on lasers.

Since 1961, A. Schawlow has been a professor of physics at Stanford University and was chairman of the department of physics from 1966 to 1970.

## Charles H. Townes

**Charles Hard Townes** was born in Greenville, South Carolina, on July 28, 1915. He attended the Greenville public schools and then Furman University in Greenville, where he completed the requirements for the Bachelor of Science degree in physics and the Bachelor of Arts degree in Modern Languages, graduating in 1935, at the age of 19. He was also interested in natural history while at Furman, serving as curator of the museum, and working during the summers as collector for Furman's biology camp. In addition he was busy with other activities, including the swimming team, the college newspaper and the football band.

Townes completed work for the Master of Arts degree in Physics at Duke University in 1936, and then entered graduate school at the California Institute of Technology, where he received the Ph.D. degree in 1939 with a thesis on isotope separation and nuclear spins.

A member of the technical staff of Bell Telephone Laboratories from 1933 to 1947, Dr. Townes worked extensively during World War II in designing radar bombing systems and has a number of patents in related technologies. From this he turned his attention to applying the microwave technique of wartime radar research to spectroscopy, which he foresaw as providing a powerful new tool for the study of the structure of atoms and molecules and as a potential new basis for controlling electromagnetic waves.

At Columbia University, where he was appointed to the faculty in 1948, he continued research in microwave physics, particularly studying the interactions between microwaves and molecules, and using microwave spectra for the study of the structure of molecules, atoms, and nuclei. In 1951, Dr. Townes conceived the idea of the maser, and a few months later he and his associates began working on a device using ammonia gas as the active medium. In early 1954, the first amplification and generation of electromagnetic waves by stimulated emission were obtained. Dr. Townes and his students coined the word "maser" for this device, which is an acronym for microwave amplification by stimulated emission of radiation. In 1958, Dr. Townes and his brother-in-law Dr. A.L. Schavlow, showed theoretically that masers could be made to operate in the optical and infrared region and proposed how this could be accomplished in particular systems. This work resulted in their joint paper on optical and infrared masers, or lasers (light amplification by stimulated emission of radiation). Other research has been in the fields of radio astronomy and nonlinear optics.

Having joined the faculty at Columbia University as Associate Professor of Physics in 1948, Townes was appointed Professor in 1950. He served as Executive Director of the Columbia Radiation Laboratory from 1950 to 1952 and was Chairman of the Physics Department from 1952 to 1955.

In 1966, he became Institute Professor at M.I.T., and made intensive research, particularly in the fields of quantum electronics and astronomy. He was appointed

University Professor at the University of California in 1967. In this position Dr. Townes was participating in teaching, research, and other activities on several campuses of the University.

Dr. Townes has served on a number of scientific committees advising governmental agencies and has been active in professional societies.

## Aleksandr M. Prokhorov

**Aleksandr Mikhailovich Prokhorov** was born on July 11th, 1916, in Australia. After the October Revolution he went in 1923 with his parents to the Soviet Union.

In 1934 Alexander Prochorov entered the Physics Department of the Leningrad State University. He attended lectures on quantum mechanics, theory of relativity, on general physics, spectroscopy and on molecular physics. After graduating in 1939 he became a postgraduate student of the P.N. Lebedev Physical Institute in Moscow, in the laboratory of oscillations. There he started to study the problems of propagation of radio waves.

In 1946 he defended his thesis on the theme Theory of Stabilization of Frequency of a Tube Oscillator in the Theory of a Small Parameter.

Starting in 1947, Prochorov carried out a study of the coherent radiation of electrons in the synchotron in the region of centimetre waves. As a result of these investigations he wrote and defended in 1951 his Ph.D. thesis a "Coherent Radiation of Electrons in the Synchotron Accelerator".

Starting from 1950 being assistant chief of the laboratory, Prochorov began to investigate on a wide scale the question of radiospectroscopy and, somewhat later, of quantum electronics. He organized a group of young scientists interested in the subjects.

In 1959 when Prochorov has already been the head of the lab, the laboratory of radio astronomy was organized from one of the departments of the laboratory of oscillations, and in 1962 another department was separated as the laboratory of quantum radiophysics (headed by Prof. N.G. Basov).

The investigations carried out by Basov and Prochorov in the field of microwave spectroscopy resulted in the idea of a molecular oscillator. They developed theoretical grounds for creation of a molecular oscillator and also constructed a molecular oscillator operating on ammonia. In 1955, Basov and Prochorov proposed a method for the production of a negative absorption which was called the pumping method.

From 1950 to 1955, Prochorov and his collaborators carried out research on molecular structures by the methods of microwave spectroscopy.

In 1955 Professor Prochorov began to develop the research on electronic paramagnetic resonance (EPR). A cycle of investigations of EPR spectra and relaxation times in various crystals was carried out.

In 1955, Prochorov studied with A.A. Manenkov the EPR spectra of ruby that made it possible to suggest it as a material for lasers in 1957. They designed and constructed masers using various materials and studied characteristics of the masers as well. This research was done in cooperation with the laboratory of radiospectroscopy of the

Institute of Nuclear Physics of the Moscow University; this laboratory was organized by Prochorov in 1957. One of the masers constructed for a wavelength of 21 cm is used in the investigations of the radioastronomical station of the Physical Institute in Pushino.

In 1958 Prochorov suggested a laser for generation offer-infrared waves. As a resonator it was proposed to use a new type of cavity which was later called "the cavity of an open type". Practically speaking, it is Fabry-Perot’s interferometer. Similar cavities are widely used in lasers.

At present Prochorov's principal scientific interests lie in the field of solid lasers and their utilization for physical purposes, in particular for studies of multiquantum processes. In 1963, he suggested together with A.S. Selivanenko, a laser using two-quantum transitions.

## Nicolay G. Basov

**Nikolay Gennadiyevich Basov** was born on December, 14, 1922 in a small town near Voronezh. His father was a professor of the Voronezh Forest Institute.

After finishing secondary school in 1941 in Voronezh Basov was called up for military service. In December 1945, he entered the Moscow Institute of Physical Engineers where he studied theoretical and experimental physics.

In 1950 N. Basov joined the P.N. Lebedev Physical Institute, where he was vice-director and head of the laboratory of quantum radiophysics. He was also a professor of the department of solid-state physics at the Moscow Institute of Physical Engineers.

In 1956 he defended his doctoral thesis on the theme "A Molecular Oscillator", which summed up the theoretical and experimental works on creation of a molecular oscillator utilizing an ammonia beam.

In 1955 N. Basov organized a group for the investigation of the frequency stability of molecular oscillators. Together with his pupils and collaborators Dr Basov studied the dependence of the oscillator frequency on different parameters. In the result of these investigations the oscillators with a frequency stability of $10^{-11}$ have been realized in 1962.

In 1957 N. Basov started to work on the design and construction of quantum oscillators in the optical range. A group of theorists and research workers began to study the possibilities for realization of quantum oscillators by means of semiconductors, and the possibility of their realization in the gas media was also investigated.

In 1964 semiconductor lasers with electronic excitation have been made and somewhat later, lasers with optical excitation were constructed. For these achievements a group of scientists of Lebedev Physical Institute was awarded the Lenin Prize for 1964.

Beginning from 1961 Dr. Basov carried out theoretical and experimental research in the field of powerful lasers.

In 1962 N. Basov and O.N. Krokhin investigated the possibility of laser radiation usage for the obtaining of thermonuclear plasmas. In 1968 Basov and his associates have succeeded in observing for the first time neutron emission in the laser-produced deuterium plasmas. In the same year Basov and his associate A.N. Oraevsky proposed a method of the thermal laser excitation. Further theoretical considerations of this method by N. Basov, A.N. Oraevsky and V.A. Sheglov encouraged the development of the so-called gasdynamic lasers.

In 1963 Dr. Basov and his colleagues began to work in the field of optoelectronics. They developed in 1967 a number of fast-operating logic elements on the basis of diode lasers.

