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NOMIDAGI TATU FARG'ONA FILIALI

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NAMED AFTER MUHAMMAD AL-KHORAZMI

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Eslatma! Jurnal materiallari to'plamiga kiritilgan ilmiy maqolalardagi raqamlar, ma'lumotlar haqqoniyligiga va keltirilgan iqtiboslar to'g'riligiga mualliflar shaxsan javobgardirlar.

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DEVELOPMENT OF PRACTICAL COMPETENCES OF STUDENTS IN NANOTECHNOLOGY AND SEMICONDUCTOR PHYSICS IN HIGHER EDUCATION

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Abstract. The article shows the use of advanced pedagogical technologies in teaching the development of practical competencies of students in nanotechnology and semiconductor physics in higher education. It is recommended to use the technologies “Lesson Design”, “Training in a block-modular and block-test system”, “Analogy, comparison of the real and the imaginary, observation of nature and society”. The tables in the article supplement the information given above.

Keywords: nanotechnology, quantum dot, conduction band, photon, heterostructure, block module, analogy, real and imaginary comparison, logical table system, semiconductor, energy zone, resonator, semiconductor diode.

Introduction. The attention paid to education, teachers and pedagogues, and the conditions created in our country in recent years are particularly worthy of attention. In particular, one of the urgent tasks of today is to ensure the implementation of the tasks stipulated in the decision of the President of the Republic of Uzbekistan dated March 19, 2021 No. PQ-5032 "On measures to increase the quality of education in the field of physics and develop scientific research" remains one. In this regard, the use of modern pedagogical technologies and information communication tools, the possibilities of these tools in the teaching of general physics courses in higher education institutions is a guarantee of training educated personnel with high intellectual potential.

It can be noted that in the context of the current situation that exists in the labor market, only self-organized, proactive, competent specialists, as well as specialists who are able to develop and improve themselves professionally and personally, will be the most in demand and competitive.

However, the contradictions that exist in theoretical science and practice are obvious. These contradictions have arisen between the need of modern society for professional and competent specialists (teachers) and the inappropriate level of professional competence of university graduates.

Methodology. An analysis of the use of innovative pedagogical technologies in teaching semiconductor physics shows that such research, especially dissertation research, has not yet been carried out. There is little to learn from experience teaching some topics. Therefore, a theoretical analysis is carried out of new pedagogical technologies that can be used in teaching topics related to semiconductors, which have begun to be introduced in education, especially in physics. It took into account the integrity of the selected topics or chapters, the complementarity of each topic in content, the reliance on a single fundamental idea and concepts, and the growing number of new practical knowledge each year.

From a pedagogical, psychological and methodological point of view, an analysis of scientific and methodological literature and existing methodological recommendations for the purpose of using the technologies “Lesson Design”, “Block-Modular Learning”, as well as a convenient comparison of new concepts on topics, observation of nature and society is appropriate. Let's look at these new pedagogical approaches directly.

Organization of training in semiconductor physics based on new pedagogical and information technology is a modern requirement, because in order to keep pace with the development of science, it is necessary to constantly change the types and forms of education, abandon traditional methods and look for new ones.

All students in the class must know exactly the purpose of the lesson, how to achieve the goal, how many hours of topic are intended for the lesson and the requirements set by the teacher for the final result. Of course, each previous topic should be the basis for studying subsequent topics [1].

In accordance with the intended goal, the teacher selects the information that will be learned in the lesson. Selecting a topic is an important and challenging task and the goal cannot be achieved without proper teacher judgment or competence. The content must be scientifically sound and logically expressed. It is important to define the idea of leadership, the choice of concepts, the way they are explained, and the role of the teacher and student in the process.

Discussion. It is impossible to teach a student everything, but you can and should teach him to independently acquire knowledge, work with a book, and apply the acquired knowledge in practice. To do this, first of all, in the lesson, great attention should be paid to expanding the scope of their independent work, limiting the state of passive listening of students. Secondly, it is necessary to expand the range of topics in each lesson, since experience shows that it is no longer effective to study large topics in several lessons. Thirdly, it is necessary to increase the time spent on consolidating knowledge [2].

The organization of lessons that meet the requirements depends on the subject or scope of subjects studied. Topics in semiconductor physics studied in physics courses at higher educational institutions should be taught in “Design” systems.

“Block module” and “Block test”.

Let us turn to the block-modular system of the following topics in semiconductor physics.

In the “Block-Module” system, the first introduction to the block is made in the first lesson, and in each subsequent lesson the topic of the block is discussed in full, but from lesson to lesson it is addressed in a new and deeper way. As a result, firstly, the student has a complete picture of the event or process being studied, secondly, the question in the block has a good understanding of the problems, and thirdly, he studies the relationships between them.

For example, the block system consists of the following lessons: 1) lecture; 2) seminar; 3) laboratory workshop; 4) doing exercises; 5) test; 6) an interesting information lesson.

