UDC: 621.315.593

EFFECT OF IONISING RADIATION DEFECT ON ELECTRICAL PROPERTIES OF THE DOUBLE-BARRIER STRUCTURE BASED ON SILICON

F.P. Abasov

Institute of Radiation Problems of ANAS
fpabasov@mail.ru

Abstract: Developed and analyzed silicon-based photo detector with high sensitivity integrated in the short range. The effect of gamma radiation on the mechanism of current transport in the structure type Schottky barrier, and in the p-n junctions. It is shown that the double-barrier structure can improve the photovoltaic parameters of conventional detectors. We studied the effect of gamma radiation on the origin of the current mechanism in the structure as a whole, and in the Schottky barrier in the p - n - transitions separately. Also studied the effect of radiation on the photoelectric and photoluminescence parameters of the two barrier structure. Shown that two barrier structures can improve the photoelectric parameters of conventional detectors. The photo detector on the basis of silicon with the increased integrated sensitivity in short-wave area of a range is developed. Influence radiation scale on the mechanism of a currents of both in structure like Schottky's barrier, and in p - п - transitions is investigated. It is shown that two-barrier structures allow to improve photo-electric parameters of traditional detectors. Investigated the impact of radiation on the photoelectric and photoluminescence parameters of two-barrier structures.

Keywords: silicon photo detectors, two barrier structure, p - п – transitions and Schottky barrier, photo luminescence.

1. Introduction

Silicon photo detectors, still the most widespread type of photo converters. One of the main directions of increase of speed and increase in spectral sensitivity of modern receivers of radiation with one transition is creation of multibarrier structures. in which thanks to internal strengthening and growth of coefficient of collecting of the photo generated carriers - it is possible to improve significantly key parameters which meet the requirements and needs of optoelectronics. Reliability of work of the received structures under the raised conditions of radiation, as detectors of ionizing radiation is an actual task and makes a subject of our researches.

Recently for expansion of area of spectral sensitivity methods [1 - 4] bringing to photocurrent growth in short-wave area of a range are widely used. Example can is – Verizon band structures; pulling fields, etc., based on reduction of speed of a superficial recombination. In our case such opportunity, but in planar execution it is possible to create at the expense of a field n-p-transition included in the opposite direction. In the fig.1.dependence of the gathering of the wavelength of incident radiation double-barrier structure, p-n- junction and Schottky barrier.

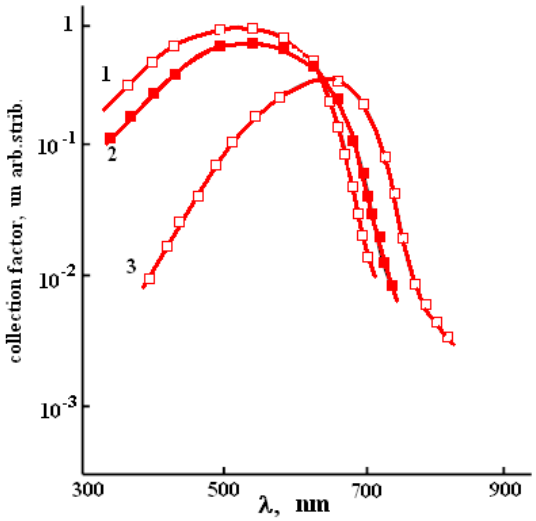

Fig.1. The dependence of the gathering of the wavelength of incident radiation: 1. double-barrier structure; 2.Schottky barrier; 3.p-n- junction.

