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Research Article

THE ROLE OF BROAD IMPLEMENTATION OF MODELING ON THE SUBJECT OF SEMICONDUCTOR IN THE HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

The paper shows the advantages of implementing modeling in research and training of students of higher engineering institutions. Theoretical prerequisites and experimental studies of the combined converter of light energy of the selective photothermogenerator are given. The results of studies using a solar concentrator with an ideal smooth surface are analyzed.

KEYWORDS

Training, technique, appliances, design, creation, research, modeling, programming, conversion, physics, semiconductor, solar converter.

INTRODUCTION

As you know, during the period of study in higher educational institutions, the future specialist goes through the last stage of indirect knowledge acquisition. It is called indirect due to the presence of a teacher who helps the student at every step in

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mastering a particular topic of study. However, after that, the teaching also continues, but this happens due to scrupulous research, independent reasoning and inventive activity of a person. From here begins the life assessment for the acquired knowledge on the scale of higher educational institutions. Based on this, we can conclude that in any case, the knowledge that is obtained in the student years must be thorough, deep and must necessarily be creative. It is necessary to accustom the student to such properties from the initial courses of the university [1÷4]. Of course, this approach to teaching has existed for a long time, but it needs to be developed and modernized. This is the condition of time. Because the steady growth of technology and technology, the level of social life of mankind requires even more advanced technical means not only for human needs, but also for the development of surface, underwater and outer spaces. One of the directions in this area, that is, in the field of instilling the skills of a researcher, innovator and applicant, is the early training of a student for research work carried out on the scale of the institute, and most importantly, the ability to use computer technology, programming and, of course, modeling [5, 6]. In this regard, the issue of modeling is considered when performing certain engineering tasks, scientific, design work.

Formulation of the problem

Many years of research work has confirmed the importance of theoretical research initially, rather than being ahead of experiments. The reason for this is the need to obtain at least approximate data on the expected result. In the past, such predictive data, to some extent, contributed to saving material costs for the creation of the proposed device, unit or device. This can be easily understood: without having at hand data on the encouraging results of the alleged invention or innovation, wasting money is not at all prudent [7,8].

Modern science is based on scientific and theoretical results. Moreover, sometimes they are obtained after solving complex mathematical calculations, using difficult formulas [9,10]. Mistakes made in the calculations lead to certain losses of one kind or another. Large errors in the results of discrepancies between theoretical, calculated and experimental data lead to the appearance of additional problems, which is an undesirable moment for the researcher.

The appearance of electronic computers to some extent facilitated the work of a researcher. The transition to programming is the success of the twentieth century. Despite this, the conditions for the implementation of research work are becoming more and more stringent. In addition, there is a need to perform some small computational work, also at an accelerated pace and with high accuracy [11÷13]. All these needs dictate the need to accustom students of higher educational institutions to modeling processes [14÷17]. Ignoring other branches of science, if we do a little analysis of the growth dynamics of industrial devices, we will see that semiconductor devices have become predominant in this direction. Semiconductor devices over the past few decades have covered almost the entire field of technology. Microelectronics, nanoelectronics are developing, based on the importance of solving the compactness of devices and multifunctionality, and their accuracy [5÷8]. Such requirements are met by devices and devices made from a source material with semiconductor properties. Therefore, not only the study of the physics of semiconductors, but also the ability to develop devices based on them, design, create, operate, carry out repair and restoration work have become important basic requirements for a modern specialist [18÷29].

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Simulation of semiconductor devices during their development and creation

There are many types of semiconductor devices in practice. Starting from ordinary semiconductor material to modern solar converters, it is a product of semiconductor engineering and technology. Hundreds of instruments covers various designs of diodes, zener diodes, transistors, thyristors and so on. The higher engineering school should not now bypass the physics of semiconductors. This is explained by the following [7,8]. First, all branches of the technical industry are rapidly transitioning to the supply of modern semiconductor integrated circuits. They are comfortable, compact and highly functional. In addition, they are highly accurate and have no mechanical moving parts, which eliminates the possibility of device breakdowns. Secondly, the nature of the dependences of electrophysical parameters on many influencing agents is complex, in connection with which one should always have appropriate data on this. Because the fate of the created device largely depends on the variability of these properties. Thirdly, during the period of operation, an important parameter of instruments and devices is the accuracy of instruments. This indicator is a guarantee of product quality. Instrument accuracy depends on accurate and error-free design of new semiconductor devices and installations.