A large contribution has been made by Dr. Basov to the field of chemical lasers. In 1970 under his guidance an original chemical laser was achieved which operates on a mixture of deuterium, F and $CO_2$ at the atmospheric pressure.

In the end of 1970 N. Basov (together with E.P. Markin, A.N. Oraevsky, A.V. Pankratov) presented experimental evidence for the stimulation of chemical reactions by the infrared laser radiation.

## Ted Maiman and the World's First Laser

**Ted Maiman** was born in Los Angeles, California, in 1927. His father was an electronics engineer and inventor, who worked for several years at Bell Labs during the war. The elder Maiman inspired his son with a love of electronics, and by the time the younger Maiman was 12 he had a job repairing valve devices. By the time he was 14, he was running the company's shop.

Maiman attended the University of Colorado, receiving a B.S. in engineering physics in 1949. He then set his sights on the Stanford University Physics Department for graduate work, but was initially rejected. He eventually got into Stanford, where he was accepted by the electronics engineering department.

At Stanford, Maiman did graduate work under Nobel Laureate Willis Lamb. While conducting the experiment he learned a great deal about optical instrumentation, which was very appropriate to his later work on the laser.

Maiman graduated with a Ph. D. in physics from Stanford in 1955.

In 1958, Bell Labs' Schawlow and Townes had predicted the operation of an optical laser. In their paper, they suggested that one way to do it was using alkali vapors. They applied for, and were granted, a patent. But a working laser had yet to be built.

Meanwhile Maiman was now working at Hughes Research, which was one of the many labs involved in the race to implement the laser.

At Hughes, Maiman found himself encountering a number of obstacles. He was under-funded, working with a budget of $50,000, which included his salary, his assistants' salaries, and equipment. Worst of all, the most important scientists of the day were scoffing at him for continuing to investigate ruby, which had been ruled out as a lasing material. It was measured that the fluorescence quantum efficiency of ruby was about 1 percent.

Maiman began investigating other materials, but, having found no alternative prospects, he returned to ruby to try to understand why it was so inefficient. He felt that if he could understand what was causing the inefficiency, he could then work with crystal experts to identify an appropriate material. He measured the quantum efficiency again, and came up with a figure of about 75 percent! Ruby was again a laser candidate.

At this time, nearly all the scientists in the major labs were trying to make a continuous laser. Few were considering the possibility that a pulsed laser might be easier to build. Maiman did not accept this idea.

At about that time he came across an article on photographic strobe lamps, and discovered that their brightness temperature was about 8000 or 9000 K. The continuous dc. arc lamp he had looked at had a brightness temperature of about 4000 K. He checked his calculations carefully (calculators and desktop computers were still science fiction in 1960). An innovative optical pump and probe and simultaneous GHz resonant cavity experiment convinced him the strobe lamp could make optical gain a reality.

By surrounding the ruby rod with the lamp and using an external collector, Maiman was able to achieve a reasonable amount of pumping efficiency. He obtained a ruby rod from Union Carbide. It was a unique request, and took the company five or six months to prepare.

In 1960, there were no coating surfaces for laser mirrors, and multilayer coatings were only at the disposal of the largest labs that could afford the technology. But Maiman knew about silvering ruby from his maser days, and he used the same technique to silver the ends of this rod.

Maiman's rigorous investigation paid off when, on 16 May 1960, the laser made the historic leap from theory to reality.

# Chapter IV

**Аннотация** (Abstract/Summary) – это краткое изложение содержания статьи (доклада, заметки) с целью дать возможность понять читателю стоит ли знакомиться с текстом более подробно. Аннотация отражает тематику текста и основную мысль автора. Обычный объем аннотации 500-600 п.зн.

Структура аннотации:

1) название работы (статьи, доклада), фамилия и инициалы автора, выходные данные оригинала, (т.е. название журнала или монографии, год издания, том, номер, и т.д.);
2) формулировка темы работы (текста, статьи, доклада);
3) краткое содержание статьи (доклада), составленное из простых предложений, связанных по определенным правилам.

Если аннотация составляется на английском языке, то допускаются только безличные предложения со сказуемым в страдательном залоге, как правило, в форме Present или Past Simple, иногда в Present Perfect Passive Voice.

Чаще всего используются следующие клише:

| | |
|---|---|
| …is/are discussed (described, mentioned)… | …обсуждаются (описываются, упоминаются)… |
| …is/are considered (outlined)… | …рассматриваются… |
| …is/are presented (shown)… | …представлены, |
| показаны… | |
| …is/are studied (investigated, examined)… | …исследуются… |
| …is/are obtained (found, established)… | …получены (обнаружены, установлены)… |

| | |
|---|---|
| A (short) description is given to … | Кратко описаны… |
| A (thorough) study is made of … | Тщательно исследованы… |
| Particular (special) attention is given (paid) to … | Особое внимание уделено … |

Иногда используются конкретизирующие наречия и сочетания, такие как:

accurately (carefully) - тщательно, внимательно

thoroughly, in detail – подробно, детально

clearly – четко, ясно

fully – во всей полноте и т.д.

Для формулировки темы работы (статьи) можно использовать сказуемое в Present Active Voice. Например: The text deals with (studies) …

Далее придаточные предложения должны быть преобразованы в причастные или инфинитивные конструкции, а примеры и иллюстрации любого вида исключены.

Пример аннотации:

**Text 1**

**Laser lidar**

Laser-based lidar (light detection and ranging) has also proven to be an important tool for oceanographers. While satellite pictures of the ocean surface provide insight into overall ocean health and hyperspectral imaging provides more insight, lidar is able to penetrate beneath the surface and obtain more specific data, even in murky coastal waters. In addition, lidar is not limited to cloudless skies or daylight hours.

"One of the difficulties of passive satellite-based systems is that there is water-surface reflectance, water-column influence, water chemistry, and also the influence of the bottom", said Chuck Bostater, director of the remote sensing lab at Florida Tech University (Melbourne, FL). "In shallow waters we want to know the quality of the water and remotely sense the water column without having the signal contaminated by the water column or the bottom".

A typical lidar system comprises a laser transmitter, receiver telescope, photodetectors, and range-resolving detection electronics. In coastal lidar studies, a 532-nm laser is typically used because it is well absorbed by the constituents in the water and so penetrates deeper in turbid or dirty water (400 to 490 nm penetrates deepest in clear ocean water). The laser transmits a short pulse of light in a specific direction. The light interacts with molecules in the air, and the molecules send a small fraction of the light back to telescope, where it is measured by the photodetectors.

Abstract (Summary). Text 1.

Laser lidar. "Laser Focus World", 2003, v 46, №3, p45.

The text focuses on the use of laser-based lidar in oceanography.

The ability of lidar to penetrate into the ocean surface to obtain specific data in murky coastal waters is specially mentioned.

Particular attention is given to the advantage of laser-based lidars over passive satellite-based systems is obtaining signals not being contaminated by the water column or the bottom.

A typical lidar system is described with emphasis on the way it works.

This information may be of interest to research teams engaged in studying shallow waters.

**Резюме (Resumé)** – вид компрессии текста. В резюме допускаются краткая оценка исходного материала и выводы из прочитанного. Обычно требуется изложение текста в виде устного резюме.

Резюме состоит из трех частей, которые соединяются в единое целое с помощью определенных речевых клише.

I. Вступление. Формулировка темы.

The text (clipping, item) deals with … } В тексте (отрывке, заметке)

The text (clipping, item) concerns … } говорится о …

The text (clipping, item) is concerned with …
The text (clipping, item) focuses on …

II. Основное содержание – краткое описание текста с некоторой оценкой.

| | |
|---|---|
| According to the text … From the text we know that … It is clear from the text … | Из текста ясно, что… |
| According to the author … | Как считает автор … |
| One of the main problems to pay attention to is … | Одной из главных проблем, на которую следует обратить внимание, является… |
| It should be mentioned (noted, pointed out) … | Следует упомянуть (отметить, указать)… |
| Particular emphasis is placed on … | Особое внимание обращается на … |
| In my opinion … | По моему мнению … |
| Thus … | Таким образом … |
| Further on … | Далее … |

III. Заключение.

| | |
|---|---|
| In conclusion we can say … | В заключении можно сказать… |
| Summing it up… | Подытоживая … |
| On the whole one can safely say … | В целом вполне можно сказать… |
| The author comes to the conclusion that … | Автор приходит к выводу, что… |
| All things considered we can conclude that … | Рассмотрев все, мы можем сделать вывод, что … |

**Resume**
**Text 1**

The text “Laser lidar” deals with the new development in laser technology and its uses, namely, a laser-based lidar. The word “lidar” stands for light detection and ranging.

