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PREPARATION OF PHOTO ELEMENTS

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Abstract. The article provides information on the creation of high-efficiency photocells using the spectral composition of radiation from the sun. The results of studies on the formation of flat multilayer multi-energy, longitudinal and transverse photovoltaic cells from chalcogenide thin films are presented. The universal properties of such photocells have been identified and a system has been developed that can work with both conductive and dielectric consumers.

Keywords: Chalcogenide and chalcogenide compounds, thin-film photocell, electron hole pair, ionization, recombination, photon receiver, photon emitter (photon source), generation, valence and conduction zones, forbidden (forbidden) zone.

Introduction. One of the most promising and effective ways out of the global energy crisis is to organize the widespread use of solar energy. The sun is a versatile energy source for huge ecological clean use. The fact that the development of solar energy for the long and near future for humanity will serve for the development of many areas is becoming more deeply ingrained in people's minds. In this field, the conversion of solar energy directly into electricity using semiconductor photocells is a very promising and effective direction. There is enough scientific and technical research in the field of photocells, which serve as a technical basis for large-scale production of solar energy.

Literature review. Photocells work based on the photovoltaic effect. This effect was first observed by Edmond Beckerel in an electrolytic cell. The photoelectric effect on solids was first observed in 1876 in London by Adams and Asem in photocells made from selenium [1]. Then, in 1930, at the St. Petersburg Institute of Physics and Technology under the leadership of A.F. Ioffe, a sulfur-thallium photocell was developed. A major step in this direction was the 1958 p-n transition of silicon, a photocell used on the Earth's satellite ("Sputnik-3") as a solar cell. By the early 1960s, the first solar photocells were created from the p-n transition of gallium arsenide. They were used as a power source in Soviet spacecraft “Lunahod-1” and “Lunahod-2” (1970 and 1972). By the mid-1980s, the development of silicon and gallium arsenide-based solar photovoltaics was largely based on relatively simple technologies in simple structures. In order to reduce the number of photovoltaic cells used in solar photovoltaic with light and recombination, “high-efficiency technologies have been proposed. [2]. Although the efficiency of laboratory samples of silicon photocells based on them was close to theoretical calculations, the cost was much higher than that of photocells obtained with simple technology [1,2]. In order to compact the photocell and reduce the losses associated with light as well as recombination (and other losses) in this study, the aim was to cover a larger area of the solar radiation spectrum using a new heteroepithelial vacuum thin-film method. The goal was to narrow down its efficiency, cost, and their geometry by creating solar cells that would allow the use of more of the photon in the solar spectrum.

The sun is a huge source of energy for the Earth. From it, 1350 joules / m^2 of energy reaches the Earth's surface per second. On average, about 3000-5000 million cubic meters per square meter of the Earth's surface per year. Energy comes around Joule. One of the most important problems of our time is the efficient use of such a large amount of solar energy. Some of the short-wave energy of radiation from the Sun is absorbed in the Earth's atmosphere, while most of the energy reaching the Earth's surface corresponds to the long-wavelength field of radiation. There are many ways to use solar energy. An efficient, high-efficiency method of converting solar energy into other types of energy is to create a solar cell (solar power plant) device by making a photocell from semiconductors. One of the important problems is to take the photocells from the semiconductors and to know the spectral composition of the radiation from the sun when creating solar cells from them. Therefore, it is important to choose semiconductor materials knowing the optical properties and characteristics of a semiconductor and the electrical, optical and photoelectric properties that can effectively convert solar energy into electricity, which determines which area of the solar spectrum can be used to use photocells as a solar element in solar power plants. The main parameter in determining such properties and characteristics of a semiconductor is the width (E_g) of the forbidden zone of the semiconductor material.