According to the famous teacher P.Ya. Galperin, “teaching in a modular system allows students to show the full path with larger and smaller perspectives, while the traditional method illuminates only a small part of this path.” When developing a lesson, the teacher selects teaching material according to the level of importance as follows:

• general idea, keywords, basic concepts and method of their explanation;

• questions, examples and tasks aimed at mastering the main idea of the lesson;

• interesting information.

The emphasis will be on creating the following conditions to increase interest in the lesson:

• introduction of innovative elements and their connection with certain data;

• an attitude to positively surprise students;

• processing of the studied material in accordance with the practical situations to which students are accustomed;

• organization of independence and activity of students;

• emphasizing all the student's achievements during the lesson.

Lesson design for the teacher is to choose a teaching method according to the following topic. The following general classification of methods can be used:

• method of demonstrative explanation;

• reproductive method (repeated reading, exercises, etc.);

• research method (independently studies new topics based on certain knowledge, performing a creative task);

• heuristic method (with the help of the teacher’s questions, students perform problem-solving tasks and solve problems).

The effectiveness of the educational process is achieved not only by the orientation and hard work of students, but also by their research independence. To do this, students must know exactly what they need to do to learn in class. Students should always know what they are learning and have a clear understanding of the methods and process of learning. The process goes like this: We observe events in nature. Problems arise from comparing them with each other and with the knowledge we have. Various hypotheses are formed to solve them. These hypotheses have been tested in practice. Methods for using the studied phenomena have been found. The basis of the scientific learning process in the course is the proposal of a reasonable hypothesis [3].

Thus, teaching semiconductor physics topics in a block-modular system allows students to form interconnected concepts, build on each new knowledge, learn more about what needs to be studied in the future and what they need to master. This, in turn, teaches students to think independently, plan, feel responsible and continue the learning process consistently and organically.

Analogy in the classroom, comparison of real and imaginary, use of logic table experiments - it is natural that students should rely on these concepts to convey new knowledge. The use of certain concepts or formulas from previously studied chapters when teaching various sections of physics courses in higher education is widely practiced. Among such research methods, one can use the concept of analogy, that is, similarity.

Analogy can be expressed in content or form. In order for a teacher to use the analogy method, the content and form of concepts must be well aware of the boundaries of mutual compatibility. This requires a serious and creative approach to educational material [4].

As you know, topics in semiconductor physics can be presented in the following sequence in a general physics course:

• electrical conductivity, electronic and hollow, special and mixed conductivity;

• temperature dependence of electrical conductivity;

• contact events, diode and its current-voltage characteristics;

transistor and its operation;

• semiconductor devices and their application, current rectification using a diode, transistor amplifier, generating electricity using a photocell.

In semiconductors, it is more difficult to explain the transfer of electric charge through the movement of a cavity. Taking a row of cinema halls, moving the next person into the space at its edge, moving the next person into his place, etc., is believed to represent an empty movement of the empty space to the other end of the row. To account for the one-way flow of direct current in a diode, a one-way flow valve tap can be used.

The analogy method is based on comparison. In different phenomena, the mutual similarity of the properties of laws is determined only by comparison based on two or more characteristics, and the similarity of other properties is inferred.The real-imaginary comparison method can be used to begin the investigation of the semiconductor coil.

Table 1. Semiconductors found in nature, their charge carriers, temperature dependence, their electrical conductivity and their applications in coil electronics.

State of matter	Electrical conductivity	Charge carriers	Temperature dependence of conductivity	Application in electronics
Gas	Vacuum Вакуум	No	–	Electron tube
	Neutral Нейтрал	No	—	Surface Drying
	Ionized	Ions and electrons	−ρ(T)	Ion doping
Liquid	Dielectric	No	—	Surface Cleaning Очистка
	Electrolyte	Ions	−ρ(T)	Electrolysis
	Semiconductor	Not studied		—
Solid	Conductor (metals)	Electrons	+ρ(T)	Ohmic contacts, buses, sheaths
	Dielectric	No	—	Insulating layers
	Semiconductor	Electrons and holes	−ρ(T)	Tool Basics

The importance of this table is that it provides generalized and comparative information about the states of matter in nature, including the position of semiconductors, the types of charged particles in them, the temperature dependence of their conductivity, and the use of such substances in electronics. The fact that the table implies the existence of a semiconductor state among liquids, but that this area has not yet been explored, tells students that significant innovation in this direction can be expected in the future.

Analogies in teaching semiconductor physics are mainly used to help students understand complex concepts and laws. The analogy method can be used in two ways to solve a problem:

• use the method of direct analogy;

• search for a system for a given problem condition. Pedagogical experience has shown that creating a logical system of topics for a creative approach and comparative study is very effective when studying physical sciences.

