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# *Methods of Solving Problems In Semiconductor Physics*

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**Abstract – There is discussed in the article the issues of organization and carrying out tasks solving methodic and lessons arrangement in physics of semiconductors.**

**Keywords – Physics; Tasks In Physics Of Semiconductors; Methods; Solution Of Task.**

## I. INTRODUCTION

The modern electronic and electrotechnic devices are based on semiconductor and dielectric materials and these materials are used more and more widely in the elaboration of new electronic devices. This is the reason why it is necessary to study the physical, technical and technological properties of these materials. The physics of semiconductors and dielectrics are studying step by step on all educational levels. However, insufficient attention is devoted to the problem solving in the physics and techniques of semiconductors and dielectrics [1]. Although there are many textbooks and educational materials on general physics, there are no problem books in the semiconductor physics (PhSC). It is impossible to learn sufficiently well and deep the physical processes and laws taking place in these materials without problem solving. One of methodologists, V. Voroshilov, said, "To learn physics without problem solving is the same as to teaching swimming no plunging in water" [2].

On the other hand, problem-solving skill is one of the main criteria of understanding of physics.

In connection with this, we have developed a methodological textbook devoted to the problem solution in PhSC.

In this textbook all the formulae the laws of nature and the natural Phenom end knowing of which is needed for the solution of the collected problems are presented including problems with solutions and exercises [3].

In the textbook the problems are divided not only on their subjects but also on the methods of solutions. The type I problems-these are oral or test problems which may be solved by logical discussing of laws of physics [4].

For example: Why the resistivity of semiconductors decreases with increasing of their temperature?

It is explained by the increasing of the concentration of free electrons and holes when the temperature of the semiconductor is increase. The type II problems-this are the problems for solution of which some calculation is needed. These problems are called as arithmetical problems. In these problems, the physical laws are not discussed, but it is sufficient to substitute concrete numerical values of the physical quantities into a given formula.

## II. ARITHMETIC METHOD

When solving a problem by the arithmetic method, only arithmetic operations are performed on physical quantities. A special feature of the arithmetic method is that it does not use an algebraic equation.

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For example: If the concentration of acceptors is $N_a$=2.3·10$^{13}$ sm$^{-3}$, the concentration of donors is $N_d$=2.2·10$^{15}$ sm$^{-3}$, then find the conductivity at 300 ° K.

As is known, the specific conductivity of semiconductors with donor and acceptor impurities is determined by the formula

$$\sigma = e\mu_n N_d + e\mu_p N_a$$

where, $e$ = 1.6·10$^{-19}$ C is the electron charge; $\mu_n$, $\mu_p$ are the mobility of electrons and holes, at a temperature of 300 K they are equal $\mu_n$ = 0.14 m$^2$/V·s, $\mu_p$ = 0.05 m$^2$/V·s; $N_a$, $N_d$ are concentration of electrons and holes. As you can see, the values of all quantities are known. Substituting these values into the formula, we obtain the σ = 8·10$^{-5}$ sim/sm value for the conductivity. In the arithmetic method, when solving problems, only computational methods are used.

## III. ALGEBRAIC METHOD

When solving problems by the algebraic method, based on algebraic knowledge, formulas are used; algebraic equations are created and solved.

For example: At what temperature is the intrinsic concentration of charge carriers in silicon equal to the intrinsic concentration of charge carriers in germanium at a temperature of 300 K?

As you know, the intrinsic concentration of charge carriers in semiconductors is determined by the expression:

$$n_i = N_0 \exp(E_F/kT_2)$$

Let's write this expression for silicon and for germanium and compare:

$$N_{01} = \exp\left(\frac{E_{F1}}{kT_1}\right) = N_{02} = \exp\left(\frac{E_p}{kT_2}\right)$$

We take the logarithm of this equation and, solving, we find the desired temperature:

$$T_2 = E_{F2}/(\frac{E_{F1}}{T_1} + klnN_{01}/N_{02}$$

Substituting the values of the quantities, we get $T_2$ = 1430 K.

When solving this problem, the logarithm and the solution of an equation with one unknown are used.