All of the above reasoning reasons dictate the inevitability of obtaining knowledge in semiconductor physics in higher technical educational institutions. One-sided knowledge of this subject is not enough to work successfully both in production and in research institutions. Here, a specialist must freely design, make complex mathematical calculations, be able to competently communicate with computer technology, model, and write programs in modern languages to perform settlement work.

Among these skills, the most significant is modeling when working with semiconductor devices. There is a gap associated with the gap between the specialties of physics and the programmer [23÷25]. Until today, a few specialists can freely engage in programming or modeling while being a physicist. And vice versa, a programmer or IT technologist does not always know and understand the physical processes occurring in the volume of a semiconductor device. The condition of modernity is the combination of modeling skills and understanding of physical processes into one single specialist [9,10]. To solve this problem, in this paper, an attempt was made to combine modeling and the study of the physical laws of physics by analyzing the methods and methods of modeling.

As is known, modeling of physical processes makes it possible to predict the course of changes in the operational parameters of semiconductor devices. This is done in a theoretical way. Moreover, when modeling, the initial conditional initial data are set. This guarantees the operating conditions of the device.

Implementation of modeling to create a selective photothermal generator

Under the guidance of one of the authors of this article, computational-theoretical and software work was carried out to study the electrical properties of the solar and thermal energy converter of a photothermal generator operating under selective radiation conditions [26]. The study of the many parameters of this current source is complex. However, the modeling process has facilitated the solution of this problem. The possibilities of increasing the efficiency of solar energy conversion were investigated. For this purpose, an analysis was made of methods and means of directing light radiation in the maximum amount on the surface of solar cells of thermoelectric converters, the distribution of the light flux on color stripes and its various areas. The developed photothermoelectric generator (FTEG) provides for the complete direction of light radiation in its distributed position to different spectra. When creating a simulation model and analyzing the optical and technical characteristics of the device, the capabilities of the Comsol Multiphysics 5.5 software were used. For the implementation of computational and theoretical studies, the following mathematical formula recommended by Zarubin was used:

$$\begin{cases} x = R_2 \cos(\theta - \beta) - \dfrac{R_2}{2} \cos\beta \cos(2\beta - \theta) \\ y = R_2 \sin(\theta - \beta) - \dfrac{R_2}{2} \cos\beta \sin(2\beta - \theta) \end{cases}$$

This formula was used based on considerations of the possibility of ensuring the maximum consistency of the positions of the focal surface with the area of the photoelectric converter. In this created model, the angle of curvature of the focusing mirror was equal to R=100 and the average working area of the radiation wavelength was 650 nm (300-900 nm), as well as the length of the photocell was 40 mm (see Fig. 1).

The created environment included the use of a solar concentrator with an average focal length f = 70 cm. A simulation model of a parabolic solar concentrator was also created by version 5.5 of the Comsol Multiphysics software. The optical-energy parameters were studied. Using the developed model, which is shown in Figure 2, experimental measurements were carried out over two different concentrators. During each measurement and study of radiation. which come out of arbitrary points in the amount of 105 were directed to the surface of the concentrator.

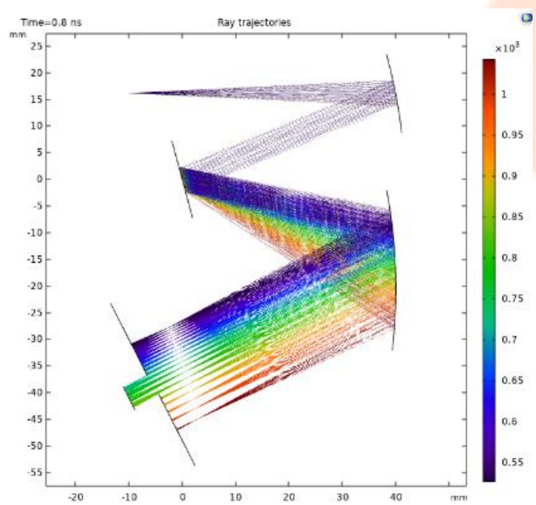

Fig.1. Schematic diagram of the distribution of photoactive radiation, designed according to the Czerny-Turner scheme (beam splitter).