The text focuses on the application of lidars in oceanography. It’s clear from the text that laser-based lidars have fundamental advantages over passive sattelite-based systems. Particular emphasis is placed on the fact that lidars produce signals not being contaminated by the water column or the bottom.

Further on, a typical lidar system with a 532 nm laser is described and the principle of its operation is briefly given. The system comprises a laser transmitter, receiver telescope and photodetectors. Finally it is shown as a short pulse of light transmitted by the laser is transformed into the signal measured by photodetectors.

In conclusion, all things considered, one can say that laser radars are especially good for coastal lidar studies.

**Text 2**

***Laser microprocessing of diamond surface***

Diamond films 300-400 μm thick were grown on polished Si substrates by a CVD technique using a microwave plasma chemical reactor. Upon separation from the substrates, the resulting freestanding diamond plates were cut with a laser, mechanically polished, and then were used for laser patterning experiments.

For selective-area material removal a KrF excimer laser operating at 248 nm, was used as the laser source in a projection optical scheme. The pulse duration is 15 ns, and the laser pulse energy is typically ~200 mJ, although only a small fraction of the output energy is utilized. The image of a mask (sqaure) was projected onto the sample surface by a short-focal length objective with linear demagnification of 1:15. A diamond sample placed on a computer-driven X-Y stage was translated controllably so that a selected region of given coordinates on the diamond surface be irradiated by a certain number of laser shots to achieve the resulting surface profile close to the calculated one. The etching depth was controlled by the laser influence and the number of laser shots. A surface profiler “Zygo” (model New View 5000) based on phase-shifting interferometry was used to examine the topology of original and laser-irradiated surface.

**Task 1.** ***Build up an abstract (summary) of text in writing.***

**Check your summary:**
1) make sure each sentence is simple and to the point;
-make sure there are no examples or illustrations;
2) remove adjectives, adverbs, repetition of words.
3) replace full clauses with participle constructions.

**Task 2.** ***Build up a resume of text 2 according to the instruction given above.***

**Реферат (Precis) -** это конспективное описание оригинального произведения (текста, статьи, доклада или монографии), передающее его основной смысл. В реферате кратко и четко излагаются все основные положения оригинала. Как правило, объем реферата составляет 1/3 оригинала.

Реферат не предполагает выводов или комментариев составителя, допускаются только выводы автора оригинала, если таковые есть.

По структуре реферат напоминает развернутую аннотацию, с употреблением вышеприведенных речевых клише.

К списку речевых клише можно добавить следующие:

I. The aim (object, purpose, task) of the study is.
Цель (задача, назначение) работы состоит в …
The paper describes new approaches (methods, techniques) to …
В статье описываются новые подходы (методы, методики) к …

The book is further developing the concept of …
В книге далее разрабатывается концепция о …

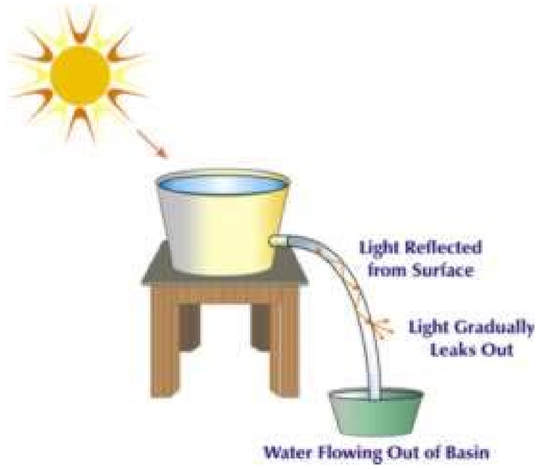
II. The study was intended to establish …(for determining) …
Это исследование было предпринято с целью установления (определения) …
New facts (as to how) … have been found …
Были обнаружены новые данные о …
If should be noted that this approach allows (permits, enables) to assume …
Следует отметить, что этот метод позволяет (дает возможность) предположить, …
The details of … are reported.
Описаны подробности о …
The theory supports the author’s assumption …
Теория подтверждает предположение автора …
The approach used presents (has, offers) several advantages…
Использованный метод имеет (представляет) несколько преимуществ.
The limitations are shown to be insignificant…
Показано, что ограничения незначительны.
Among other problems the paper raises the problem of …
Среди других проблем в статье поднимается вопрос о …
Another approach was offered (suggested) …
Был предложен другой подход …
What is more … - Более того….
Not only…but also… - не только … но и…
On the one hand/on the other hand – с одной стороны/с другой стороны
Therefore – Следовательно
Nevertheless – тем не менее

III. A general conclusion is made concerning as to …
Делается общий вывод относительно …
Thus, a conclusion is made that …
Таким образом, сделан вывод, что …
Having analyzed the information the author comes to the conclusion that…
Проанализировав всю информацию, автор делает вывод, что …

# A Brief History of Fiber Optic

## The Nineteenth Century

Figure 1 - John Tyndall's Experiment



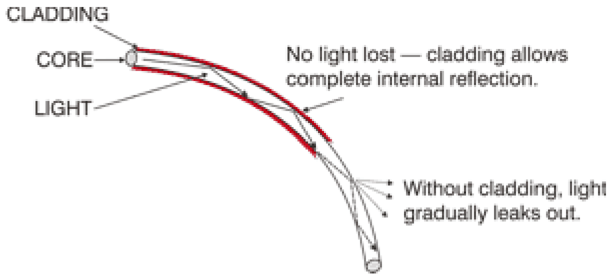

1. In 1870, John Tyndall, using a jet of water that flowed from one container to another and a beam of light, demonstrated that light used internal reflection to follow a specific path. As water poured out through the spout of the first container, Tyndall directed a beam of sunlight at the path of the water. The light, as seen by the audience, followed a zigzag path inside the curved path of the water. This simple experiment, illustrated in Figure 1, marked the first research into the guided transmission of light.

2. William Wheeling, in 1880, patented a method of light transfer called "piping light." Wheeling believed that by using mirrored pipes branching off from a single source of illumination, i.e. a bright electric arc, he could send the light to many different rooms in the same way that water, through plumbing, is carried throughout buildings today. Due to the ineffectiveness of Wheeling's idea and to the concurrent introduction of Edison's highly successful incandescent light bulb, the concept of piping light never took off.

3. That same year, Alexander Graham Bell developed an optical voice transmission system he called the photophone. The photophone used free-space light to carry the human voice 200 meters. Specially placed mirrors reflected sunlight onto a diaphragm attached within the mouthpiece of the photophone. At the other end, mounted within a parabolic reflector, was a light-sensitive selenium resistor. This resistor was connected to a battery that was, in turn, wired to a telephone receiver. As one spoke into the photophone, the illuminated diaphragm vibrated, casting various intensities of light onto the selenium resistor. The changing intensity of light altered the current that passed through the telephone receiver which then converted the light back into speech. Bell believed this invention was superior to the telephone because it did not need wires to connect the transmitter and receiver. Today, free-space optical links find extensive use in metropolitan applications.

4. Fiber optic technology experienced a phenomenal rate of progress in the second half of the twentieth century. Early success came during the 1950's with the development of the fiberscope. This image-transmitting device, which used the first practical all-glass fiber, was concurrently devised by Brian O'Brien at the American Optical Company and Narinder Kapany (who first coined the term "fiber optics" in 1956) and colleagues at the Imperial College of Science and Technology in London. Early all-glass fibers experienced excessive optical loss, the loss of the light signal as it traveled the fiber, limiting transmission distances.

