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THE INVESTIGATION OF THE MAIN PROPERTIES OF PHOTO-PROCESSORS ON THE BASIS OF SILICON TO SELECT THE METHOD OF PRODUCTION AND MANUFACTURE OF HIGH-EFFICIENT HETEROTRANSFERRING SOLAR ELEMENTS

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ИССЛЕДОВАНИЕ ОСНОВНЫХ СВОЙСТВ ФОТОПРЕОБРАЗОВАТЕЛЕЙ НА ОСНОВЕ ИЗ КРЕМНИЯ С ЦЕЛЬЮ ВЫБОРА СПОСОБА ПОЛУЧЕНИЯ И ИЗГОТОВЛЕНИЯ ВЫСОКОЭФФЕКТИВНЫХ ГЕТЕРОПЕРЕХОДНЫХ СОЛНЕЧНЫХ ЭЛЕМЕНТОВ

Abstract. *The electrophysical properties of photoconverters from silicon are analyzed with the study and research of scientific literature in this work. The main problematic aspects of the initial materials are pointed out and the directions of finding the ways for creating highly efficient solar cells are determined.*
Key words: photoconverter, normal zone, forbidden zone, conduction zone, full power, heat energy, light, spectrum, temperature, donor, p-type impurity, electrical energy.

Аннотация. *В работе, изучением и исследованием научных литератур, проанализированы электрофизические свойства фотопреобразователей из кремния. Выявлены основные проблемные стороны исходных материалов и определены направления изыскания путей создания высокоэффективных солнечных элементов.*
Ключевые слова: фотопреобразователь, валентная зона, запрещенная зона, зона проводимости, полезная мощность, тепловая энергия, свет, спектр, температура, донор, акцептор, электрическая энергия.

Аннотация. *Мақолада илмий адабиётларда келтирилган маълумотлар асосида кремнийдан тайёрланган фотоўзгартиргичларнинг электрофизик хусусиятлари таҳлил қилинган. Асосий материалларнинг муаммоли томонлари аниқланиб, юқори самарадорликка эга бўлган қуёш элементларини яратиш йўллари аниқланган.*
Таянч сўзлар: фотоўзгартиргич, валент зона, таъқиқланган зона, ўтказувчан зона, фойдали қувват, иссиқлик энергияси, ёруғлик, спектр, ҳарорат, донор, акцептор, электр энергияси.

a) Statement of the problem

In connection with spreading methods for obtaining electrical energy in virtually all developed countries of the world, the interest in creating increasingly highly efficient solar cells (SE) has increased even more. Researchers in addition to finding new materials for photoelectric conversion (FEC), are searching for highly efficient solar cells with a modified structure and physicochemical compositions, and also improving their manufacturing techniques. Many published works, based on the results of domestic and foreign research, suggest that there are optimal solutions in this area. Therefore, our research works are aimed at studying existing elements with a high coefficient of efficiency and find ways to increase this energy parameter even more. However, in the way of this goal, there are many tasks that need to be addressed. Such tasks include: determination and comparison of highly effective solar cells, study of their manufacturing technology, composition of impurity substances, their concentration, analysis of the band transition, the role of impurity levels in obtaining an electric current, the mechanism of the generation-recombination process, etc.

As it is known that in recent years silicon solar cells have been popular. The reason for this is its wide distribution in the earth's crust. This first of all guarantees the economy of the resulting converters. In addition, in addition to ineffective homotransfer SE, several variants of highly effective heterophoto-converters (GFPE) were obtained [1-3]. Cpd such elements reaches up to

25%. The authors of these studies believe that an increase in the value of efficiency of the converter indicate the presence of a resounding concentration of the p-n junction [1,2], the presence of a donor impurity at a certain concentration [3]. There remain many obscure physical phenomena associated with changes in the lattice parameters when the amount of donor or acceptor substances changes, the dependence of the band gap on temperature, and the electrophysical parameters of the FEC components.

b) Analysis of research results from literature data and investigation of the effect of components on the electrical properties of converters

If we pay attention to the fact that the parameter of the lattice of a semiconductor, with a change in its composition varies in different ways [4]. Moreover, if we analyze and judge by the same literature, then the results obtained by different authors practically do not coincide with each other. For example, the obtained data based on the results of a study by BV Baranov and NA Goryunova [4] and Woole and Smith of the AlSb-InSb semiconductor compound gives information on the linear decrease in the lattice constant from 6.48Å to 6.13Å at a one-hundred-percent mole ratio , then the same studies on these substances with a nonequilibrium value give very different results. Perhaps this can be explained, firstly, by the physical nature of the materials used. Secondly, the combination of semiconductor elements not only of different groups, but also neighboring cells of the periodic system of Mendeleyev, contributes to a change in the internal structure of the resulting material. The change of one of the materials in this component to another (instead of indium to introduce Ga and to obtain AlSb-GaSb), shows an inverse relationship between the lattice parameter and the composition of the system, that is, the lattice parameters increase linearly in this range. This phenomenon requires studying and revealing the physical phenomenon occurring in the volume of the composition!