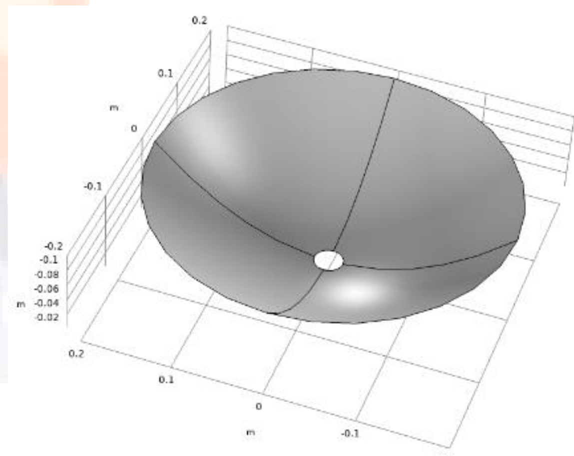

Fig.2 Parabolic concentrator model designed in Comsol Multiphysics v 5.5 simulation environment.

The first experiment did not take into account the dark effect around the solar ring. The surface of the concentrator was also assumed to be ideally smooth. It was conditionally accepted as a counter-reflector. In the second experiment,

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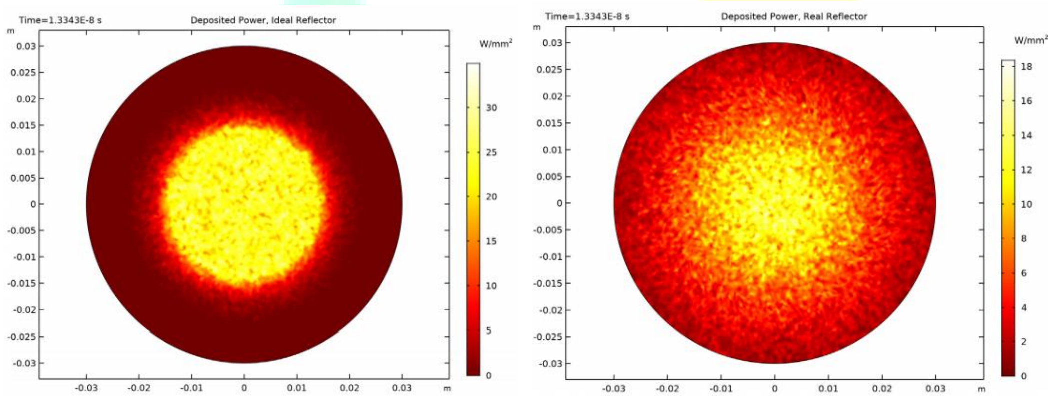
a model was used that takes into account the boundary dark effect. For the case of a perfectly smooth surface of the concentrator, in order to calculate the ratio of the concentration of light radiation, the formula recommended by S.M.Jeter was used:

$$C(r) = \frac{1}{I_0}\int_{\Omega}^{f} \frac{\cos(\theta)\cos(\theta_c)}{|r - r_c|^2} dA_c \qquad (2)$$

$$f(\delta) = \begin{cases} \frac{I_0}{\pi \sin(\psi_m)^2}, & \delta \le \psi_m \\ 0, & \delta > \psi_m \end{cases} \qquad (3)$$

For clarity, Figure 3 shows the distribution of thermal energy on the surface of a parabolic concentrator with an ideal surface and a counter-reflective coefficient, taking into account the dark effect at the boundaries of the solar ring (a) and without taking into account this phenomenon.



a) b)

Fig.3. Distribution of thermal energy on the surface of a parabolic concentrator with an ideal surface and a counter-reflective coefficient, taking into account the dark effect at the boundaries of the solar ring (a) and without taking into account this phenomenon.