Figure 2 - Optical Fiber with Cladding




5. This motivated scientists to develop glass fibers that included a separate glass coating. The innermost region of the fiber, or core, was used to transmit the light, while the glass coating, or cladding, prevented the light from leaking out of the core by reflecting the light within the boundaries of the core. This concept is explained by Snell's Law which states that the angle at which light is reflected is dependent on the refractive indices of the two materials — in this case, the core and the cladding. The lower refractive index of the cladding (with respect to the core) causes the light to be angled back into the core as illustrated in Figure 2.

The fiberscope quickly found application inspecting welds inside reactor vessels and combustion chambers of jet aircraft engines as well as in the medical field. Fiberscope technology has evolved over the years to make laparoscopic surgery one of the great medical advances of the twentieth century.

6. The development of laser technology was the next important step in the establishment of the industry of fiber optics. Only the laser diode (LD) or its lower-power cousin, the light-emitting diode (LED), had the potential to generate large amounts of light in a spot tiny enough to be useful for fiber optics. In 1957, Gordon Gould popularized the idea of using lasers when, as a graduate student at Columbia University, he described the laser as an intense light source. Shortly after, Charles Townes and Arthur Schawlow at Bell Laboratories supported the laser in scientific circles. Lasers went through several generations including the development of the ruby laser and the helium-neon laser in 1960. Semiconductor lasers were first realized in 1962; these lasers are the type most widely used in fiber optics today.

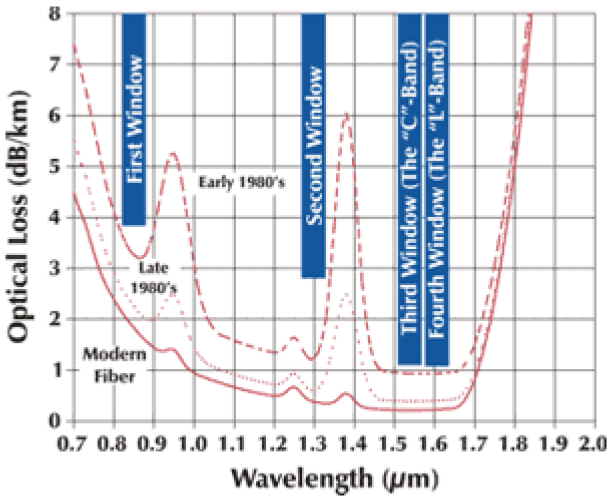
7. Because of their higher modulation frequency capability, the importance of lasers

as a means of carrying information did not go unnoticed by communications engineers. Light has an information-carrying capacity 10,000 times that of the highest radio frequencies being used. However, the laser is unsuited for open-air transmission because it is adversely affected by environmental conditions such as rain, snow, hail, and smog. Faced with the challenge of finding a transmission medium other than air, Charles Kao and Charles Hockham, working at the Standard Telecommunication Laboratory in England in 1966, published a landmark paper proposing that optical fiber might be a suitable transmission medium if its attenuation could be kept under 20 decibels per kilometer (dB/km). At the time of this proposal, optical fibers exhibited losses of 1,000 dB/ km or more. At a loss of only 20 dB/km, 99% of the light would be lost over only 3,300 feet. In other words, only 1/100th of the optical power that was transmitted reached the receiver. Intuitively, researchers postulated that the current, higher optical losses were the result of impurities in the glass and not the glass itself. An optical loss of 20 dB/km was within the capability of the electronics and opto-electronic components of the day.

8. Intrigued by Kao and Hockham's proposal, glass researchers began to work on the problem of purifying glass. In 1970, Drs. Robert Maurer, Donald Keck, and Peter Schultz of Corning succeeded in developing a glass fiber that exhibited attenuation at less than 20 dB/km, the threshold for making fiber optics a viable technology. It was the purest glass ever made.

9. The early work on fiber optic light source and detector was slow and often had to borrow technology developed for other reasons. For example, the first fiber optic light sources were derived from visible indicator LEDs. As demand grew, light sources were developed for fiber optics that offered higher switching speed, more appropriate wavelengths, and higher output power. For more information on light emitters see Laser Diodes and LEDs.

Figure 3 - Four Wavelength Regions of Optical Fiber




10. Fiber optics developed over the years in a series of generations that can be closely tied to wavelength. Figure 3 shows three curves. The top, dashed, curve corresponds to early 1980's fiber, the middle, dotted, curve corresponds to late 1980's fiber, and the bottom, solid, curve corresponds to modern optical fiber. The earliest fiber optic systems were developed at an operating wavelength of about 850 nm. This wavelength corresponds to the so-called "first window" in a silica-based optical fiber. This window refers to a wavelength region that offers low optical loss. It sits between several large absorption peaks caused primarily by moisture in the fiber

and Rayleigh scattering.

11. The 850 nm region was initially attractive because the technology for light emitters at this wavelength had already been perfected in visible indicator LEDs. Low-cost silicon detectors could also be used at the 850 nm wavelength. As technology progressed, the first window became less attractive because of its relatively high 3 dB/km loss limit.

12. Most companies jumped to the “second window” at 1310 nm with lower attenuation of about 0.5 dB/km. In late 1977, Nippon Telegraph and Telephone (NTT) developed the “third window” at 1550 nm. It offered the theoretical minimum optical loss for silica-based fibers, about 0.2 dB/km.

13. Today, 850 nm, 1310 nm, and 1550 nm systems are all manufactured and deployed along with very low-end, short distance, systems using visible wavelengths near 660 nm. Each wavelength has its advantage. Longer wavelengths offer higher performance, but always come with higher cost. The shortest link lengths can be handled with wavelengths of 660 nm or 850 nm. The longest link lengths require 1550 nm wavelength systems. A “fourth window,” near 1625 nm, is being developed. While it is not lower loss than the 1550 nm window, the loss is comparable, and it might simplify some of the complexities of long-length, multiple-wavelength communications systems.

## Applications in the Real World

14. The U.S. military moved quickly to use fiber optics for improved communications and tactical systems. In the early 1970’s, the U.S. Navy installed a fiber optic telephone link aboard the U.S.S. Little Rock. The Air Force followed suit by developing its Airborne Light Optical Fiber Technology (ALOFT) program in 1976. Encouraged by the success of these applications, military R&D programs were funded to develop stronger fibers, tactical cables, ruggedized, high-performance components, and numerous demonstration systems ranging from aircraft to undersea applications.

15. Commercial applications followed soon after. In 1977, both AT&T and GTE installed fiber optic telephone systems in Chicago and Boston respectively. These successful applications led to the increase of fiber optic telephone networks. By the early 1980’s, single-mode fiber operating in the 1310 nm and later the 1550 nm wavelength windows became the standard fiber installed for these networks. Initially, computers, information networks, and data communications were slower to embrace fiber, but today they too find use for a transmission system that has lighter weight cable, resists lightning strikes, and carries more information faster and over longer distances.

16. The broadcast industry also embraced fiber optic transmission. In 1980, broadcasters of the Winter Olympics, in Lake Placid, New York, requested a fiber optic video transmission system for backup video feeds. The fiber optic feed, because

of its quality and reliability, soon became the primary video feed, making the 1980 Winter Olympics the first fiber optic television transmission. Later, at the 1994 Winter Olympics in Lillehammer, Norway, fiber optics transmitted the first ever digital video signal, an application that continues to evolve today.

In the mid-1980's the United States government deregulated telephone service, allowing small telephone companies to compete with the giant, AT&T. Companies like MCI and Sprint quickly went to work installing regional fiber optic telecommunications networks throughout the world. Taking advantage of railroad lines, gas pipes, and other natural rights of way, these companies laid miles fiber optic cable, allowing the deployment of these networks to continue throughout the 1980's. However, this created the need to expand fiber's transmission capabilities.

