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CONTROL OF THE ELECTROPHYSICAL CHARACTERISTICS OF TWO-BARRIER SILICON STRUCTURES WITH A NANOSTRUCTURED BASE USING GAMMA RADIATION

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During this experimental study, samples of double-barrier structures were irradiated with various doses from a ^{60}Co source. The current-voltage characteristics of two-barrier structures from a silicon-based nanostructured base and the change in their spectral photocurrent before and after gamma irradiation were recorded and studied. Experimental results show that voltage values such as open-circuit voltage (V_{OC}) as well as short-circuit current (I_{SC}) and efficiency (η) change with the magnitude of the collection-dissipation voltage.

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INTRODUCTION

Application of semiconductor double-barrier structures to convert the sun's rays into electrical energy and the use of clean and free solar energy, monocrystalline silicon solar cells are still the best option for solar photovoltaic systems. The photovoltaic performance of silicon solar cells is affected by environmental conditions. During operation, photovoltaic solar cells are exposed to radiation similar to that encountered when used in satellite systems in space. Irradiation of photo converting structures with high-energy particles in the form of gamma quanta, neutrons, charged particles, etc. e. defect to radiation changes and defects in the detection of elements and to a significant degradation of the parameters of samples of silicon structures [1, 2].

Structure output parameters such as increased power, efficiency, duty cycle, short circuit current and no-load voltage are very different from the individual characteristics of such structural elements as series resistance, RS, saturation current, I0.

It was found that an increase in each of the bove structural elements leads to the appearance of output characteristic properties [3–5]. In the study of radiation defects at various doses of irradiation in the aggregate, the presence of the necessary observation of the degradation of the lifetime of non-main charge carriers. Deterioration of minority carrier lifetime and attraction to device properties. is considered an important indicator of minority carrier life for the silicon structure of a natural element of heredity in its high degree of importance, both for short circuit current and open circuit voltage [6, 7].

1. EXPERIMENTAL METHODS

In this work, four sample structures of silicon solar cells with improved characteristics are measured, which are shown in Table. Solar cells were fabricated in a single-crystal structure using phosphorus diffusion into a p-type silicon wafer. All samples were irradiated with a ^{60}Co gamma source with an energy of 1.23 MeV.

Properties of samples of double-barrier structures (before irradiation)

Material	V_{OC}, mV	I_{SC}, mA/cm^2	P_{mmp}, mW/cm	FF	η, %
Si	650	42	14	0.72	13.95

The spectral characteristics of the structures under study were measured in the wavelength range from 400 to 1200 nm using a spectral response measurement system. Consumption measurements at ambient temperature using high-precision measuring instruments.

2. RESULTS AND DISCUSSION

The I–V characteristics of the structures deteriorated with an increase in the radiation dose. From Fig. 1, you can get the main parameters of the incoming elements, such as open circuit voltage (V_{OC}), short circuit current (I_{SC}), duty cycle (FF) and efficiency (η) [10–13].

On Fig. 1. Current-voltage characteristics of the two-barrier structure before and after irradiation at different irradiation doses-discussion under AM1.5 illumination conditions. The fill factor (FF) parameters for the structures can be expressed as (1) where V_{oc} and I_{sc} are open circuit voltage and short circuit current, V_{mp} and I_{mp} are voltage and current in power reproduction respectively. Efficiency (η) of the decision of the decision element (2) where P_{in} is the power of the incident light [14].

Fig. 1 shows the changes in double-barriers structure silicon parameters as a function of gamma dose. The parameters are normalized to the values obtained before samples irradiated. It was found that the degradation of the solar cell parameters is dependent on the gamma radiation dose and the irradiation has affected the solar cell parameters to a certain extent.

There is no substantial variation in the fill factor, which in some cases showed increased or relatively steady values. According to the results, the gamma radiation causes a significant Reduction in the short circuit current and efficiency while the open circuit voltage is slightly reduced [14–16].

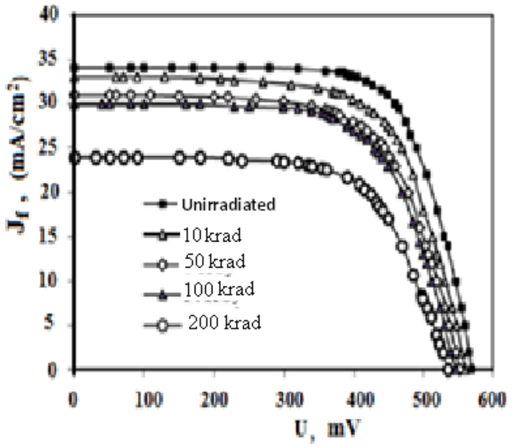

Fig. 1. The I–V characteristics of double-barriers structure silicon irradiated with various doses of gamma radiation

The detail of double-barriers structure parameters degraded under gamma doses of is shown in Fig. 2.

The decrease in short-circuit current and other fundamental parameters of double-barrier structures for ionizing radiation detectors under the action of gamma radiation is mainly related to the lifetime of minor charge carriers.

The lifetime of minority carriers in structure crystals is the average time that minority carriers can spend in an excited state after the generation of electrons and holes before they recombine.