Managing physical parameters using light can be obtained in the photosensitive double barriers structures and you can achieve a significant increase in integral sensitivity compared to conventional photodiodes. With a view to improving the performance of semiconductor structures and devices on their basis, providing technological reproducibility, the extension of the frequency range work, improve reliability and increase good output devices without the deterioration of the current transfer ratio is static. The goal is achieved by the fact that in the way of manufacturing semiconductor devices, at the final stage of manufacture, after irradiation devices electrons or gamma-quanta Co60 they processed by high-energy magnetic fields in the volume of the pyramid for a period of not less than 5 h followed by a stabilizing annealing at temperatures of 100-250° c for 5-50 min. When exposed to magnetic fields for semiconductors in volume and surface transportation. characteristics of structures looking device Silicon photo voltaic with photo luminescence shortwave solar radiation in the area of maximum photosensitivity, with radial p-n transitions in micro structure and vertical antenna with conductive quantum threads in the amount of single crystal silicon. Increased specific electric conductivity in the planar structures creates clustered groupings of silicon atoms in amorphous State atoms doped impurities. Arrays of quantum filaments are the main structural factor when creating photo-elements of the third generation with high conversion efficiency, radiation stability and high resource exploitation for terrestrial and cosmic energy.

It is showing great interest in the study of photoluminescence features (PL) of short-wave radiation in the visible spectrumfor efficiency c-Si-solar cells [5 - 9]. Thus, the problemimprove efficiency (c-Si) – photo elements consists of two parts: 1 - the re-emission of short-wavelength photons in the visible spectrum edge through the mechanism of direct optical transitions zone-zone silicon monohydrate, 2 - the effective conclusion of photogenerated carriers across the spectrum of solar radiation.

The forms of the spectra of these emissions, normalized to its maximum value each symmetrical with respect to the line:

$$\nu_s = \frac{\nu_{ex} + \nu_{\xi}}{2}$$

where, ν_{ex} - the frequency of the exciting radiation;
ν_l - frequency fluorescent light.

When excited photoluminescence monochromatic radiation is most likely the appearance of a low-frequency fluorescent light, although it is possible and the emergence of a high-frequency (anti-Stokes) radiation.The spectra of the Stokes and anti-Stokes photoluminescence emissions. Spectral rules of photoluminescence due to the fact that the absorption of the exciting photon with energy.

$W_в = h\nu_в$,

where, h - Planck constant; $\nu_в$ - the frequency of the exciting radiation,

$W_l = h\nu_l$,

where, ν_l- fluorescent light frequency.

The energy difference $W_b – W_l$ spent on various processes in the material, in addition to photoluminescence. In cases where a photon energy of the exciting radiation is added to some of the energy of the thermal motion of the phosphor particles

$Hv_l = h\nu_b + akT$,

where, a - coefficient depending on the nature of the phosphor;
k - is Boltzmann constant; T - absolute temperature of the phosphor, there is anti-Stokes photoluminescence.

2. Technique of experiment and discussion of results

Features of two-barrier structures created on one plane are for the first time received and studied. It is shown advantages before traditional structures. For creation of photodetectors of planar execution with internal strengthening Au-Si Schottky barrier is created. As an initial material the structure p - n - type on a silicon substrate is used. The realization of management by current by means of light was enabled by selection of supply voltage of K-E in such a way that collector transition is closed, and emitter — is open, at free base. Under the influence of light in it electrons and holes are generated. At collector transition there is a division electronic hole couples which have reached owing diffusions of border transition. Holes are thrown by a field of transition to a collector, increasing own current, and electrons remain in base, lowering its potential. Thus on emitter transition there is additional direct tension that strengthens injection of holes from the emitter in base. The injected holes, reaching collector transition cause additional increase in current of a collector. As total collector current is proportional to coefficient of internal strengthening, increase of spectral sensitivity - reaching 0,65 A/W. The purpose of work consists in studying of influence of a charging condition of no equilibrium vacancies on processes occurring during radiation and silicon heat treatment with $Nn = 10^{16}$ sm^3, and also clarification of the mechanism of increase in integrated sensitivity of two-barrier structures of rather ordinary photo diodes.