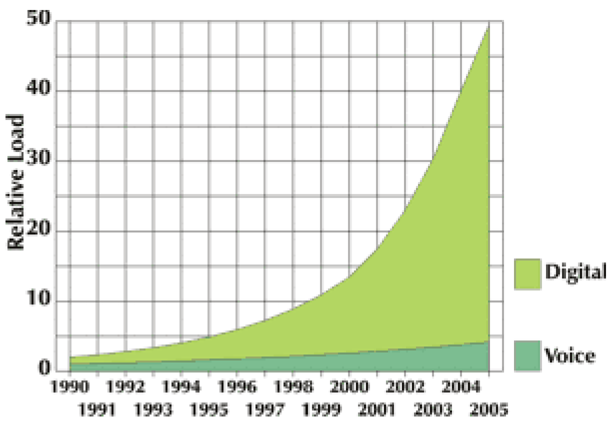
17. In 1990, Bell Labs transmitted a 2.5 Gb/s signal over 7,500 km without regeneration. The system used a soliton laser and an erbium-doped fiber amplifier (EDFA) that allowed the light wave to maintain its shape and density. In 1998, they went one better as researchers transmitted 100 simultaneous optical signals, each at a data rate of 10 gigabits (giga means billion) per second for a distance of nearly 250 miles (400 km). In this experiment, dense wavelength-division multiplexing (DWDM technology, which allows multiple wavelengths to be combined into one optical signal, increased the total data rate on one fiber to one terabit per second ($10^{12}$ bits per second).

For more information on fiber optic applications see Fiber Optic Transport Solutions

### The Twenty-First Century and Beyond

18. Today, DWDM technology continues to develop. As the demand for data bandwidth increases, driven by the phenomenal growth of the Internet, the move to optical networking is the focus of new technologies. At this writing, nearly half a billion people have Internet access and use it regularly. Some 40 million or more households are "wired." The world wide web already hosts over 2 billion web pages, and according to estimates people upload more than 3.5 million new web pages everyday.

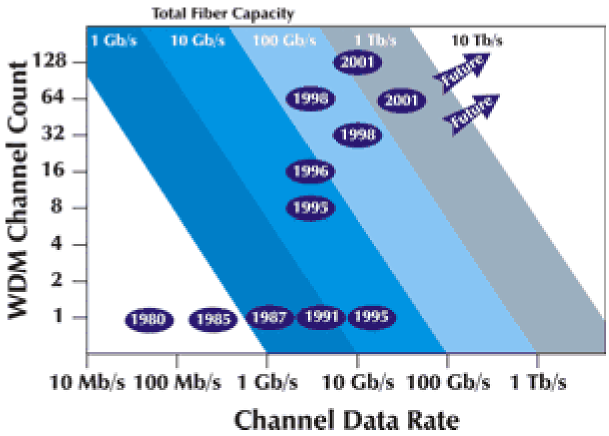
Figure 4 - Projected Internet Traffic Increases




19. The important factor in these developments is the increase in fiber transmission capacity, which has grown by a factor of 200 in the last decade. Figure 5 illustrates this trend. **B**ecause of fiber optic technology's

Figure 5 - The Growth of Optical Fiber Transmission Capacity

immense potential bandwidth, 50 THz or greater, there are extraordinary possibilities for future fiber optic applications. Already, the push to bring broadband services, including data, audio, and especially video, into the home is well underway.




20. Broadband service available to a mass market opens up a wide variety of interactive communications for both consumers and businesses, bringing to reality interactive video networks, interactive banking and shopping from the home, and interactive distance learning. The "last mile" for optical fiber goes from the curb to the television set top, known as fiber-to-the-home (FTTH) and fiber-to-the-curb (FTTC), allowing video on demand to become a reality.

**Tasks to the texts:**

***1. Write the précis of the in English.***
***2. Translate into Russian in writing paragraphs 5-7, 18-20.***
***3. Add to the text what you now about present usage of optical fiber.***

## “Spaser” Shakes Up the Nanoworld

1. Researchers at Georgia State University in Atlanta and Tel Aviv University in Israel have proposed a device based on surface plasmons* to shake things up in very small systems. In a manner analogous to the way a laser operates, the “spaser” (surface plasmon amplification by stimulated emission of radiation) would amplify a specific surface plasmon excitation mode using a metallic particle as a resonant cavity.

2. Surface plasmons are highly localized energy excitations on the surface of materials. Although small in volume, they can cause big effects, making them suitable for probing nanostructures. Today surface plasmons are generated with a laser or by other resonant optical methods.

3. Unlike a laser, the spaser itself would be a nanoscale device. As theorized, it would consist of quantum dots surrounding metallic nanoparticles. When excited optically, electrically or chemically, the quantum dots would interact with their surroundings and generate surface plasmons amplified by and accumulated in the metallic nanoparticle, much like a resonant cavity in a laser.

4. The spaser would offer a number of advantages over current techniques, explained Mark I. Stockman, a professor of physics and astronomy at Georgia State University, who developed the concept with David J. Bergman. Because of its size, the energy would be concentrated in a small area and in a specific and single mode. A laser, in contrast, spreads its energy over the focal volume and over many plasmon modes. This is inefficient and noisy, making precise nanoscale measurements difficult. And again unlike a laser, a spaser would not be limited to creating luminous surface plasmon modes. So-called dark surface plasmon modes exist, and they also could be used to probe nanostructures with no stray radiation.

5. The device exists only in theory, but Stockman and Bergman are working with Victor Klimov’s research group at Los Alamos National Laboratory in New Mexico to implement it experimentally.

*plasmon – квант плазменных колебаний

**Task 1.** ***Find in the text advantages of spaser over laser. Name and explain them.***
**Task 2.** ***Write out key-words and wordcombinations and give their Russian equivalents.***
**Task 3.** ***Headline each paragraph.***

## Laser printer

A laser printer is a common type of computer printer that rapidly produces high quality text and graphics on plain paper.

The first laser printer was produced by Xerox when Xerox researcher Gary Starkweather modified a Xerox copier in 1971. Laser printing eventually became a multibillion-dollar business for Xerox. The first laser printer designed for use with an individual computer was released with the Xerox Star 8010 in 1981; however, although it was highly innovative, the Star was an expensive ($17,000) system that was only purchased by a small number of laboratories and institutions.

There are typically six steps involved in the laser printing process:

1. Charging: A corona wire (in older printers) or a primary charge roller projects an electrostatic charge onto the photoreceptor. a revolving photosensitive drum or belt which is capable of holding an electrostatic charge on its surface as long as it hasn't been exposed to certain wavelengths of electromagnetic radiation.
2. Writing: A Raster Image Processor (RIP) chip converts incoming images to a raster image suitable for scanning onto the photoreceptor. The laser is aimed at a moving mirror which directs the laser beam through a system of lenses and mirrors onto the photoreceptor. Lasers (now typically laser diodes) are used because they generate a coherent beam of light for a high degree of accuracy. Wherever the laser strikes the photoreceptor the charge is reversed, thus creating a latent electro-photographic image on the photoreceptor surface.
3. Developing: The surface containing the latent image is exposed to toner, very fine particles of dry plastic powder mixed with carbon black or coloring agents. The charged toner particles are electrostatically attracted to the photoreceptor where the laser wrote the latent image.
4. Transferring: The photoreceptor is pressed or rolled over paper, transferring the image. Higher end machines use a positively charged transfer roller on the back-side of the paper to pull the toner from the photoreceptor to the paper.
5. Fusing: The paper passes through a fuser assembly, which, having rollers that provide heat and pressure (up to 200 degrees Celsius), bonds the plastic powder to the paper.
6. Cleaning: When the print is complete an electrically neutral rubber blade cleans any excess toner from the photoreceptor and deposits it into a waste reservoir, and a discharge lamp removes the remaining charge from the photoreceptor.

Different printers implement these steps in distinct ways. Some laser printers actually use a linear array of light-emitting diodes to write the light on the drum. The toner is based on either wax or plastic, so that when the paper passes through the fuser assembly, the particles of toner melt. The paper may or may not be oppositely charged. The fuser can be an infrared oven, a heated pressure roller, or (on some very fast, expensive printers) a xenon flash lamp. Many printers have a toner-conservation mode or economode, which can be substantially more economical at the price of slightly lower contrast. Color laser printers add colored toner (typically but not always cyan, yellow, and magenta) in three additional steps or passes.