## IV. GEOMETRIC METHOD

When solving the problem by the geometric method, geometric relationships are used.

For example: At what temperature the concentration of charge carriers in silicon is equal to the concentration of the charge carriers in germanium at T=300°K?

For solving of this problem we should to make up a system of two equations by taking into account the temperature dependence of concentration

$$n = n_0 \exp(E_{F\gamma}/kT).$$

And then solving of this system we determine $T_2$ for the silicon. The type IV problems-for solving of these problems it is required a geometrical consideration and scaling relations.

For example: The solution of problems taking into accounts the geometrical dimensions and configurations of' a sample or the determination of semiconductor parameters from a diagram of dependence of physical parameters.

The type V problem s-these are experimental tasks, they require providing of experiments on some devices (or the so-called Gedanken experiment), or virtual computer experiment.

For example: Determine the rate of forward and backward currents for a semiconductor diode in some range of voltage.

For solving of such task it is necessary at First to invent some convenient electric circuit, then to make an experiment and on the basis of the experimental data to draw a diagram of dependence I=f(U). From this diagram may be defined values of currents for corresponding values of voltages. The next type of problems requires creative thinking ability. These problems demand that students to be good scientifically trained, in particular, in the PhSc. These problems generally have difficult character and when solving a problem, the student should find some "highlighting point" based on the suitable physical law. The pedagogical experience shows that differentiation of the physical problems in dependence on their solution methods, including the differentiation on the levels difficulties, allows to intensification training of students and their problem solving ability. Henceforth, allows raising their knowledge and thinking level. Due to these reasons, we have elaborated a teaching textbook "A collection of problems and questions in semiconductor physics". In contrast with other textbooks [3, 4] in our textbook, the problems are divided in to four categories:

1-category: oral or test problems, they must be solved orally based on logical discussion of physical laws. These problems are intended for students of academic lyceums.

2-category: the level of complexity of these problems corresponds to middle level students of academic lyceums and for their solutions it is necessary two or three formulas and relations.

3-category: is intended for university bachelors. To solving these problems, it is necessary knowing of general laws, phenomena and processes taking place in semiconductor materials and devices.

4-category: these are complicated problems with solutions. These are intended for both skilled bachelors and master-students. Bonch Bruevich et al. "A collection of problems in semiconductor physics" gather the problems included at this level in accordance with the textbook. In contrast to this book our textbook contains more detailed solutions to problems and it is in Uzbek language.

Such a textbook allows to get skills on problem solving in SCPh step by step, because our textbook is divided in to different categories of complexity-from school-level to university level. This allows to remove psychological barriers for students who begin to solve the problems independently.

The textbook contains 100-test questions on the semiconductor physics and 100-test questions on the dielectric physics. This allows controlling progress of students at different stages of the education. The textbook contains questions on theoretical course of the semiconductor physics, which allows not only to control student's progress, but also allows self-control by student's himself.

Thus, an universal textbook is prepared - "A collection of problems and questions on PhSC"-which consists of problems divided in to 4 levels of complexity, control questions on theoretical material and test tasks on physics of semiconductors and dielectrics. This allows improving the teaching process, to learn more deeply the physics of semiconductors and dielectrics.

The correct scientific and methodological organization and conducting classes on solving problems can strengthen and deepen the knowledge of students, foster their creative thinking, love of discipline and form the ability for scientific research.

## REFERENCES

[1] V.I. Fistul. Vvedenie v fiziku poluphovodnikov. - M.: "Visshaya shkola", 1984. 352 p

[2] V. V. Gorbachev, L. G. Cpitsina. Fizika poluphovodnikov i metallov. - M.: "Metallurgiya", 1976. 368 p.

[3] V.A. Bonch - Bruevich, 1. P. Zvyagin, I. V. Karpenko, A. G. Mironov. Sbomik zadach po fizike poluphovodnikov. - M.: "Nauka", 1968. 112 p.

[4] V.A. Terexov. Zadachnik po elektrovakuum nini poluphovodnikovim priboram. - L.: "Enyrgiya", 1971. 128 p.