In fig. 2 spectral characteristics of two-barrier structure before radiation are shown, at the room temperature at the return tension of $U_{cont.} = 0$B, and $U_{cont.} = 0{,}5$B. From drawing it is visible that with growth of the enclosed return shift on r-p-transition photocurrent increases what to lead to photosensitivity growth, at an optimum choice of the return tension on r-p-structure transition.

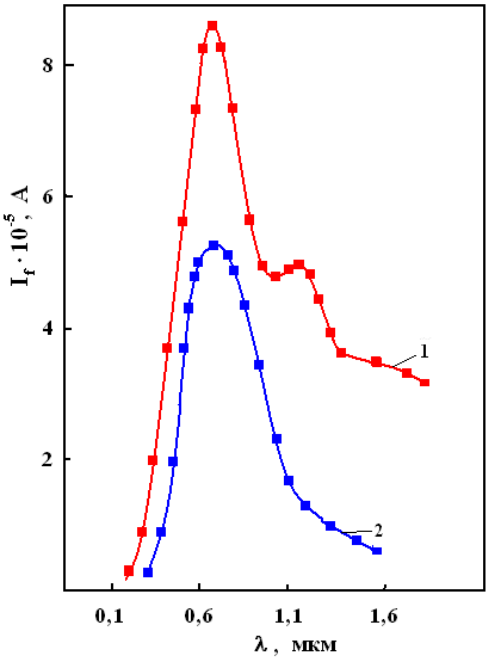

Fig. 2. Spectral characteristic ofthe double-barrier structures toradiation: 1.-$U_{rev.}$=0V; 2.-$U_{rev.}$=0.5 V. T = 300 K

At further increase in U_{cont}. spectral sensitivity falls. Such behavior of S_λ connected with growth of area of a volume charge and improvement of coefficient of collecting of photo carriers. With a further growth of U_{cont} because of overlapping of zones, photo injection of BSh is blocked and the structure works in a mode of one photo diode (fig. 3).

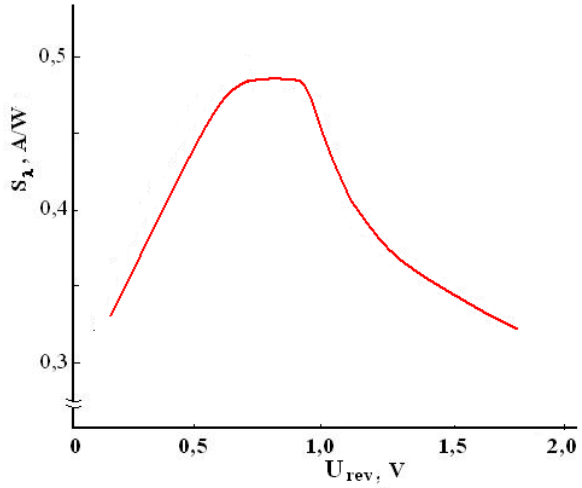

Fig. 3. Dependence of the spectralsensitivity ofthe structure the appliedreverse biasthe p-n-junction

The structure was irradiated at T=300 K in gamma quanta of Co^{60}. Isochronous (30 min.) annealing of radiation defects was carried out in the range of temperatures of Ta = 200-450 K.

Method of photo MF of $V_{oc}=\frac{1}{1+b}\frac{kT}{q}\ln\left(\frac{\langle G\rangle^2\tau_1\tau_2}{n_i^2}\right)+\frac{b}{1+b}\frac{kT}{q}\ln\left(\frac{\langle G\rangle^2\tau_2 P_{p0}}{n_i^2}\right)=V_j+V_B$

I showed that primary radiation defects (RD) in p-Si crystals at 300 K are loaded positively.

