Method of Teaching Students to Study the Electro physics Properties of Semiconductors and Mathematical Formula

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ABSTRACT

The article presents the results of theoretical prerequisites and the results of a study of the possibility of developing new teaching methods, using the theory of similarity based on everyday examples, especially for conducting classes in technical educational institutions. .

Keywords: Teaching, technique, method, semiconductor, device, element, formula, graph, theory, experiment, research, analysis.

Formulation of the problem

Teaching students of technical higher and professional educational institutions requires the development of special teaching methods and new pedagogical technologies [1,2]. Therefore, teachers of technical educational institutions, with constant interest, observe the results of the published works of applicants in this direction. However, as you know, in the field of teaching methods, professionals of the humanities mainly work, where sometimes one or another approach to teaching developed and recommended by them is not applicable for technical schools. This situation is explained by their lack of technical education and skills in working with technological devices, machines and inventory. Therefore, the only true and correct solution in this matter, in our opinion, is to rely on the knowledge and pedagogical skills of teachers with many years of experience in technical higher and secondary specialized educational institutions with indicators of the best student achievement [3].

In connection with the above, we have made an attempt to introduce some methods of explaining topics related to semiconductor physics. The main reason for choosing this direction is the development of technology and technology based on semiconductor devices, micro and nanoelectronics. Not only in the production of countries, but also in ground and space technology, in underwater structures, mechatronics and robotics, semiconductor devices are very widely used. Without a deep understanding of their physics nature, electrical, chemical, mechanical and operational properties, it is impossible not only to develop new devices, but also to use them effectively. All the listed properties of not only semiconductors, but also other natural bodies should be carefully studied. In any case, it is impossible to give the necessary correct assessment of the developed or operated

device, without the concept and mathematical calculation of the corresponding properties of the material. This task requires some skill. And, since many specialists - scientists recommend game methods for explaining topics for students of schools and universities, taking into account good expected results, in our studies there was a bias towards such advice [4-6].

Theoretical prerequisites for the developed method

We proceed from the fact that in practice the design, development, modernization and operation of electronic devices must be preliminarily prepared on paper. This includes theoretical calculations of the electrophysics properties of a semiconductor material, the dependence of their parameters on the influence of environmental influences, such as temperature, humidity, wind speed, direct sunlight, etc. In addition, an important parameter is their geometric dimensions [7]. Because, as is well understood by specialists, some parameters (for example: resistance, electrical conductivity, etc.) strongly depend on the dimension of the material. In order to understand the influence (or absence) of some factors on their performance, formulas are used. A big problem arises in working with formulas. Uninteresting, dry and incomprehensible numbers sometimes cause some kind of negative attitude towards mathematical formulas and it will be difficult to understand their essence, remember, and also use at the right time. In this case, it is necessary to make sure that the student at least remembers the moment the teacher explains the content of the formula. It can even be some kind of gesture, facial expression, word or movement of individual parts of the lecturer's body [8]. It is still impossible for us, the authors of this work, from school experience to forget the state of a teacher with a swing of his arms and legs (like a five-pointed star!), when explaining the valence and covalent bonds of the chemical elements of the periodic system of Mendeleev! Therefore, attention should be paid to the listed ways of teaching the younger generation in technical subjects. In the field of energy and electronics, where work is carried out with the presence of electric current, one cannot make a mistake. Each mistake will lead to a tragic outcome.

Thus, in order to be very easy to understand, it is necessary to explain to students that it is also possible to talk with formulas, or even talk. The student and the formula must have their own dictionary. The dictionary is symbols that characterize one or another parameter of a semiconductor. For example, σ-electrical conductivity, **ρ**-specific resistance of the material, ε-dielectric constant, χ-thermal conductivity, I-electric current, U-electrical voltage, W-electrical power, R is the active resistance of the material in question [7] and so on. Until the trainee has mastered which symbol indicates which parameter, one cannot expect him to continue learning further material of the subject well. After explaining the importance of learning symbols, you can move on to simple mathematical expressions consisting of fractions. Here we recommend using the “Enemy or Friend?” method. Why is the method so named? This is explained by the following: firstly, it is known from the school course that the figure on the numerator (see formula (1)), contribute to an increase in the value of the parameter located on the left side of the equal sign (Ohm's law):