When light strikes a semiconductor, the energy of the light photon must have an energy not less than the bandwidth of the band gap, i.e. $h\nu \geq Eg,$ so that a stream of photons with a lower energy cannot emit electrons from the valence band of the semiconductor material into the conduction band. According to the photoeffect theory, the selection of a semiconductor with a small enough forbidden zone from the photon energy (E_g) also does not give good results. Because the difference in E_g decreases, $h\nu - E_g$ the excess energy of the photon increases, resulting in an increase in the temperature of the semiconductor and a decrease in the efficiency of the photocell. If a semiconductor with a large E_g is selected, the activity of the radiation photons $\left(h\nu < E_g\right)$ decreases and some of the photons in the spectrum do not participate in the absorption, because the short circuit ($I_{q.t}$) of the photocell $h\nu \geq E_g$ is determined by the number of photons that satisfy the photocurrent condition. The visible part of the spectral field of electromagnetic radiation is in the range of 0.38 to 0.72 μm. The infrared part occupies a range of 0.72 to 1000 μm.

The formula for photon energy is to measure photon energy in electron volts (EV) and wavelength λ in microns. $E = \frac{1{,}234}{\lambda}$ is written in appearance. The graph of the expression is shown in Figure 1.

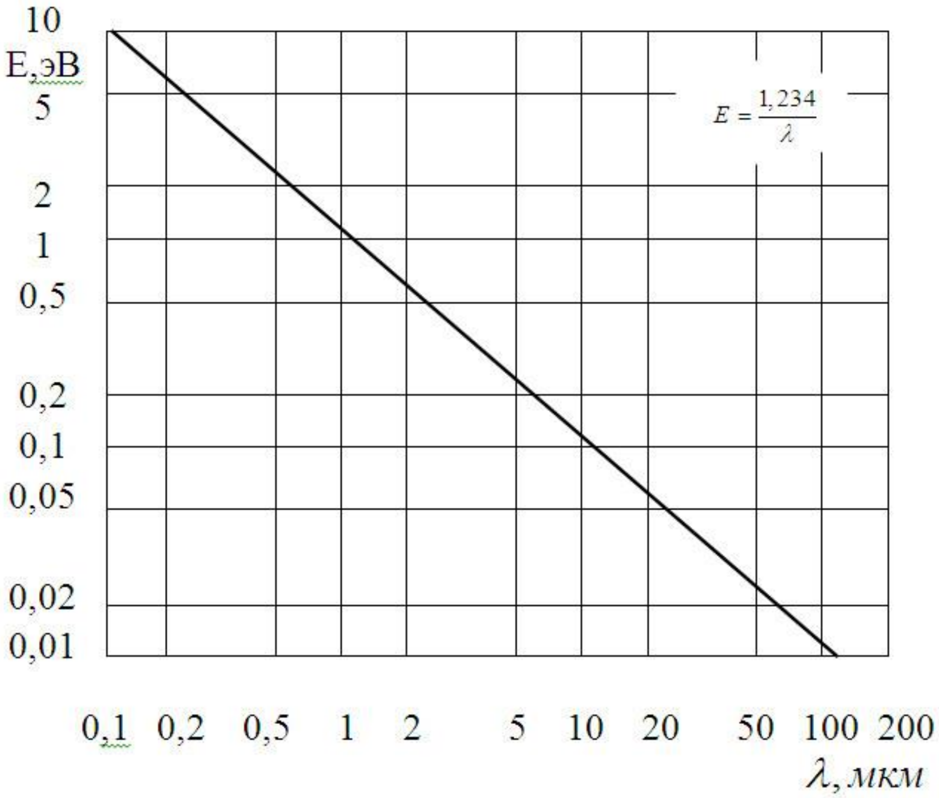

Figure 1: The relationship between photon energy and radiation wavelength.