The analysis VAC (Fig. 3) and spectral characteristics showed that recombination currents increase in process of increase in a dose of radiation. Annealing of diodes leads to decrease in recombination currents. At Ta temperature ≈ 300°C there is an annealing and reorganization of divakansion to formation of the V2 complexes + O, and at Ta = 350°C the A-centers (V + O) and complexes (V2 + O) are actively annealed. The analysis of change of a current of through BSh and n-p- transition showed distinction of influence of annealing near a surface and in the depth of a crystal. It can be explained with growth of a photo response of BSh connected with accumulation of a charge and improvement of coefficient of collecting.

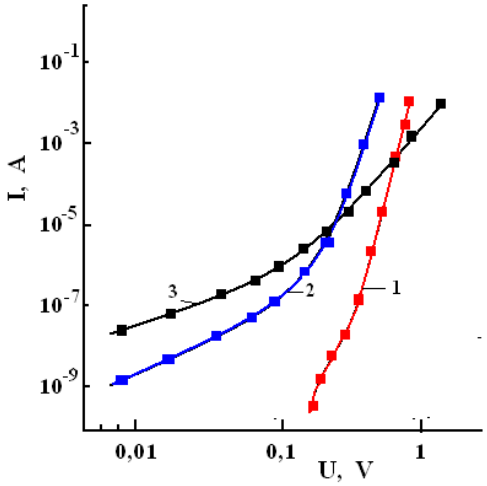

Fig. 4. Volt-ampere characteristics of p-n-junction 1.original. 2. Dγ = 100krad.3. Dγ = 200krad. Annealingresultsare insignificant

In fig. 5 curves of spectral dependence of photocurrent before and after radiation scale are represented at various doses and after annealing at T=400°C within 30 min. Annealing influences spectral characteristics slightly. With dose increase the radiation scale growth of photocurrent decreases.

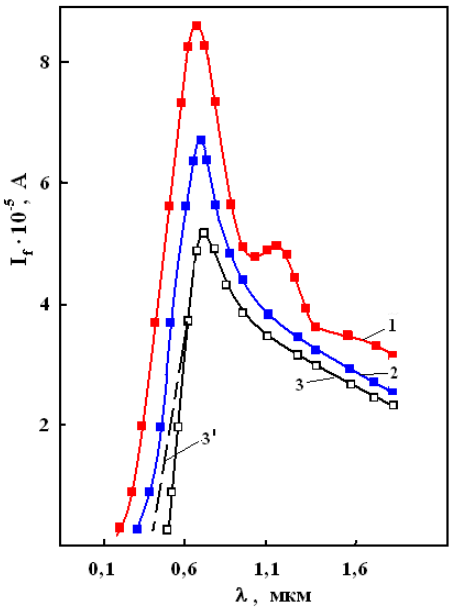

Fig. 5. Spectral characteristic double-barrier structure after irradiation withgammarays: 1-up irradiation, 2-dose 150krad., 3) dose of 200krad., 3') annealedat T= 400° C for 30min

In fig. 6. Photo luminescence spectra of samples irradiated with gamma rays Spectral rules of photoluminescence due to the fact that the absorption of the exciting photon with energy.

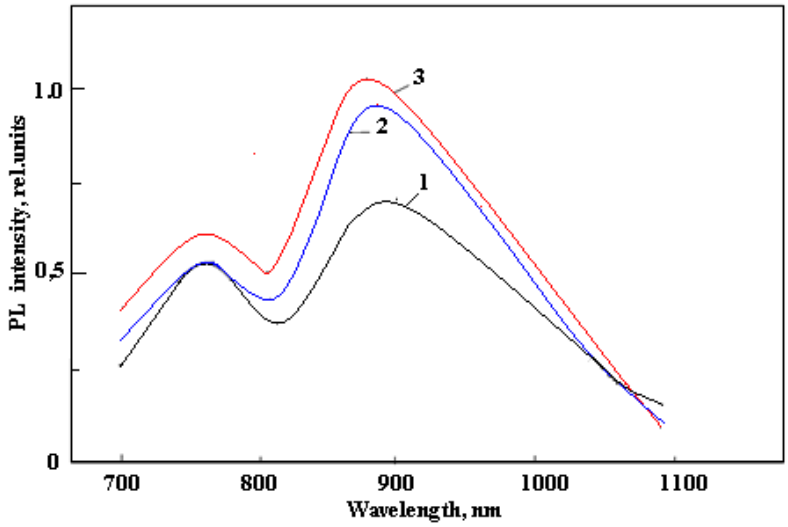

Fig. 6. PL spectra of samples irradiated with gamma rays: 1- prior to irradiation, 2- D_γ - 150krad., 3) D_γ - 200krad.