$$I = \frac{U}{R} \quad (1)$$

that is, the greater the voltage, with a constant value of the parameter R-resistance of the material, the electric current is greater. We explain the value of U to the student as a friend of the parameter I. Further, the growth of the parameter R (at U = const, that is, the constant voltage) leads to a decrease in the current value, which means it will be an obstacle to raising I, or in other words, hostile. So he acts like an enemy. This regularity in almost all mathematical formulas ironically retains its

character. When a student understands such a phenomenon inside a solid body, he begins to think in what ways, ways it is possible to regulate the values of these parameters. An exploratory approach to the matter is already awakening. Secondly, the parameter of the left side is highly dependent on the value of the parameters of the right side of the equals sign.

It should be noted that there are many words in mathematical formulas of foreign origin. So, for example, integral, differential, sum, determinant, matrix, function, trigonometric terms such as sine, cosine, etc. These terms are almost always used without translation into other languages. Not every teacher explains the essence and content of these words. Of course, the reader may not share our opinions, saying that if he does not explain, then why does he teach? After all, we are counting our article especially for a young specialist with a technical education, who recently graduated from a higher educational institution and became a university teacher. He did not study pedagogy, he has a poor understanding of the psychology of students, he does not know the methods, well, in general, you need to work with him. No one can guarantee the professionalism of such a teacher. Therefore, a strict recommendation to explain the essence of these terms is not without usefulness.