It can be seen that in order for an electron-hole pair to be formed when light (sunlight) is absorbed, it is necessary to select a forbidden zonal semiconductor corresponding to the radiation energy. About 90% of the energy of solar radiation falls on the visible light field. For this reason, it is advisable to use a semiconductor material with a bandwidth of 1.0-2.2 eV when making a solar cell. The electron-hole pairs generated by sunlight in such semiconductors should not be recombined and destroyed without potential barrier. Their (current carriers) viability should be high, as well as the surface recombination rate (very) low. This is because the electron-hole pairs that form the light are formed in a thin layer of the semiconductor surface in the order of 1 μm. They enter the semiconductor from the surface. The energy losses of electrons and holes in this process must be minimal. The photocell works based on the effect of light on the semiconductor. When a semiconductor p-n-transition region is illuminated, electrons and holes are formed. Electronically, the holes separate at the potential barrier of the p-n junction. In the salt mode, they accumulate at the p-n-junction poles without being able to travel to the outer circuit and generate an electromotive force (E.Y.K), the resulting photo E.Y.K. $U = E_f = \frac{kT}{l} ln\left(1+\frac{I_f}{I_t}\right)$ is found from the expression. Thus, if the p-n-junction is connected to an external chain (consumer), a photocurrent (I_f) passes through the chain. Hence, a p-n-transition photocell can be used as a source that converts light directly into electrical energy. The photocell converts only part of the light that falls on it into electricity. This is because there is a loss of light energy due to the return of light from the semiconductor, passing through it, and its constituents that are absorbed but do not form an electron hole. There are also energy losses associated with the semiconductor. It should be taken into account that the energy of inert light of the electron-hole pair and the efficiency of the photocell are related to the width of the semiconductor band gap.

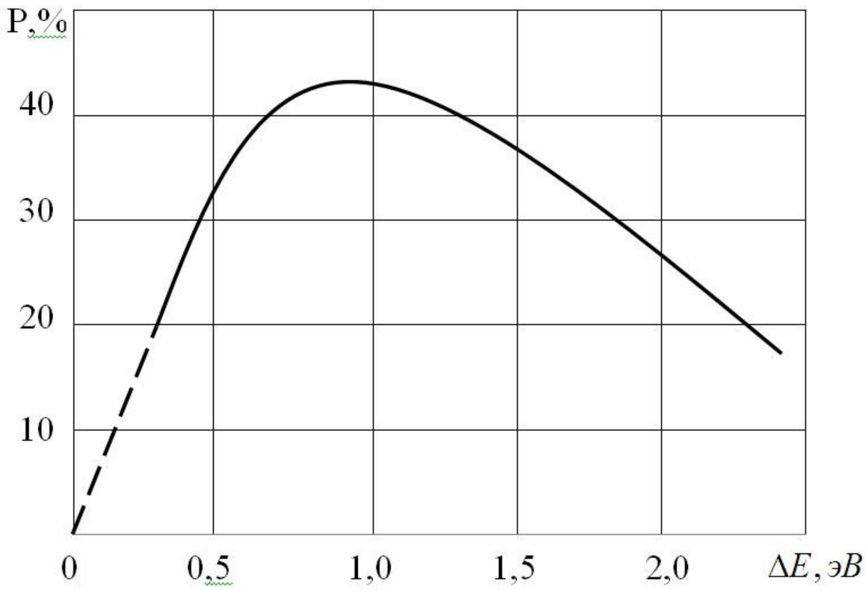

Figure 2: Dependence of solar radiation energy used to form electron-hole pairs on the bandwidth of a semiconductor