Aside from these components, typical maintenance is to vacuum the mechanism, and eventually clean or replace the paper-handling rollers. The rollers have a thick rubber coating which eventually become covered with slippery paper dust and suffer wear. They can usually be cleaned with a damp lint-free rag and there are chemical solutions that can help restore the traction of the rubber.

Modern color laser printers mark printouts by a nearly invisible dot raster. The dots are yellow and about 0.1 mm in size, with a raster of about 1 mm. This is purportedly the result of a deal between the US government and printer manufacturers to help track counterfeiters.

The dots encode the printing date, time, and printer serial number in binary-coded decimal on every sheet of paper printed, which allows pieces of paper to be traced by the manufacturer to identify the place of purchase, and sometimes the buyer. Some are concerned that this is a threat to the privacy and anonymity of those who print.

**Tasks to the text.**

1. ***Divide the text into its logical parts.***
2. ***Formulate the topic of each part.***
3. ***What have you learnt about the main steps involved in the laser printing process?***
4. ***Render the text in English (10-12 sentences).***

# Lasers for Atmospheric Studies

## 1. Using Lasers to Study Our Atmosphere

The Earth's atmosphere and climate have become big concerns – and not just to scientists. Terms like greenhouse effect, ozone hole and global climate are now household words which conjure up either concern or controversy. What is causing them? How serious are they?

Since the 1930s, when scientists first discovered ozone, a lot of progress has been made in defining and measuring both natural and human influences on our atmosphere. Using advances in technology such as radar and lasers, scientists have gained a greater understanding of Earth's atmosphere and how it might be changing.

Our ability to gather data from ground-based, airborne and now spaceborne remote sensing devices has given us a new global perspective on our atmosphere.

## 2. Uses of Lasers

One key to understanding the atmosphere is the ability to study its components, including clouds (liquid), aerosols (suspended particles) and ozone and water vapor (gases). Researchers at NASA Langley use laser-based systems called lidars (light detection and ranging) to study the atmosphere with high precision. A lidar can penetrate thin or broken clouds in the lower atmosphere, where humans live, letting researchers "see" the vertical structure of the atmosphere. A space-based lidar can provide global measurements of the vertical structure of clouds and atmospheric gases. Both ozone and water vapor are involved in many important atmospheric processes that can affect life on Earth, climate change, weather, the Earth's energy budget, and regional and global pollution levels.

Perhaps the greatest value of lasers as remote sensing tools is the unprecedented accuracy with which they can measure clouds. The latest advancements in laser remote sensing can fill the gaps we have in our understanding of how clouds reflect and absorb solar energy, and how heat and moisture are exchanged between the air, ocean and earth.

## 3. How Does A Lidar Work?

A lidar is similar to a radar, which is commonly used to track everything from airplanes in flight to thunderstorms. Instead of bouncing radio waves off its target, however, a lidar uses short pulses of laser light to detect particles or gases in the atmosphere. Traveling as a tight, unbroken beam, the laser light disperses very little as it moves away from its origin – such as from space down to the Earth's surface. Some of the laser's light reflects off of tiny particles – even molecules – in the atmosphere. The reflected light comes back to a telescope and is collected and measured.

## 4. Why Put Lasers in Space?

Ground-based lidar instruments can profile the atmosphere over a single viewing site, while lidars aboard aircraft can gather data over a larger area. Each of these methods, however, is limited to sampling a comparatively small region of the Earth.

Spaceborne lidars, including instruments on satellites, have the potential for collecting data on a global scale, including remote areas like the open ocean, in a very short period of time.

**5. Remote Sensing Lasers in Space.**

In September 1994, NASA launched the Lidar In-Space Technology Experiment (LITE). LITE was the first use of a lidar system for atmospheric studies from space. LITE orbited the Earth while positioned inside the payload bay of the Space Shuttle Discovery (STS-64). During the ten-day mission, LITE measured the Earth's clouds and various kinds of aerosols in the atmosphere for 53 hours.

Because this type of lidar had never flown in space before, the LITE mission was primarily a technology test. Scientists and engineers wanted to verify that the entire system worked as planned while on orbit.

An important secondary goal of the LITE mission was to explore the applications of space-based lidars and gain operational experience for a future satellite-based lidar system. Such a satellite could provide continuous global atmospheric data.

NASA Langley researchers are now exploring the feasibility and potential advantages of using lidar instruments on Earth-observing satellites.

**6. The Future of Laser Remote Sensing**

LITE and LASE collected data on a wide range of phenomena, from aerosols in the upper atmosphere, to cloud droplets, pollutants and ozone in the lower atmosphere. Future lidar instruments will be tailored to more specific purposes. While one instrument studies the vertical structure of clouds, another will track urban smog or desert dust storms; all of which affect Earth's atmosphere, and, in turn, its weather and climate.

Only by gathering more accurate information scientists can improve their understanding of the atmosphere to the point where they can confidently predict its behavior, and determine how it is being affected by human activities. This improved understanding would enable us to prepare for natural telescope, scientists can accurately determine the location, distribution and nature of the particles.

A lidar carries its own source of laser light, which means it can make measurements both in the daytime and at night. The result is a revolutionary new tool for studying what's in our atmosphere from cloud droplets to industrial pollutants – many of which are difficult to detect by other means.

**7. Measuring Atmospheric Gases**

While lidars like LITE measure the vertical distribution of clouds and small particles in the atmosphere, they cannot measure important atmospheric gases, such as water vapor and ozone. This type of measurement can be made with a Differential Absorption Lidar (DIAL). The DIAL technique was first demonstrated in the mid-1960s, and DIAL systems have been flying on research aircraft for over a decade.

DIAL uses two pulsed beams of light at two slightly different wavelengths. One beam determines the location of the particles or gases- its beam strength remains relatively unchanged regardless of how many particles or how much gas is present. The second beam, which is tuned to a slightly different wavelength, is partially absorbed by the particles or gas. The amount of the second beam that is absorbed is used to determine the amount of gas or particles present.

The LITE project paved the way for using laser technology on satellites.

**Tasks to the text.**

***1. Match the following questions with the blocks of the text, rearrange questions in their logical order and answer them.***

1) When did scientists for the first time use a lidar system for atmospheric studies from space?
2) What is the purpose of ground – based and spaceborne lidars?
3) What stands for the abbreviation a DIAL and what measurements can be made with a DIAL?
4) When was it possible for scientists to get better understanding of Earth's atmosphere? Why did it become possible?
5) What new opportunities will lidar instruments give to scientists?
6) Where can a lidar penetrate and what can a space-based lidar provide?
7) What instrument is a lidar similar to?

***2. Describe the principle of a lidar's (the 3$^{d}$ blocks) and a DIAL's (the 7$^{th}$ blocks) operation.***

***3. What have you learnt from the 6$^{th}$ block of the text about important goals of the LITE mission?***

***4. Write the abstract of the text (in English).***

## PRACTICAL USES OF X-RAY LASERS

1. The following is a literature survey on the practical engineering applications of X-ray lasers. The coherent ultra-short wavelengths would be the only practical way to manufacturing nanometer scale structures required in the fields of quantum-electronics and for construction of nanometer sized robots (nanides). These lasers could also be the only conceivable way to make holograms of complicated bio-molecules while they are still within a living cell. And the promise of X-ray lasers for inertial confinement fusion holds the promise of unlimited energy for humanity.

2. Nano-Electronics

The circuits required for quantum-electronics are much smaller than current semiconductor technology. These devices hold the potential of operating with insignificant dissipation by using properties of electrons confined to ultra-small cavities of the order of the wavelength of the electron, taking advantage of wavefunction quantization. Present day semiconductor VLSI manufacturing technology considers this quantum wavefunction overlap as an impediment to the quasi-classical electron-fluid approximation. This outdated approach severely limits the minimum size of circuit elements before the noise attributed to the 'tunneling' of electrons from nearby components causes irretrievable signal loss. Instead of fighting this purely quantum effect, why not take advantage of it by shifting the emphasis away from the classical conception of an electron-fluid towards the more 'natural' and powerful quantum concept. Computers based on nano-electronics would be ultra-dense, hyper-fast and superconducting; priceless attributes for a world starving for table-top giga-flops and giga-bits for micro-dollars.