In fig.7.Relaxation of photoconductivity when excited it rectangular pulse.

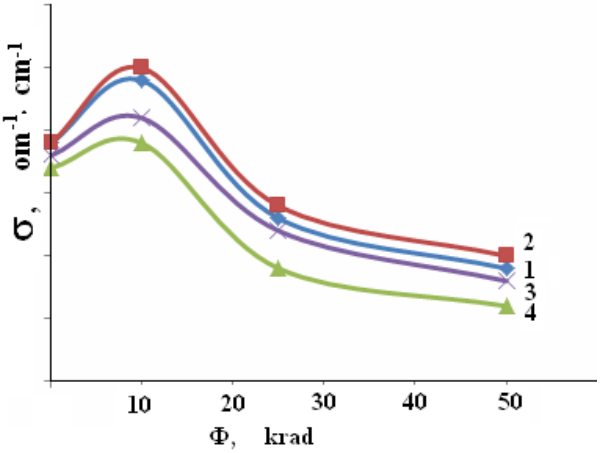

Fig. 7. Relaxation of photoconductivity when excited it rectangular pulse. 1-U=0,3 V, 2-U=0,5V, 3-U=1,0V, 4-U=1,2V

3. Conclusions

Thus, it is possible to claim that the main role in electric losses the studied silicon structures is played by the oxygen-containing centers (V2+O and V + O). At increase in a dose of radiation and increase in temperature of annealing, feature VAC and spectral characteristics are caused by change of resistance of n-Si (basic area of structure), the caused accumulation (at increase in a dose) or disappearance and reorganization (when annealing) radiation defects. It is known that the speed of capture by defect of electrons and (or) holes first of all depends on the section of capture and the provision of power level in the forbidden zone. These parameters in fact are the "individual" characteristic of defect [3,4]. When annealing structures there is a

reorganization of dot radiation defects and their disappearance. Thus mainly there is an accumulation of the same defects. Comparison to literary data shows that the main role in photo-electric losses of the studied structures is played by the oxygen-containing centers (V2+O and V+O) [5-9]. At further increase in a dose of radiation there is an irreversible reduction of photosensitivity due to significant increase in resistance of base.