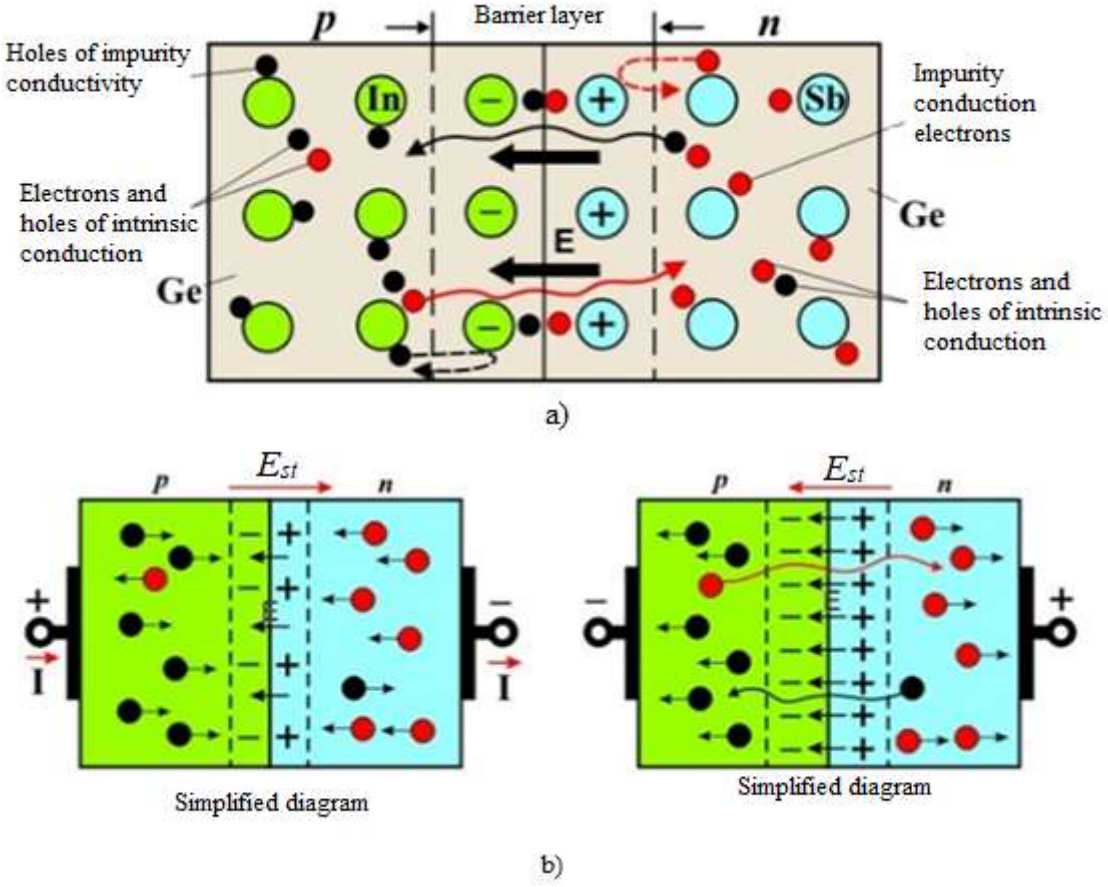


Fig.1. The principle of operation of a semiconductor diode based on a p-n junction a) a scheme for the formation of an electric field E at the interface of p - and n - semiconductors, b) a simplified scheme

It should be noted that in advanced training courses, methodologists often pay attention to individual learning of students. To do this, it is recommended to divide the group into small subgroups and study the topic by way of discussion.

However, as is known, in higher educational institutions, where there are

lectures for students in the amount of 50-75 people in special disciplines, in practice, division into groups is impractical.

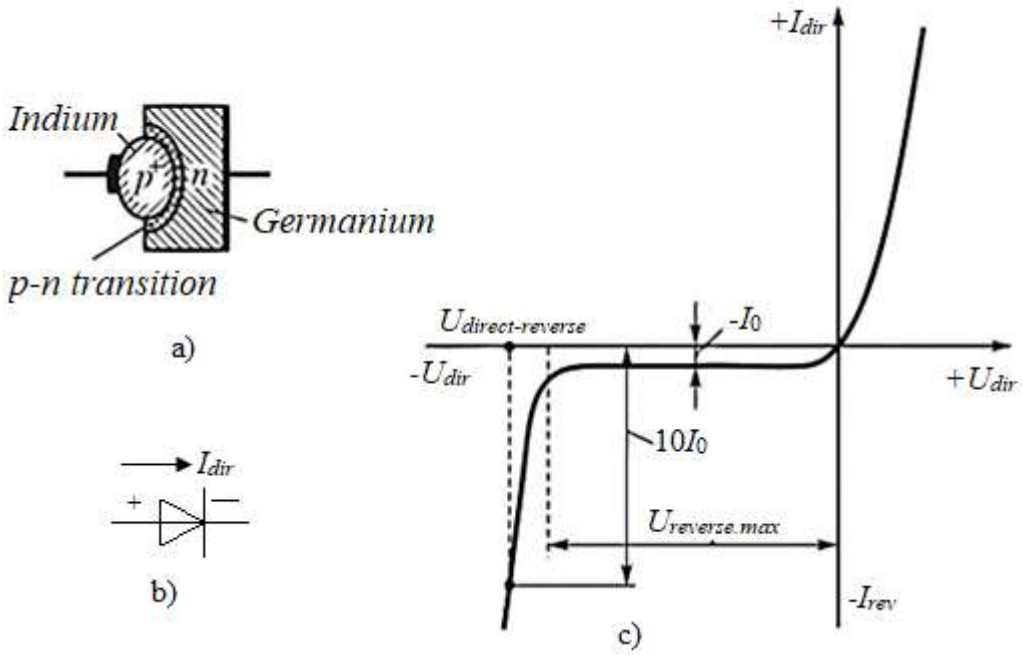


Fig.2. The dependence of the value of the transmission current on the breakdown voltage a) kinematic diagram, b) symbol, c) current-voltage characteristic

Because most of the useful time is spent on organizational issues for the division of the group. In addition, when the teacher's attention is directed to one subgroup, the rest of the class participants may be distracted, talking and creating an unfavorable atmosphere in the classroom. Therefore, the best way to teach is to apply the theory of similarity. And similar examples can be taken from everyday life [9].

Thus, to implement our ideas, we move on to conducting experimental classes.

Experimental experiences

The experiments were carried out among bachelor students of the Andijan Machine-Building Institute, studying in the direction of "Power Engineering". The number of students in the experimental audience was 51 people. The subject was chosen "Industrial Electronics". The topic of the lecture was "Semiconductor Diodes".