3. Nanotechnology Robots

The high spatial resolution of X-ray lasers could be used to shape parts for nanometer scale robots. These 'nanides' would revolutionize industry and medicine. In manufacturing technology they could be programmed to fabricate anything merely by providing them with enough raw materials in a water based medium. They could build entire personal computers inside something that looks like a jug of milky liquid. They could even be programmed to reproduce themselves in case more are needed. In medicine they could be programmed to perform nano-surgical repairs anywhere within a living host.

4. Bio-Holography

The coherence and short wavelength of pulsed X-ray lasers could be used to make holographic snapshots of single bio-molecules within the living cell. This would allow microbiologists the unprecedented freedom to examine complicated and fragile organic molecules in their natural environment, while they still reside within living cells. Under suitable conditions these molecules could even be 'caught in the act' of important chemical changes during their normal functioning. No longer would there be a need for the long laborious task of isolating, purifying and growing perfect crystals on the space shuttle. Most of the larger bio-molecules change their shape when removed from their natural watery environment, or when they are removed from the cell.

**Tasks to the text.**

***1. Read paragraph 1.***

a) Formulate the topic of the paragraph.

b)Give Russian equivalent of: “…nanides”.

***2. Read paragraph 2.***

a) Compare quantum-effect-based technology with current semiconductor technology.

b)Characterize computers based on nano-electronics.

***3. Read paragraph 3.***

a) State the main idea pf the paragraph.

b) Translate paragraph 3 in writing.

***4. Read paragraph 4.***

a)Extract the topic sentence from the paragraph.

b)Say, what makes nano-technology so fruitful for microbiology.

## Laser Welding Penetrates the Plastics Market

1. Lasers seem the obvious choice for welding plastics. Their flexibility is second to none, and the quality of the weld is better than that achieved with most other techniques. Despite these and many other advantages, however, their penetration into the plastics market has been slow.

2. According to market analysts, there are several reasons for this. To successfully use a laser to weld plastics, you not only have to redesign the plastic part to be suitable for this process, you also have to adapt the material itself.

3. Metals and plastics react to laser energy very differently. Most polymers absorb light in the UV and IR regions of the spectrum. In the visible and near-IR range, they are usually transparent, and, to make them suitable for laser welding, additional pigments must be embedded into the polymer matrix.

4. The color of the plastic affects its transmission and absorption characteristics as well, but it has been shown that most kinds of thermoplastic elastomers can be laser welded, even those with a high glass-fiber content. Different polymer materials can be welded together, provided that they are chemically compatible and that the melting temperature ranges match. Generally, those materials that can be welded with ultrasonic methods also can be laser welded.

**$CO_2$ vs. transmission welding.**

5. Currently, the two main types of laser welding for plastics are $CO_2$ and transmission laser welding. Plastics readily absorb $CO_2$ laser radiation, allowing quick joints to be made; however, the depth of the beam's penetration is limited, which restricts the technique to film applications. Very rapid processing of thin plastic film is possible, even with fairly modest laser powers (<1000 W). The $CO_2$ laser beam cannot be transmitted down a silica optical fiber, but it can be manipulated around a complex process path using mirrors and either gantry or robotic movement.

6. Plastics absorb the radiation produced by Nd:YAG and diode lasers less easily. These lasers are suitable for performing transmission laser welding, where one plastic must be transmissive to laser light and the other must be able to absorb the laser energy.

7. Transmission laser welding is by far the more common form or laser technique for this application. Because the weld is between the overlapping planes, the surface has an undamaged finish. The beam is transmitted by the transparent plastic on top and then absorbed by the lower plastic layer, which heats up and transfers the heat to the upper laver, where the two molten polymers merge and solidify into one melt.

***Notes to the text:***

1. to embed – вставлять
2. gantry – радиолокационная антенна

**Benefits of Using Lasers to Weld Plastics**

For welding plastics, lasers provide many advantages over conventional welding techniques such as ultrasonic or vibration welding.

- A perfect surface is attainable.
- Welding seam contours are flexible.
- Minimal thermal and mechanical power input is required.
- The weld is at least as strong as that achieved with the ultrasonic technique.
- There are no microparticles – significant for medical applications.
- Very fine structures with welding seams close to heat-sensitive components can be achieved.
- There is no melt ejection.
- It has an excellent reject rate.
- Controllable beam power reduces the risk of distortion or damage.
- Precise focusing allows accurate joint formation.
- The noncontract process is clean and hygienic.

**Tasks to the text.**

***1. Match the following questions with the blocks of the text.***

a. What are the reasons for slowing down laser welding penetration into the plastics market?

b. Why transmission laser welding is performed with Nd:YAG and diode lasers?

***2. Write the abstract of the text in Russian.***

***3. Render the text in English (10-12 sentences).***

## Dictionary

**A**

ablate, v – удалять
absorb, v – поглощать
abundant, adj – обильный, изобилующий
accomplish, v – выполнять, завершать
according to, adv – в зависимости от (ч.-л.), (согласно ч.-л.)
achieve, v – достигать, добиваться
acquire, v – приобретать, достигать
alignment, n – настройка, выравнивание
ambient temperature – температура окружающей среды
amount, n – количество, величена
amplify, v – усиливать
apply, v – применять, прикладывать
appropriate, adj – подходящий, соответствующий
approximately, adv – приблизительно, почти
available, adj – доступный, годный
augment, v – увеличивать (ся), усиливать (ся)

**B**

band, n – полоса, зона
absorption ~ - полоса поглощения
conduction ~ - зона проводимости
emission ~ - полоса излучения
forbidden ~ - запрещенная зона
frequency ~ - полоса частот
impurity ~ - примесная зона
transmittion ~ - полоса пропускания
valence ~ - валентная зона
beam, n – луч, пучок лучей
oblique ~ - косой пучок
vortex ~ - вихревой пучок
belong, v –принадлежать, относиться
bright, adj – яркий
burn, v – жечь, сжигать, сгорать

**C**

calculate, v – вычислять, подсчитывать
capabilities, n, pl – возможности
cavity, n – полость, (объемный) резонатор
cell, n – ячейка, клетка
circuit, n – схема
printed ~ - печатная плата

circumstance, n – обстоятельство
coating, n – обшивка, слой (покрытие)
collapse, v – рушиться, сильно ослабеть
collision, n – столкновение
come about, v – происходить, случаться
common, a – общий, обычный, распространенный
component, n – составная часть (элемент), узел, блок
condition, n – 1) условие; 2) режим
confine, v – ограничивать, заключать в
constituent, n – составная часть
construct, v – строить, конструировать, создавать
contain, v – содержать в себе, вмещать
conventional, adj – обычный, общепринятый
convert, v – преобразовать, превращать
conversion, n – превращение, преобразование, переход (из одного состояния в другое)
cool, v – охлаждать (ся)
cornea, n – роговая оболочка глаза
correspond, v – соответствовать
cover, v – охватывать, относиться к
coverage, n – охват, покрытие
    spectral ~ – спектральный диапазон
coworker, n – сослуживец, коллега
current, n – ток
currently, adv – в настоящее время

**D**

decrease, v – уменьшать
delicate, adj – нежный, хрупкий, (зд.)чувствительный
density, n – плотность
depend, v – зависеть
detonation, n – детонация, взрыв
develop, v – развивать (ся), совершенствовать (ся)
device, n – устройство, прибор, механизм
dimension, n – размер, величина, измерение
discovery, n – открытие
dipole, n – диполь, вибратор
    electronic ~ - электронный диполь
distinguish, v – различать
divide, v – делить (ся), подразделять (ся)
dope, v – заправлять, добавлять
drop, v – падать, снижаться