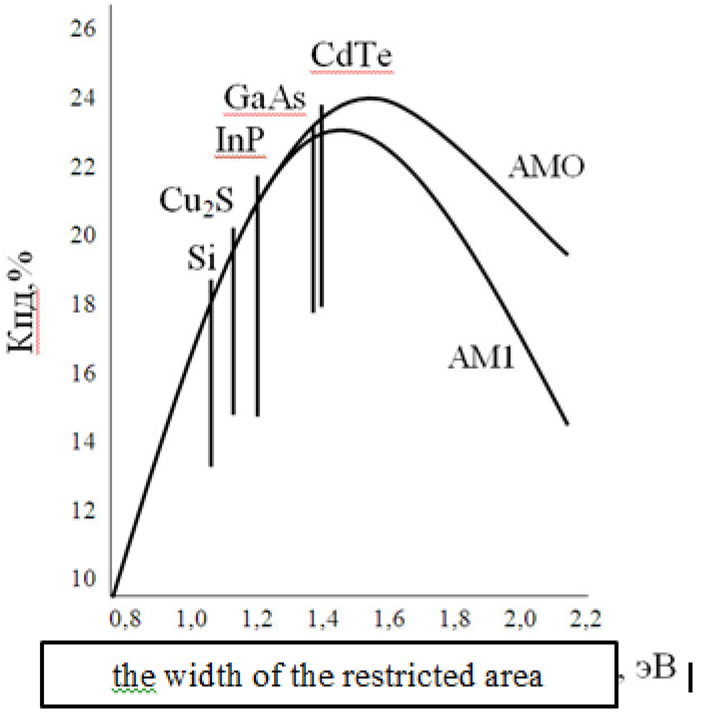

Figure 3: The relationship between the band gap and the solar cell

Based on the above interpretation, analysis, we present some physical fundamentals of creating high-efficiency compact, durable photocells. Due to the photosensitivity of almost all chalcogenides, high mobility and viability of charge carriers, it is possible to create high-efficiency compact photon receivers by making simple and complex photocells from them. Normal photocells consist of a single p-n junction, the voltage $\frac{kT}{q}$ of which is limited in order, and the current transmitted to the consumer is small. To increase its voltage, a large number of ordinary photocells are connected and a battery of photocells is formed. The complexity of the technical and technological implementation of this process and the consumption of semiconductor material are also sufficient. It is also possible to use an energy-saving, simple and minimal material waste method when creating a photocell battery. For example, a series of longitudinal chains of polycrystalline microparticles (crystalline) appear on the surface of anisatropically evaporated thin films of chalcogenides at high vacuum. As a result of anisatropic evaporation [3,4], these microparticles are arranged in such a way that each of them acts as a separate elemental photocell. As a result, chalcogenide thin films form a super system (CMC) of a large number of p-n junctions. When the super system of such micro-transitions [5] is illuminated, an anomalous high photovoltage is generated and becomes a source of a strong electric field. Such electric field sources work with dielectric consumers, for example, can be used in many electronic devices with MDP-transistors and devices in the quantum group [6]. The consumer of photocells is metal, which can use the monochromatic selectivity of the light spectrum under the influence of a semiconductor to provide it with high voltage and power transmission performance. To do this, it is necessary to create a transverse system of p-n-junctions.

Based on monochromatic selectivity, the penetration of monochromatic rays in the spectrum $\left(\frac{1}{\alpha}, \alpha - - \text{absorption coefficient}\right)$ into a semiconductor (including thin films) varies. That is, long-wavelength rays in the spectrum go deeper when they hit the surface of a semiconductor, and can also pass through if the wavelength is large enough. Therefore, the absorption of long-wavelength rays in areas close to the surface is weak ($d < \frac{1}{\alpha}, d$ - the depth of penetration of light from the surface where the semiconductor light falls). In the shortwave field, the absorption is high near the surface of the semiconductor. Due to the small energy of the photons in the long-wavelength range of the spectrum $\left(E_f = h \cdot \nu = \frac{hc}{\lambda}\right)$, the photoactivity in semiconductors large enough in the band gap leads to a decrease in the number of useful photons. However, there is an optimal value of the width of the zone, in which a relative increase in absorption is observed [7]. Based on the monochromatic selectivity under the influence of light with a semiconductor, it is possible to create a photocell consisting of a system of transverse multilayer heteroconductors (HCE) [8] consisting of different zonal semiconductor membranes. The following semiconductor chalcogenide series can be selected as an example for the practical implementation (construction) of a system of multilayer HCEs.

The location of ZnS, CdS, CdSe, CdTe or PbTe, PbSe, PbS, corresponding to the monochromatic selectivity and the bandwidth of the layer semiconductor, is shown in Figure 4.