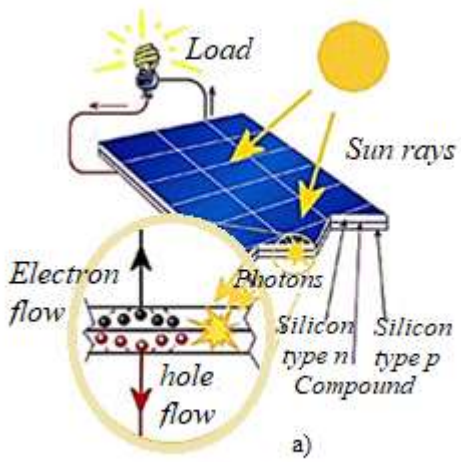
After explaining the general characteristics of the diode (Fig. 1), I moved on to studying the principles of its operation. The scheme of Figure 1 shows the transition of charge carriers through the contact zone, their trajectories and directions for the exchange of carriers. But, before that, it is important to explain in which case an electron (or a positive charge - a hole) can participate as a carrier of electric current.

The Electron Army method [10] was used. The reason for introducing this method was that the group included the majority of students who had served in the army. They are quite well aware of the physics training of soldiers and the superiority of physics strength, which can easily be replaced by the energy imparted to the electron. The most obvious example for the implementation of our "**FRIEND OR FOE**" method is the electrical characteristic of a diode (Fig. 2.). The graph clearly demonstrates the process of the flow of electro-physics phenomena in the volume of the device. Here you can personally observe and evaluate the dependences of some electro-physics parameters of the diode and determine

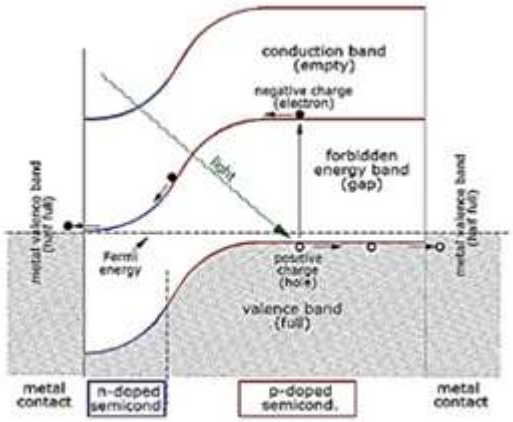
which parameter has a positive effect on the increase of one or another parameter.

For example, the upper quadrant of the right side of the graph shows that the forward current (transmission current) sharply increases with an increase in the breakdown voltage. So the value of the breakdown voltage is practically a "friend" of the transmitted current. The lecturer in this case had to masterfully explain about the "hidden enemy" - resistance. This is not clearly visible on the graph, but based on Ohm's law, it is explained how the resistance of the material prevents the initial increase in the value of the load current. Moreover, the essence of the breakdown voltage was also explained by the application of the theory of similarity [11] on the example of overcoming the "enemy".

The order of the experiment was as follows: after explaining the theoretical part of the semiconductor diode and the essence of the method, students were shown on the presentation screen Figure -3 and 4, which shows the band diagram of the solar cell, its current-voltage characteristic and was given the task to determine which electron can participate in the transfer of electric current. It was also required to determine, with a decrease in which electro-physics parameter (i.e., the “enemy”), the solar cell could generate longer electrical energy and have good efficiency values. As can be seen in Figure 3b, the electrical power generated by the solar cell reaches its maximum value at some optimal values of voltage and current. The object under study, a solar cell, is similar in principle to a diode and is used to convert sunlight into electrical energy [11]. In this case, unlike the diode, the impetus for the movement of the electron is light quanta (for the electrons of the diode, energy is imparted by an electric current). Then, after a response time, the most interested student was called to the board to answer. His answers and considerations were heard. Oral discussions were not held for the purpose of learning the knowledge of other students and summarizing them. Then a written substantiation of the students' other opinions was entrusted.



a)



b)

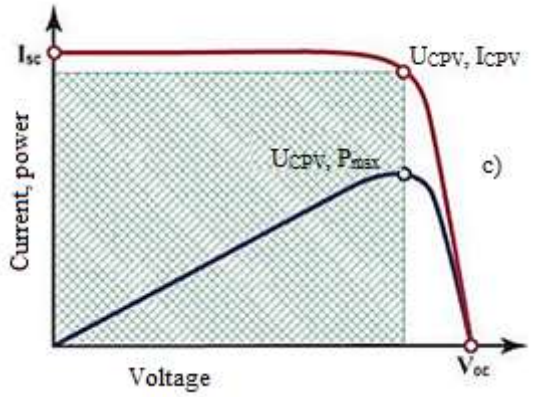


Fig.3. General view (a), band diagram (b) and volt-ampere characteristic (c) of the solar cell.