The method of using the logical tables system is to theoretically divide educational material into complete blocks that meet didactic and psychological requirements within the framework of scientific theory, which are placed or drawn in a sequence of logical origin. The psychological basis of this method is the analytical nature of mental work with complex educational material [5].

Using a logical table system makes it easier to study complex topics or branches of science. The use of this method is based on the following principle, if any complex material can be easily mastered:

• the material is divided into small parts that are easy for students to master;

• unnecessary data is removed from the system;

• concepts are arranged in a sequence of logical origin from each other;

• parts are provided with additional signs, drawings, etc.;

• particles are abbreviated as much as possible, keywords are used.

Conclusion. The first table of the logical table system is information about some semiconductor substances.

Table 2

Types of semiconductors depending on their structure, composition and electrical conductivity, their production and application.

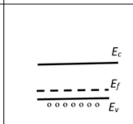
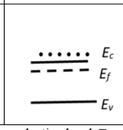
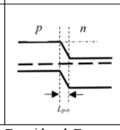
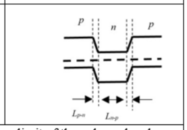
Types of Semiconductors	Semiconductor Mining	Applications of Semiconductors
I. According to the structure of the crystal lattice		

1	Monocrystal	Grown according to the Czochralski method	Used to produce epitaxial layers in semiconductor device technology
2	Polycrystal	Crystallization is formed as a result of polymorphic phase processes and aggregation of crystalline powders	Single crystals are used in cultivation and in the production of tools
3	Liquid semiconductors	A semiconductor is formed by diluting a substance	
4	Amorphous semiconductors	SiH4 is obtained by decomposition of monozylene using a 10% argon mixture at low pressure	Optical sensors are used as the basis for memory elements and LEDs for video recording, defect detection in the textile and metallurgical industries
5	Organic semiconductors	Produced by heating organic matter	Used in microelectronics as photosensitive substances
II. By chemical composition			
1	Elementary semiconductors	Silicon is obtained by reduction of trichlorosilane with hydrogen, elemental germanium is obtained by reduction oxide GeO2 IV with pure hydrogen.	In the manufacture of devices and systems in the electronics industry
2	Semiconductors consisting of binary compounds	Produced by epitaxial growth	Used as infrared radiation receivers
III. By electrical conductivity			
1	Private semiconductors	Obtained using the Czochralski method	Used in the manufacture of thermistors and photoresistors
2	Mixed semiconductors 1) p-type semiconductors	Obtained by adding elements from group III of the periodic table	Used in the manufacture of semiconductor diodes, transistors and integrated circuits
	2) n-type semiconductors	Obtained by adding elements group V of the periodic table	

The second table of the system of logical tables is the energy bands of semiconductors and their changes in contact

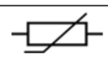
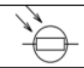
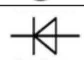
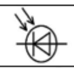
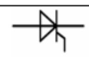
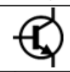
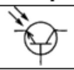
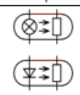
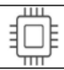
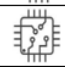
Table 3.

Energy bands of semiconductors and their changes in contact

	p-type	n-type	p-n junction	p-n-p junction
Zone diagram view				
Brief definitions	E_c – bottom of the conduction band, E_F – Fermi level, E_v – upper limit of the valence band, U_k – contact potential difference, $L_{p\text{-}n}$ – p-n junction length, $L_{n\text{-}p}$ – 2-n-p junction length, ● – electron, o – hole			

The third table of the logical system is a table that contains information about the conductivity of the semiconductor or its application in semiconductor electronics, depending on the type of transition

Table 4. Some information about the conductivity of a semiconductor or its application in semiconductor electronics depending on the type of junction

Conduction and transition type	Semiconductor tool	Tool sign	Basic semiconductor	Application
n-type p-type	Resistor		Si	Radio engineering
			Si	Electrical engineering, radio engineering
	Thermistor		Si, CdHgTe	Automation
	Diode		Si, Ge	Automation, electrical engineering, radio engineering
	Photodiode		Si, Ge	Automation
p-n n-p	Light-emitting diode		AsGa	Automation, electrical engineering, radio engineering
p^{+}-nn^{+}-p	Laser		AsGa	Automation, electrical engineering, radio engineering
	Thyristor		Si	Automation, electrical engineering, radio engineering
	Transistor		Si, Ge	Automation, electrical engineering, radio engineering
p-n-p n-p-n	Phototransistor		Si, Ge	Automation, electrical engineering, radio engineering
	Optocoupler		Si, AsGa	
p-n-p n-p-n	Chip		Si,Ge, AsGa	Automation, electrical engineering, radio engineering
p-n-p-n n-p-n-p	Integrated circuit		Si,Ge, AsGa	Automation, electrical engineering, radio engineering

This table can be used by undergraduate and graduate students, researchers and young teachers in the course “Physics of Semiconductors and Dielectrics”.

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