Without giving in to the details of all the investigated semiconductor compounds, relying only on an analysis of the results of the published work, one can be convinced of the complexity of the interrelation between the lattice parameter of the connected elements and the composition of the system.

In the search for highly efficient solar energy converters is the energy of the band gap of semiconductors (Eg). This indicator, being a fundamental parameter of semiconductor materials, solves many questions. The physical meaning of Eg is the necessary energy for releasing the valence electrons involved in the covalent (or partially ionic) bond of the electrons of the crystal lattice for their participation in the conductivity of the material. This necessary energy for the transition of electrons from the valence band to the conduction band. The concentration of free charge carriers, as well as the intrinsic conductivity of the material, depends on the value of Eg. The value of Eg is determined by the state of the valence electrons in the electronic structure of the atom and by the type of chemical bond.

An important property of Eg is that this parameter can not be a constant for a given semiconductor always. It depends on the temperature, pressure and degree of alloying of the material. The temperature dependence of the width of the forbidden band, as well as its dependence on pressure, can be described in the following form:

$$E_g = E_{g_0}(1 \pm \alpha T),\ эВ \quad (1)$$

$$E_g = E_{g_0}(1 \pm \beta T), эВ \quad (2)$$

where α is the temperature coefficient of the width of the forbidden band; β-barrier coefficient of the same parameter, these parameters depend on the electrophysical properties of the material.

If we pay attention to the fact that the width of the band gap determines the intrinsic concentration and the corresponding conductivity of the semiconductor material at any temperature, which is well confirmed by the formula

$$n_i = (N_c N_v) \wedge (1/2) \exp(- (E_{g0} (1-\alpha T)) / 2kT), \quad (3)$$

then one can be sure about the correctness of the choice of the research on the improvement of the manufacturing technology and design of photoelectric converters by introducing donor or acceptor

impurities into the element. In the last formula, N_c N_v is the effective density of electron states in the conduction band and holes in the valence band, k is the Boltzmann constant k-8.6 * 10-5 eV / K. E_g0 is the width of the forbidden band of a semiconductor at T = 0K. E_g-width of the band gap at a given temperature, α-temperature coefficient.

Based on the results of a large number of studies, an almost strong dependence of the width of the forbidden bands of semiconductor elements and compounds has been established. With the discovery of new alloys and compounds, the field of investigation of this parameter in a wide range of temperatures is becoming ever wider. This confirms the need for carrying out monitoring and measurement, theoretical and experimental studies for all components of the resulting material of a solar transducer or other semiconductor device. A surprising factor is the difference in the signs of the temperature coefficients of individual semiconductors and compounds [4]. According to this literature, silicon has a relatively lower temperature coefficient (α = -4 eV / degree), compared to other semiconductors (for example, Se: α = -9 eV / deg, Al2Se3: α = -11.2 eV / deg).

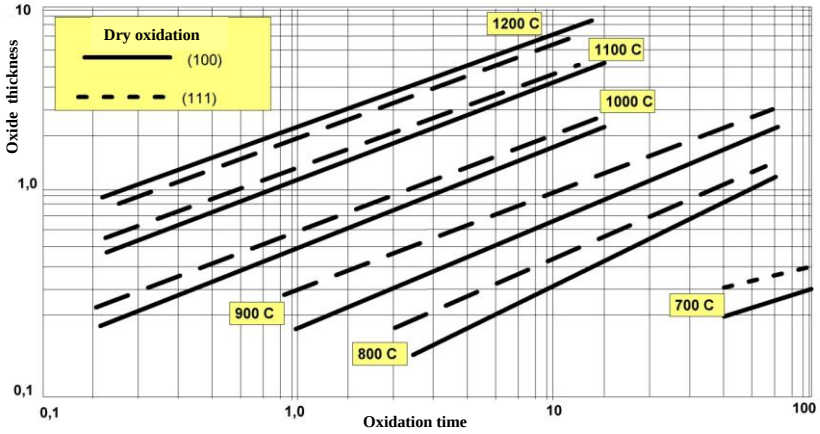

Figure 1. Dependence of oxide thickness on oxidation time and temperature for orientation of two types with growth in dry oxygen.

