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# PROVIDING SCIENTIFIC AND PRACTICAL OPTICAL EDUCATION THROUGH THE PROGRAM SYSTEM "PV LIGHTHOUSE"

**R. Aliev*; Kh. N. Kodirova****

*DSc., professor,
Andijan State University, UZBEKISTAN
Email id: alievuz@yahoo.com

**Freelance Researcher,
Andijan State University, UZBEKISTAN
Email id: hamida1983@yavdex.com,

## ABSTRACT

*The article in higher education institutions contains a list of scientific and practical tasks for students to conduct independent research using the "PV lighthouse " program and the "PVlighthouse " program as a method of actively involving students in scientific research while ensuring the scientific and practical significance of the content of "Optics" (influence of plate thickness, effect material, surface effect, light return, absorption, transition control capabilities). In addition, a set of independent research topics for students, guides and guidelines to help develop skills in the PV lighthouse software system, an interactive presentation-based software product that builds the ability to use the PV lighthouse software system.*

**KEYWORDS:** *PV Lighthouse Software Package, Optical Layer, Radiation Parameters, Plate Thickness Effect, Material Effect, Surface Effect, Light Return And Absorption.*

## INTRODUCTION

Training of high-potential specialists who can meet the requirements of the times, taking into account the prospects of the Republic of Uzbekistan, qualified, competitive, highly educated, contributing to the development of science, culture, economy, social spheres of the country, independent thinking, high spirituality purpose. Science, culture, technology, modern achievements of the economy, the systematic improvement of training methods, taking into account the social prospects of the country's economy and culture, is one of the most pressing issues today [1].

Great attention should be paid to the scientific nature of science in the teaching of "General Physics" courses in higher educational institutions (HEIs) of Uzbekistan. One of the traditional ways to do this is to cite theoretical science-based concepts with experimental confirmations. But it is advisable to direct students directly to scientific research in order to educate them among those who want to connect their future with scientific research. If it is much easier to solve the problem in universities with appropriate scientific laboratories, how can universities without such material and technical base behave? In response to this question and in the process of teaching the "Optics" section, the main goal of this work is to develop and implement a realistic method of solving the problem.

The authors chose the software system "PV lighthouse" as a method of active involvement of students in scientific research, while ensuring the scientific and practical significance of the content of the section "Optics".

First of all, let's talk about the general information about the software system "PV lighthouse". The PV Lighthouse web application was launched in June 2011 and is currently being expanded by Keith MacIntosh, Malcolm Abbott, Ben Sudbury and several other photoelectronics professionals. The number of current users of the system is growing rapidly, and the number of calls to it exceeds 10,000 per month.The system works on an online basis and a lot of research can be done with the help of the program. In particular, it is possible to theoretically analyze the materials selected in the creation of solar elements by entering the parameters. To do this, select the "CALCULATORS" menu from the main window of this system. The resulting section is entered from the menu into the "WAFERS" section. This section contains the Wafer Dimensions and Wafer ray tracer commands, from which you can select Wafer ray tracer [2]. Using this section, the optical factors of the solar elements or the base material selected for them - absorption, return and transition parameters - are studied. The important thing is that several types of silicon and its different thicknesses can be selected as the base material [3].

The following initial parameters are also selected for the study: Illumination - radiation parameters: at the zenith - the vertical angle of the sun, the spectrum - the type (spectrum) of the light source, such as sunlight, absolute black matter, halogen or xenon lamp . Surface morphology: the frontal layer is selected - planar, optical layer or texture, and for the back layer - planar, optical layer or texture. Layer materials: where the type of optical layer material and its thickness are selected. It is possible to select single and multilayer optical layers and form them in different sequences [4].

As an example, let us analyze the dependence of the wavelength of light on the return, absorption and transmission of sunlight incident on the surface of a silicon crystal [5]. To do this, let us choose different thicknesses of the silicon wafer: d = 200 μm in case 1, d = 100 μm in case 2 and d = 10 μm in case 3. Let us examine the initial calculations in which no optical layers are coated on the silicon surface and no textures are formed.

The amount of photogeneration or absorption current that can be generated in it is the amount of dependence of the light wavelength of IA, holding the silicon wafer under study under normal daylight, as usual, falling vertically from above (frontal surface). The calculation results can be obtained in tabular or graphical form. Based on similar calculations, it is possible to determine the return (IR) and transit (IT) of light from the silicon surface.

It can be seen in Figure -1 that the calculation results for the silicon wafer are graphically expressed as the dependence of the total return R (l), absorption A (l) and conduction T (l) on the light wavelength (l).

Graphical or tabular data are obtained for different thicknesses of silicon wafer as shown in Figure 1. Using them, it is possible to obtain secondary link graphs or tables that are convenient for physical analysis. Figure 2 shows a graph of the correlation of the light absorption index of a silicon wafer of different thickness (1 – d = 200 μm; 2 – d = 100 μm; 1 – d = 10 μm). Figure 3 also shows a graph of the correlation of the light transmittance of a silicon wafer of different thickness to the wavelength of light (1 – d = 200 μm; 2 – d = 100 μm; 1 – d = 10 μm) [6].