**E**
eject, v – выбрасывать, выпускать, выталкивать, извергать
emission, n – эмиссия, излучение, испускание (электронов)
emit, v – испускать, излучать
emittance, n – лучеиспускательная способность
emitter, n – излучатель, эмиттер
employ, v – 1) применять, использовать; 2) предоставлять работу
engineering, n – техника, конструирование
exact, adj – точный, верный
excite, v – возбуждать, накачивать
exist, v – существовать, находиться
equal, adj – равный
expansion, n – расширение, распространение
explore, v – исследовать, изучать
exploration, n – исследование
explode, v – взрывать (ся)
extend, v – простирать (ся), тянуть (ся), протягивать
expenditure, n – трата, расход
extract, v – извлекать
evaporate, v – испарять (ся), выпаривать (ся)
evidence, n – основание, доказательство

**F**
facilitate, v – ускорять
feature, v – показывать, являться характерной чертой
flow, n – поток
    axial ~ – аксиальный поток
forbid (forbade, forbidden), v – запрещать
frequency, n – частота, повторяемость
fuel, n – топливо, горючее
fulfill, v – выполнять
fundamental, adj – основной, коренной
fusion, n – синтез, слияние

**G**
gain, v – получать, достигать, добиваться
generate, v – производить, генерировать
give off, v – выделять, испускать

**H**
handle, v – управлять, регулировать, обращаться (с к.-л., с ч.-л.)
hard, adj – твердый, крепкий, жесткий
heat, n – теплота, степень нагрева

**I**
identify, v – устанавливать тождество, опознавать
impurity, n – примесь
incandescent, adj – действующий при накаливании
incoherent, a – некогерентный, несвязный, раскаленный
increase, v – увеличивать (ся) (повышать), возрастать (расти)
indicate, v – показывать, указывать
influence, v – влиять
inherently, adv – по природе
inject, v – вбрызгивать, вводить
instant, n – момент, мгновение
intensity, n – интенсивность, сила, энергия, (эл. - напряженность)
insulator, n – изолятор
interaction, n – взаимодействие
invent, v – изобретать, делать открытие
invention, n – изобретение
inversion, n – инверсия, изменение
invert, v – переворачивать, переставлять, инвертировать
irradiate, v – излучать, облучать, освещать
issue, n – спорный вопрос, предмет спора, разногласие

**J**
junction, n – 1) узел, соединение, 2) стык, спай

**L**
lack, n – отсутствие
last, v – продолжаться, длиться
lattice, n – решетка
lead, v – вести, приводить, управлять, руководить
at least, adv – по крайней мере
level, n – уровень
light, n – свет, освещение,
~, adj – светлый, легкий
low, n – низкий, слабый

**M**
manufacture, v – производить, обрабатывать
mean, v – означать, иметь ввиду
mean, adj – средний
means, n – 1) средство (-а), способ (-ы); 2) устройство, прибор
by ~ of – посредством
medium, n – 1) среда, вещество; 2) средство, способ
microwave, adj – микроволновый
minimum, adj – минимальный
shallow ~ - небольшое минимальное значение

mixture, n – смесь, смешивание
monochromatic, adj – одноцветный, монохроматический
multiply, v – умножать, увеличивать (ся), усиливать (ся)

**N**
narrow, adj – узкий, тесный
nearly, adv – близко
notable, adj – примечательный, заметный
nozzle, n – сопло, наконечник
    supersonic ~ - сверхзвуковое сопло

**O**
occur, v – происходить
offer, v – предлагать, выдвигать
operate, v – работать, действовать
oscillate, v – колебаться, вибрировать
oscillator, n – излучатель, вибратор, генератор
ordinary, adj – обычный, нормальный, простой

**P**
pattern, n – образец, шаблон
performance, n – (зд.) работа; характеристики
pink, adj – розовый
phenomenon, n – явление
power, n – сила, мощность, энергия
profile, n – профиль, сечение
precious, adj – драгоценный, предельно точный
primary, adj – первичный, основной, главный
prove, v – 1) доказывать, подтверждать; 2) оказываться
provide, v – снабжать, обеспечивать
pump, v – накачивать, (качать)
pure, adj – чистый, беспримесный

**Q**
quantitative, adj – количественный

**R**
radiation, n – излучение. радиация
raise, v – поднимать (ся)
range, n – 1) диапазон; 2) дальность (расстояние, длина); 3) радиус действия
rapid, a – быстрый, скорый
rare, a – редкий
rather than, adj – в большей мере, чем; вернее
reach, v – достигать, (доходить)
receiver, n – приемник

recognize, v – узнавать, признавать
region, n – область, зона, полоса, слой (атмосферы)
relatively, adv – относительно
release, v – выделять, испускать, высвобождать
relevant, adj – относительный
require, v – требовать
research, n – (научное) исследование, изучение, исследовательская работа
resistance, n – сопротивление, противодействие
resistant, adj – сопротивляющийся, стойкий, прочный
resolution, n – разрешающая способность (сила), разрешение
ruby, n – рубин

**S**
semiconductor, n – полупроводник
separate, v – разделять(ся)
shaded, adj – заштрихованный
shell, n – оболочка, корпус, (остов)
shift, v – менять (ся), переключать, переводить
significance, adj – важность, значимость
simultaneously, adv – одновременно
single, adj – один, единственный
solution, n – раствор
solvent, n – растворитель
splice, v – соединение внахлестку, место сращения
source, n – источник
stable, adj – устойчивый, стабильный, прочный
stage, n – ступень, цикл, этап, стадия, период, фаза
stand for, v – означать
state, n – состояние, положение
    free ~ - свободное состояние
    lower ~ свободное состояние
    repulsive ~ - состояние отталкивания
    upper ~ -ограниченное состояние
stimulate, v – побуждать, стимулировать
suitable, adj – подходящий, годный, соответствующий
sufficient, adj – достаточный
surface, n – поверхность

**T**
technique, n – 1) техника, технические приборы; 2) технология;
    3) техническое оснащение (аппаратура)
thickness, n – толщина, плотность
treat, v – рассматривать
tremble, v – дрожать, трястись
tremendous, adj – огромный, потрясающий

transverse – поперечный
trigger, v – запускать, отпирать,
    ~, n – пусковое устройство, триггер
tumor, n – опухоль
tunability, n – настройка

**V**
variety, n – множество
vicinity, n – окрестность, близость
    in the ~ of – около, приблизительно
vigorously, adv – энергично
by virtue of – благодаря чему-то, на основании чего-то
visible, a – видимый

**W**
wave, n – волна
wavelength, n – длина волны

# Literature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В 2007 году СПбГУ ИТМО стал победителем конкурса инновационных образовательных программ вузов России на 2007–2008 годы. Реализация инновационной образовательной программы «Инновационная система подготовки специалистов нового поколения в области информационных и оптических технологий» позволит выйти на качественно новый уровень подготовки выпускников и удовлетворить возрастающий спрос на специалистов в информационной, оптической и других высокотехнологичных отраслях экономики.

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## The Department of Foreign Languages

The department of foreign languages was established on 20 September 1931. At that time the first new structural subdivision was singled out and the first head of the department, the associate –professor Falk K.I. (1931-1941) was assigned.

13 teachers worked at the department, namely, 7 teachers of English and 6 teachers of German.

The department of foreign languages was headed by:

1941-1951 senior teacher Mitskevich Z.P.

1953-1973 senior teacher Lisikhina B.L.

1973-1993 senior teacher Dygina M.S.

Professor Markushevskaya L.P. has headed the department since 1993.

At present the department consists of four sections: English, French, Russian and German, 30 teachers working in the staff.

More then 60 manuals were published at the department. The electronic versions of English Grammar, Computer in Use, Studying Optics have been produced. It helps students to improve their knowledge working on computers.

Much attention is given to working out different tests for distance education.

**IN THE WORLD OF LASERS …**
**(В мире лазеров …)**

*Учебное пособие*
*для студентов инженерно-физического факультета*
Издание второе (переработанное и дополненное)


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ст. преп. Ермошина Н.В.
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