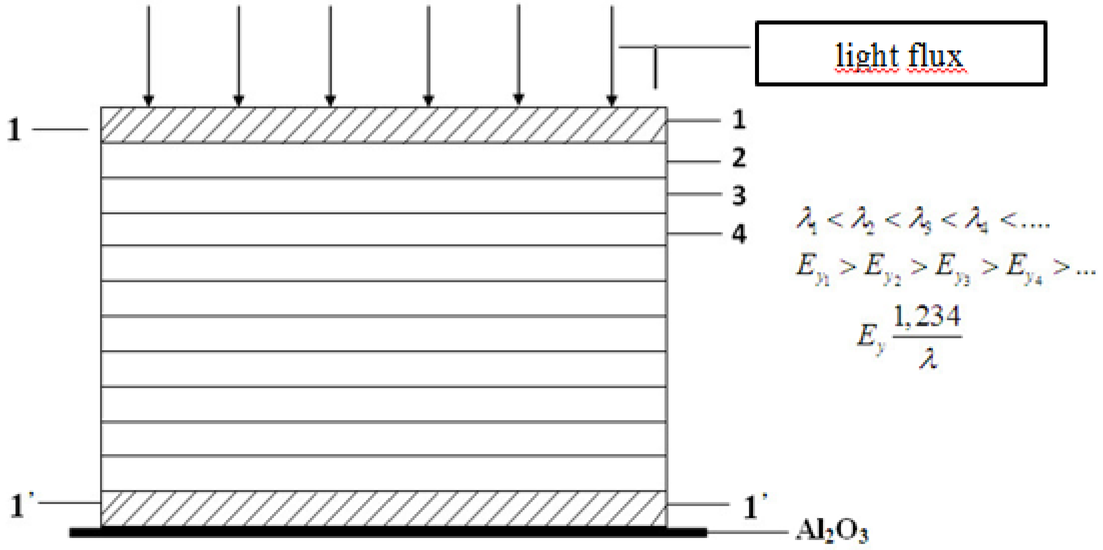

Figure 4. Multilayer HCE s battery

1-Transparent metal electrode (SnO_2) on the light-emitting surface of HCE

1- The second metal electrode is placed on the Al_2O_3 base

In the field of optical rays ($5\cdot10^{-4}$-10^{-9} м, $6\cdot10^{11}$-$3\cdot10^{17}$ Hz) the luminous flux falls on a wide (2) semiconductor layer through a transparent metal electrode (1). The spectrally corresponding short-wavelength rays (λ_1) are absorbed, and the remaining relatively longer wavelength rays (λ_2, λ_3, λ_4 ...) pass to the next layer (3). Thus monochromatic selection of light waves occurs [9]. As a result, more rays in the light flux spectrum ($\sim I_0$) are involved in the photoelectric process. So far, the theoretical method of determining the optimal number of layers in a multilayer photocell has not been scientifically substantiated, but the maximum value of voltage ($E_m = U$) and short-circuit current ($I_{sh.c}$) for the 3-4 layer photovoltaic model have been calculated, respectively $E_m = 2{,}25 \div 3V; I_{sh,c} = 40 - 45\frac{mA}{sm^2}$. For such a photocell, F.I.K. reaches 36.4%.

Conclusion. The physical basis for the creation of highly efficient compact, durable photocells based on chalcogenide semiconductor compounds has been created. These photocells are thin-film and can be created on the basis of a single vacuum technology. It has been experimentally and theoretically proven that they consist of a super numerous system of longitudinal elemental photocells. Such photocells are universal, operating in the longitudinal direction as a source of strong electric field to the dielectric consumer, while operating in the transverse direction in the spectral selective mode, allowing the use of more photons in the spectrum (from purple to infrared). These photocells can also work in the transverse direction to the metal consumer. They can be used in microelectronics, quantum electronics and optoelectronic automatic remote control systems.

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