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Management of Radiation Exposure Photoelectric Properties of the Double-Barrier Structure Based on Silicon

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Abstract

Developed and analyzed two-barrier structures-silicon-based photodetectors with high sensitivity in the field of integrated short-range. We studied the effect of gamma radiation on the origin of the current mechanism in the structure as awhole, 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 currents of both in structure like Schottky's barrier, and in p-n-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-n-transitions and Schottky barrier; Photo luminescence

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 multi barrier structures. In which thanks to internal strengthening and growth of coefficient of collecting of the photogenerated 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 us researches.

Recently for expansion of area of spectral sensitivity methods [1,2] bringing to photocurrent growth in short-wave area of a range are widely used. Example can be - Varizon 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.

It is showing great interest in the study of photoluminescence features (PL) of short-wave radiation in the visible spectrum for efficiency c-Si-solar cells. Thus, the problem improve 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:

$$v_s = \frac{v_{ex} + v_{\xi}}{2}$$

where v_{ex}: the frequency of the exciting radiation;

v_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 since the absorption of the exciting photon with energy.

$W_в = hv_в$,

where, h: Planck constant;

$v_в$: the frequency of the exciting radiation;

$W_l = hv_l$,

where, v_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

$Hv_l = hv_b + akT$,

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.

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

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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 takes place A/W. The purpose of work consists in studying of influence of a charging condition of nonequilibrium vacancies on processes occurring during radiation and silicon heat treatment with $Nn=10^{16}$ sm^3, and clarification of the mechanism of increase in integrated sensitivity of two-barrier structures of rather ordinary photo diodes.

In Figure 1 spectral characteristics of two-barrier structure before radiation are shown, at the room temperature at the return tension of U_{cont} =0B, and U_{cont} =0.5B. 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.

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 photocarriers. 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 (Figure 2).

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 Voc=ln+ln=Vj+VB

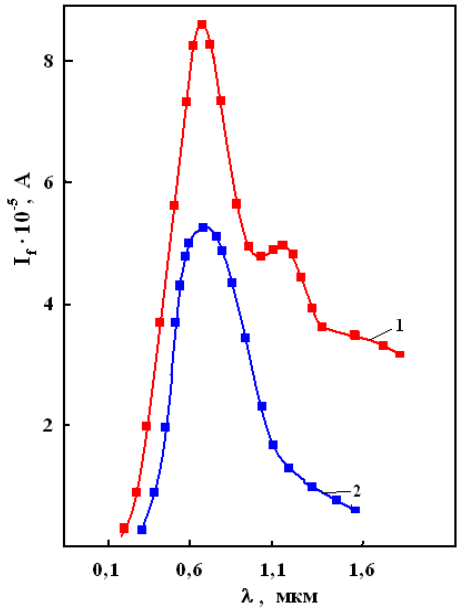

Figure 1: Spectral characteristic of the double-barrier structures to radiation. 1.-$U_{rev.}$=0V; 2.-$U_{rev.}$=0.5 V. T=300 K.

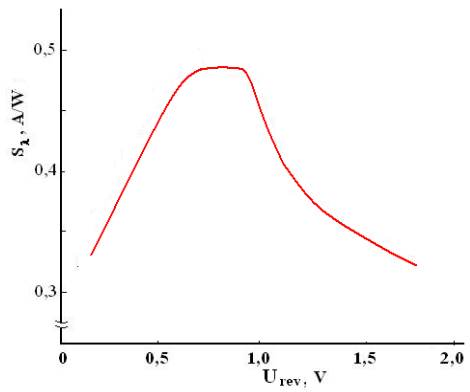

Figure 2: Dependence of the spectral sensitivity of the structure the applied reverse bias the p-n-junction.

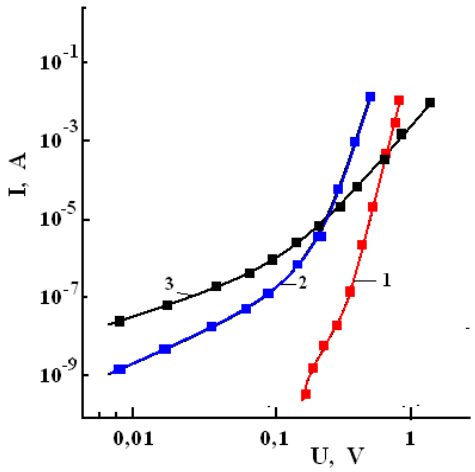

Figure 3: Volt-ampere characteristics of p-n-junction 1.original. 2. Dγ=100 krad.3. Dγ=200 krad. Annealing results are insignificant.

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

The analysis VAC (Figure 3) and spectral characteristics showed that recombinational currents increase in process of increase in a dose of radiation. Annealing of diodes leads to decrease in recombinational currents. At Ta temperature ≈300°C there is an annealing and reorganization of divakansiya 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 photoresponse of BSh connected with accumulation of a charge and improvement of coefficient of collecting.

In Figure 4 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 (Figure 5).

Conclusions

Thus, it is possible to claim that the main role in electric losses the

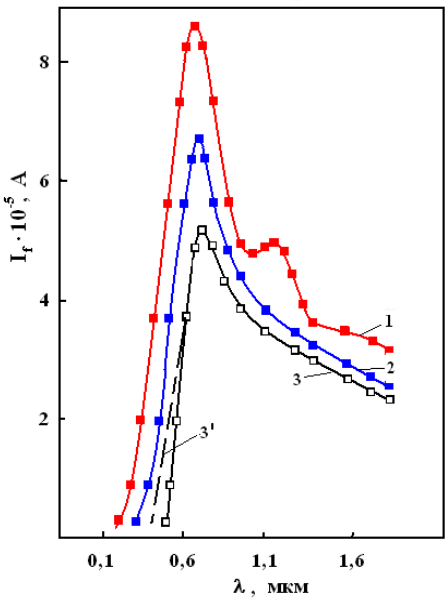

Figure 4: Spectral characteristic double-barrier structure after irradiation with gamma rays: 1-up irradiation, 2-dose 150 krad., 3) dose of 200 krad., 3') annealed at T=400°C for 30 min.

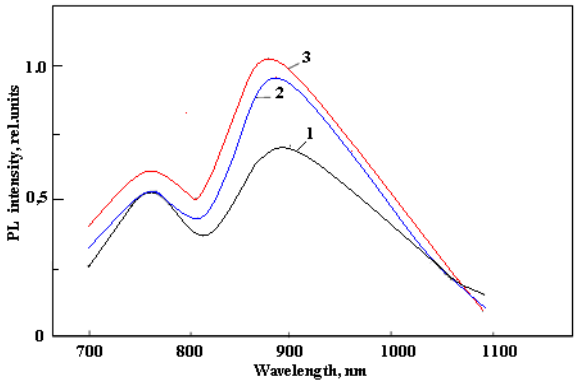

Figure 5: PL spectra of samples irradiated with gamma rays: (1) prior to irradiation, (2) D_γ - 150 krad., 3) D_γ - 200 krad.

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 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 [5-10]. Thus, mainly there is an accumulation of the same defects. Comparison to literary data show that the main role in photo-electric losses of the studied structures is played by the oxygen-containing centers (V2+O and V+O). At further increase in a dose of radiation there is an irreversible reduction of photosensitivity due to significant increase in resistance of base.

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