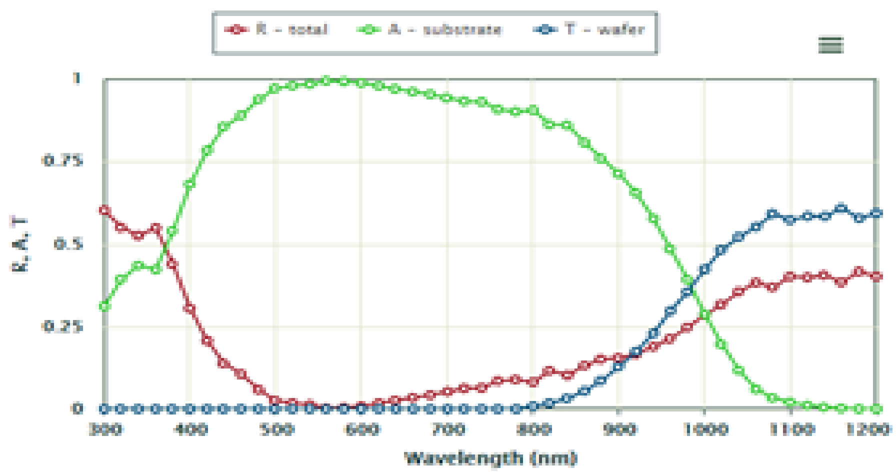


Figure-1. Spectral graph of light wavelength dependence of light reflection, absorption and conduction index for a crystalline silicon wafer with thickness d = 200 μm.

Analyzing such results, we can explain that the curves 1, 2 and 3 in Fig. 2 and Fig. 3 differ radically with increasing light wavelength due to the fact that the absorption indices of photons of different wavelengths in silicon have different values. . The passage of the rest of the absorbed light through the silicon wafer is explained by the curves in Figure 3.

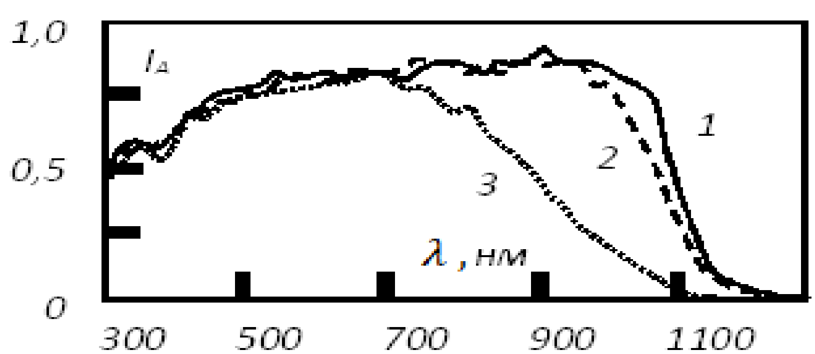


Figure-2. Graph of correlation of light absorption index of light absorption index of silicon wafers of different thicknesses: 1 – d = 200 μm; 2 – d = 100 μm; 1 – d = 10 μm.

Thus, using this method, students learn to measure the optical factors of solar elements or the basic material selected for them - absorption, return and transition parameters, to determine the return (IR) and transit (IT) of light from the silicon surface, to work with tables and graphs. From the scientific point of view, the analysis of statistical data from a physical point of view, the fact that curves differ radically with increasing wavelength of light, the absorption of photons of different wavelengths in silicon have different values learns to do scientific observation.

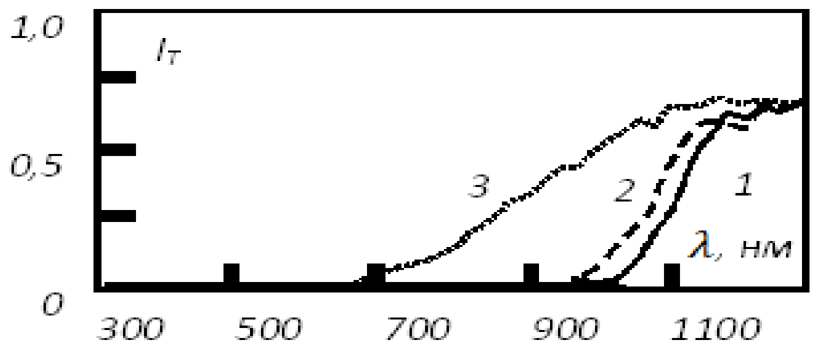


Figure-3. Graph of correlation of light transmittance of a silicon wafer of different thickness to the wavelength of light: 1 – d = 200 μm; 2 – d = 100 μm;1 – d = 10 μm.

A list of scientific and practical tasks (effect of plate thickness, material effect, surface effect, ability to control the return, absorption, passage of light) was developed for students to conduct independent research using the software system "PV lighthouse".

Using the learned software system, students and teachers can analyze the results obtained by performing research i.e. covering the surface with optical layers or forming regular textures to reflect light, absorb, change transmission parameters and determine optimal conditions.

Thus, the experimental research conducted in 2017-2020 on the application of the proposed new method of teaching "Optics" to undergraduate students in the field of "Physics" allowed to form the following important conclusions:

- Students have the skills to conduct independent research;
- A set of independent research topics was developed for students;
- Developed guidelines and recommendations to help students develop skills in working with the software system "PV lighthouse";
- Developed a computer product based on an interactive presentation that provides access to the software system "PV lighthouse" for students and researchers;
- Radical improvement of students' mastery of the department "Optics" with in-depth scientific and practical aspects.

Another important aspect of the proposed methodological development is that it is used in the teaching of "Molecular Physics and Thermodynamics", "Electromagnetism", "Atomic and Nuclear Physics" sections of "General Physics", as well as "Semiconductor Physics", "Theoretical Physics", " It can also be actively used in the teaching of other disciplines, such as "condensed matter physics".

Thus, with the help of the software system "PV lighthouse" students and teachers can conduct independent experiments, analyze the results and graphs on the basis of physical laws, concepts, conduct independent research. This will contribute to the development of young people in Uzbekistan to contribute to the development of the country, independent thinking, creative approach, effective use of Internet materials, skills and competencies in research.

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