References

1. S.M. Sze, Physics of Semiconductor Devices, New York: Wiley, 1984. 455 p.
2. L.A. Bakaleynikov, Flegontova EJ, Pogrebitsky K., Eremin IV / Theoretical principles ofsemiconductor detector based on the p-n junction. / Technical Physics, vol 9, p.74, 2004.
3. I.V. Savchenko, Theoretical Foundations of dosimetry.1985 388s.
4. LA Kosyachenko, Maslyanchuk EL, Rarenko IM, Sklyarchuk VM / Issledoanie carrier collection CdZnTe-ray detectors and - radiation photoelectrically. / Semiconductors, v.388, p. 1018,2004;
5. R.S. Madatov, M.A. Mehrabova, .F.P. Abasov, Fast acting detectors for γ- quantums on the Au-Si. The IV euroasian conference on nuclear science and its application. 2006, Baku, Azerbaijan, p.145-14
6. Мадатов Р.С., Ф.П. Абасов, Мустафаев Ю.М. Влияние гамма облучения на фотоэлектрические параметры двухбарьерной структуры на основе кремния. Российская конференция по проблемам полупроводников Новосибирск 22-26 августа 2011г.
7. Ф.П. Абасов, Получение тонких пленок для создания солнечных элементов //«ФОТОНИКА» 2(44) 2014. с.72-90.
8. F.P. Abasov, Influence of gamma radiation on electrik propertien of silicon solar cells. Internatiolnal journal of Pure and Aplied Science and Technology 21(1) (2014). Pp.12-16.2
9. F.P. Abasov, Effect of gamma irradiation on electrophysical and photoelectric parameters of double-barrier structure based on silicon. Nuclear Science and its ApplicationVll Eurasian Conference Baku 2014 pp.233**.**
10. F.P. Abasov, Effect of Gamma Irradiation on Photoelectric Parameters of Double-Barrier Structure Based on Silicon. Journal of Material Sciences and Enginering.USA, 2016, 5:269. http://dx.doi.org/10.4172/2169-0022.1000269.
11. F.P. Abasov. Study of radiation effects on photoelectric and luminescence parameters of two-barrier structures based on silicon.2nd International Conference on Condensed Matter physics which is going to be held on October 26-28, 2016 in Chicago, USA.
12. F.P. Abasov. Determining the amount of hydrogen in thin films well for solar cells. International Journal of Scientific Research in Engineering www.ijsrejournal.com ISSN: USA, Applied, Vol. 1, Issue 1, Sep.2016, pp.01-14.

ЭФФЕКТ РАДИАЦИОННОГО ДЕФЕКТООБРАЗОВАНИЯ НА ФОТОЭЛЕКТРИЧЕСКИЕ И ФОТОЛЮМИНЕЦСЕНТНЫЕ СВОЙСТВА ДВУХБАРЬЕРНЫХ СТРУКТУР НА ОСНОВЕ КРЕМНИЯ

Ф.П. Абасов

Резюме: Разработаны и проанализированы двух барьерные структуры - на основе кремния фотоприёмники с высокой чувствительностью коротковолновой области спектра. Мы изучали

влияние гамма-излучения на происхождение существующего механизма в структуре в целом, так и в барьера Шоттки и в р - п - переходахв отдельности. Также было изучено влияние радиации на фотоэлектрические и фотолюминесцентные параметров двухбарьернойструктуры. Показано, что двух барьерные структуры могут значительно улучшить фотоэлектрические параметры обычных детекторов. Исследовали влияние радиации на фотоэлектрические и фотолюминесцентные параметры двух барьерных структур.

Ключевые словар: кремниевые фотодетекторы, двухбарьерные структуры, структуры с p-n-переходом и барьером Шоттки, фото люминесценция.

SİLİSİUM ƏSASINDA İKİBARYERLİ STRUKTURLARIN FOTOELEKTRİK XASSƏLƏRİNİN RADİOAKTİV DEFEKTYARANMANIN TƏSİRİ

F.P. Abasov

Xülasə: Yüksək həssaslığa malik silisium əsaslı fotoqəbuledicilər -iki baryerli strukturlar yaradılmış və təhlil edilmişdir. Bütövlükdə strukturun vəŞottki və p - n – keçidlərinə ayrılıqda qamma radiasiyanın təsirimexanizmitədqiq edilmiş, həmçinin, fotoelektrik və fotolüminessensiyası parametrləri ikibaryerli strukturda radiasiya təsiri tədqiq edilmişdir. Iki maneəli strukturlareffektiv fotoelektrik çeviricilər kimi və yüksək enerjili süaların qeydedici detektorları kimitətbiq edilə bilər.İki maneəli strukturların fotoelektrik və fotolüminessensiyası parametrləri və ənənəvi fotodiod strukturları qarşısında üstünlükləri tədqiq olunmuşdur.

Açar sözlər: silisium fotodetektorlar, ikibaryerli strukturlar, p-n- keçidli və Şottki baryerli strukturlar, fotolüminessensiya.