As can be seen from the figure, the energy entering the center of the focal plane has very high values. In our experiments, it was achieved up to 23 W/mm² (a) and 14 W/mm² (b). Due to the presence of errors in the design, at some points on the border of the center, this indicator reached values of 30 W/mm².

As an alternative solution to the method for determining the dependence of the electrophysical parameters selected for a system of semiconductor photoelectric converters on external factors, the possibilities of modern information technologies were used. For the same purpose and for the processing of large-volume initial data, an algorithmic model (Fig. 4a) and software (Fig. 4b) were created, designed to calculate the electrophysical parameters of the converters.

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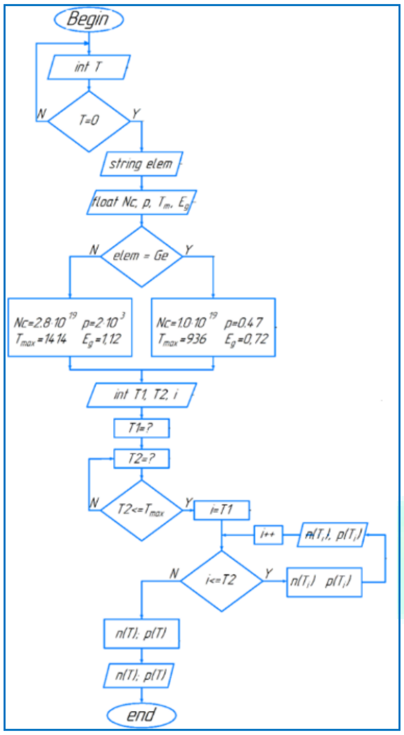

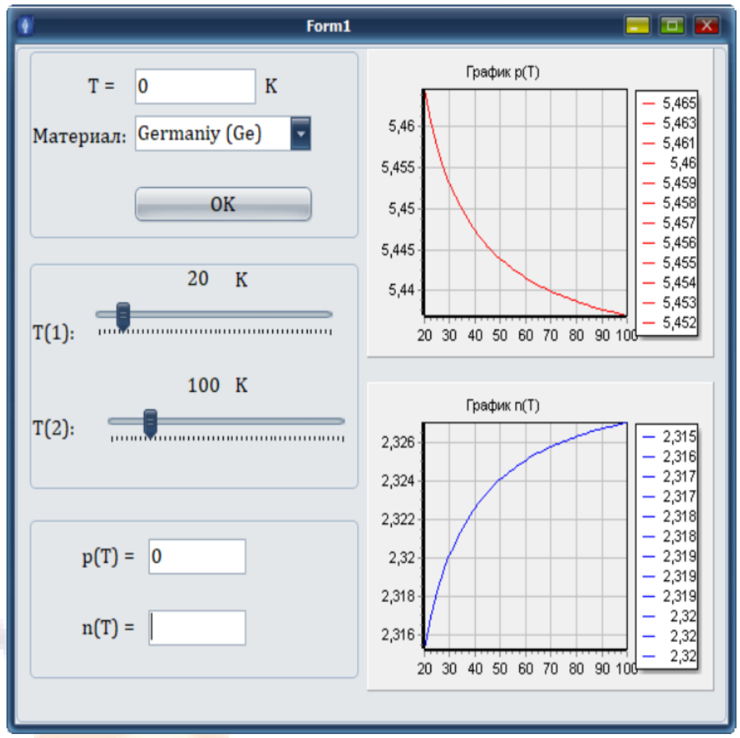

а) б)

Fig.4. Algorithmic model for calculating the electrophysical parameters of a semiconductor converter (a) and its software.

CONCLUSION

Thus, the use of computer technology, modeling and programming allows you to deeply and with high accuracy of the physical processes occurring not only in the volume of semiconductor devices, but also quite well predicts the phenomena and the final effects of external factors on its operating modes. In addition, the product of the design of installations and devices on the basis of such mathematical and software calculations makes it possible to obtain results that do not differ much from the experimental values. The duration of the calculation with this method lasts only 1-2 minutes, and makes it possible to carry out computational studies for analog devices. The productivity of scientific research is increasing, which confirms the importance of modeling in the field of semiconductor physics.

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