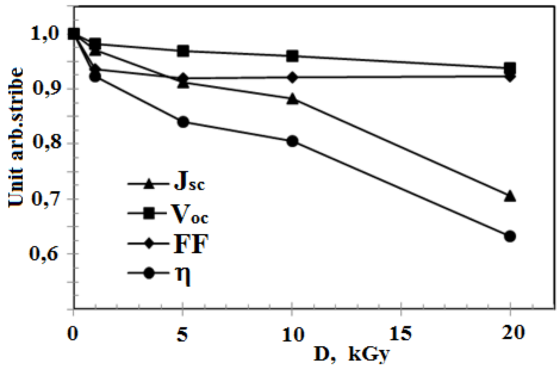

Fig. 2. Parameters of the two-barrier structure in relative unit depending on the dose of gamma radiation

The lifetime of minority carriers is sensitive to radiation defects, which mainly act as recombination points [17, 18].

The lifetime is related to the recombination rate by the relationship:

$$\tau = \frac{\Delta n}{R},$$

where τ is the minority carrier lifetime, *Δn* is the excess minority carriers concentration and *R* is the recombination rate.

Change in the lifetime of minority carriers of silicon samples of elements before and after gamma irradiation depending on the manifestation of rice manifestation.

The variation of minority carrier lifetime of silicon solar cell samples before and after gamma irradiation as a function of dose is shown in Fig. 3.

Minority carrier diffusion length is a more applicable parameter for solar cell analysis. With increasing the gamma radiation dose, the electron-hole recombination points increases. Therefore the concentration of minority carrier traps will increase. Decrease in the minority carrier lifetime reduced the solar cells electrical properties [10].

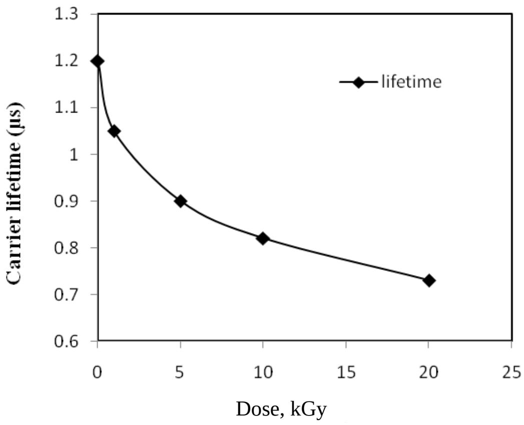

Fig. 3. The variation of minority carrier lifetime with various doses of gamma irradiation

Fig. 4 shows the change in spectral photo current, I (λ), of silicon solar cell samples under gamma irradiation. It can be seen that in the whole wavelength range the highest photo current values belong to the un-irradiated solar cell and the photo current values decreased with increasing gamma radiation dose.

According to the results, a significant degradation in photo current output of samples has been found for lower wavelengths region and there is no considerable degradation for higher wavelength range. This means that the effect of gamma radiation on silicon solar cells and production defects is greater in region close to the surface cells. As well as, a solar cell that exposed to high dose of gamma radiation (20 kGy), radiation damage and degradation of photo current occurred in the whole wavelength range [11].

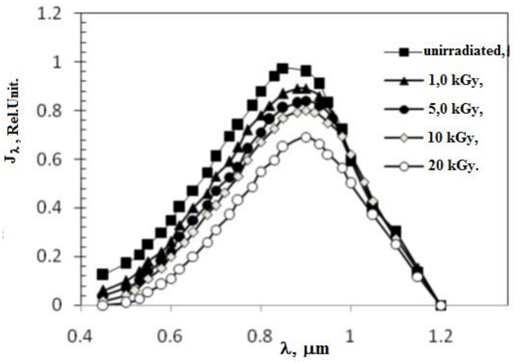

Fig. 4. Photocurrent of silicon double-barrier structures depending on the hit at different doses of gamma irradiation

CONCLUSIONS

The deterioration of the characteristics of photoconverting structures during irradiation was observed with the appearance of a concentration-irradiation set (20 kGy). Except for a few cases, the coverage ratio showed increased or relatively stable values, while V_{oc} slightly decreased. The reduction in short circuit current and other key parameters is mainly due to the lifetime of minority carriers

The life time of minority charge carriers before radiation exposure is defects, which mainly appear in the form of points during recombination, and a decrease in the time of minority charge carriers. According to the results of the spectral photocurrent after gamma irradiation of structures, defects associated with expression irradiation are revealed, and they appear near the crystal surface.

As a result of our research, it is possible to confirm the performance of double-barrier structures at elevated doses of gamma radiation and are suitable for use in the manufacture of ionized radiation detectors.

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УПРАВЛІННЯ ЕЛЕКТРОФІЗИЧНИМИ ХАРАКТЕРИСТИКАМИ ДВОБАР'ЄРНИХ КРЕМНІЄВИХ СТРУКТУР З НАНОСТРУКТУРОВАНОЮ ОСНОВОЮ ЗА ДОПОМОГОЮ ГАММА-ВИПРОМІНЮВАННЯ

Р.С. Мадатов, Ф.П. Абасов, Ф.Г. Асадов

В результаті даного експериментального дослідження зразки двобар'єрних структур опромінювалися різними дозами від джерела ^{60}Co. Виміряно та досліджено вольт-амперні характеристики двобар'єрних структур з наноструктурованою основою на базі кремнію та їх спектральні зміни фотоструму до та після гамма-опромінення. Експериментальні результати показують, що значення напруги, такі як напруга холостого ходу (V_{oc}), струм короткого замикання (I_{sc}) та ефективність (η) залежать від величини напруги накопичення – розряду.