Despite the similarities in the principles of operation of the diode and the solar cell, the characteristic curves differ greatly in shape. This version of the task is also beneficial in that it involuntarily makes the student think. If the student explains incorrectly, the teacher explains why and for what reasons such a difference takes place in the characteristic.

Experimental results and discussion

The analysis of written discussions showed a noticeable increase in students' interest in commenting on physics phenomena in the volume of semiconductors and devices. The main thing is that the audience of lecture listeners were attracted 100%. The eyes burned with the desire to complete the answer and resist the wrong explanations and reasoning of other listeners. Disputes arose. In the end, they came to the same conclusion.

Figure 4 shows a diagram of the results of the implementation of the developed methodology in the experimental group. To compare the advantages of the methodology, the results of the final test in the group of ordinary teaching are also given there. Here, depending on the explanation of the physics processes and the successful implementation of the teaching method, marks were given according to a five-point system.

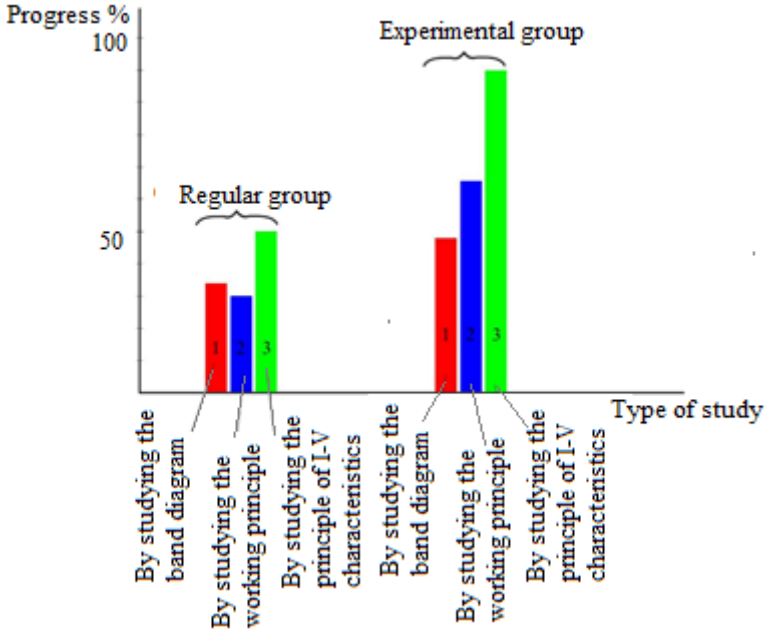


Fig.4. The result of the implementation of the methodology in the experimental group

As can be seen from the figure, the most successful mastering of the topic covered was observed in the group in which the recommended method was introduced. Here the full participation of the students of the audience is important. Moreover, all opinions correspond to the topic under consideration. Additional suggestions were made by the students and they were sure to remember everything said for a long time. The question of finding out the reason for long memorization was answered by the imaginations of "enemy and friend" in the volume of a semiconductor. It should be noted that discussions continued even during the break.

Conclusion

Based on the results of the conducted research, the following conclusions can be drawn. Indeed, the development of methods and new pedagogical technologies of teaching, to attract students and other students of the school audience of technical educational institutions, is very important for raising learning achievement [12,13]. Regardless of age, most students are interested in examples of everyday observation. Only the interest of the listener helps him master the subject and gives a good result in terms of presentations. The recommended technique is very easy and successful to apply to understand mathematical expressions of medium complexity. In addition, they can be used to understand graphical dependencies. Because graphs are very important when doing research. Only a correct analysis of graphical dependencies opens up wide possibilities for choosing a research direction with minimal errors. Considering that the basis of theoretical research is mathematical formulas, instilling the skills of "talking with a formula" in a student is an urgent task.

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