A careful analysis of the results of the study of the temperature dependence of the width of the forbidden band shows that in the low-temperature region (below 200 ° K), in most semiconductors the temperature coefficient varies nonlinearly. Here its one meaning can not be described. But, taking into account the main range of operating temperature of solar cells, one can neglect nonlinearity. There is no positive linear linear dependence of the width of the forbidden band on the temperature of lead chalcogenides. Therefore, in our opinion, the importance of studying the temperature dependence of the band gap, both individual semiconductors and their compounds, remains in force.

Since our object of study is silicon and compounds based on it, it is important to have a thorough analysis of the results of research in this field and to determine the unexplored side of this material.

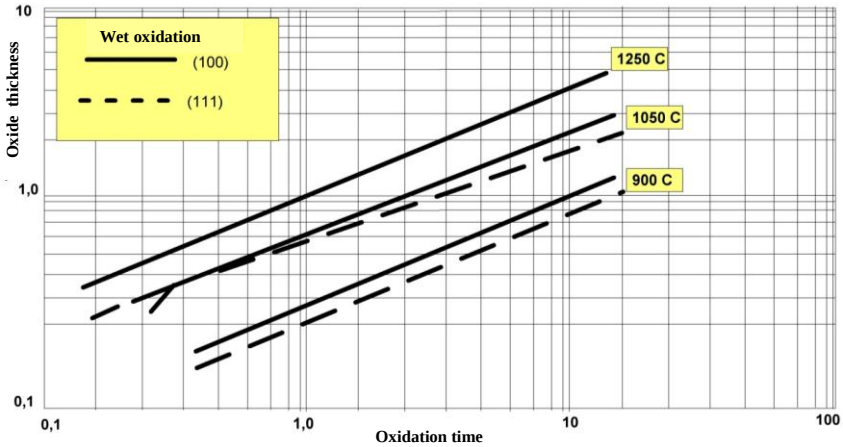

Figure 2. Dependence of oxide thickness on oxidation time and temperature for orientation of two types with growth in dry oxygen.

Of course, Si is the main element in the production of serial samples of homo- and heterojunction photoelectric converters. A lot of work on the study of optical, electrophysical and operational parameters of solar cells from this element. However, the appearance of heterojunction converters opens up broad prospects for the need to study the various properties of a multielement and many transient source of electrical energy. Particularly different properties of amorphous, polycrystalline and monocrystalline silicon mobilize the army of researchers in this direction. It should be noted that the necessary step in the manufacture of semiconductor devices, integrated microcircuits, solar cells based on polished plates of single-crystal silicon is the creation of silicon

dioxide (SiO2) of a certain thickness. SiO2 provides selective diffusion of the impurity, control of the diffusion coefficient, protection of the surface of the plates, a decrease in the fraction of reflected light, and accordingly an increase in the fraction of the absorbed light. There are several methods for obtaining oxide films on the surface of silicon. A method of thermal oxidation was widely used. However, according to [5 ÷ 8], films grown in an atmosphere of pure oxygen have a more perfect structure. Selective diffusion of impurities is used when conducting local diffusion into a given region of the silicon wafer through special windows opened in the SiO2 layer. Of acceptor impurities, only boron has a lower diffusion coefficient in the oxide than in silicon. Gallium diffuses in the oxide 400 times faster than in silicon, and aluminum diffuses even faster than gallium. The donor impurities P, As, Sb diffuse relatively slowly in SiO2 than in silicon. The slowest diffusing impurity, as we know, is phosphorus atoms. Silicon dioxide also significantly reduces the penetration depth of ions when they are implanted into a semiconductor material.

Figures 1 and 2 show the temperature dependences of the oxide thickness on the oxidation time using dry (Fig. 1) and wet (Fig. 2) oxidation methods. As can be seen from the figure, with dry oxidation with orientations of 100 and 111, there is a spread of parameters With increasing sample temperature, this difference becomes smaller. In the entire range of time investigated, the linear relationship is preserved. The growth of the film thickness, with increasing temperature, becomes slower. The same dependence is observed at a temperature of 700 ° C. Wet oxidation for SiO2 (Fig. 2) with the same orientations yields very close values in the results. There is a small spread at 900 ° C, and more noticeably at T-1050 ° C after thirty hours on a logarithmic scale.

c) Conclusion

In conclusion, based on the results of a study of the properties of the width of the inhibitive zone of semiconductors, donor and acceptor elements and silicon dioxide, the following conclusions can be drawn: To create high-efficiency solar cells from silicon, it is necessary to make the right choice of the concentration of donor and acceptor impurities, because at diffraction from optimal values it looses the meaning of effective transformation and also to make a choice of materials for the creation of p-n-layers based on the electrophysical and temperature properties of the components as for homo- and for heterojunction photovoltaic cells.

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