RAPID DETECTORS FOR γ QUANTA ON THE BASE OF Au-Si.

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ABSTRACT

The distributions of the electron-hole pairs generated by light and values of coefficient of carriers collecting, collected under action of the enclosed displacement has been calculated. The photoconductivity has been calculated depending on absorption α and voltage of displacement U. The sensitivity of structure Si-Au is more than for Si. At γ irradiation there is a generation of electron- hole pairs on structure Au-Si, thus speed of accumulation of charges on contact depends on intensity of electric field.

1. INTRODUCTION

Now there was an interest to detectors of nuclear radiations on the basis of semiconductors. As a base material Ge, Ga As, CdTe, Si, etc. are used [1]. The principle of work of the semiconductor detector is based on effect of the ionization made by an ionizing radiateon in its sensitive volume. This type of detectors is the most perspective for the reasons that the size of active area is small and it is possible to secure of high sensitivity by creating highly active area on the basis of planar technology [2]. Unique and basic lack of detector materials on the basis of the semiconductor materials received by the various ways, is the presence of a significant amount of various natures defects in them, which worsen their characteristics.

In the present work results of development and researches of metal-semiconductor structure the allowing as much as possible to keep high photosensivity and considerably to improve of time characteristics of silicon detectors are utilized.

2. THE EXPERIMENT

For preparing structure, the n-type conductivity silicon plate with specific resistance 100 Om sm has been used After clearing the surface of plate, the p-n transitions has been created by a thermal method. Then thin layer (~5 mkm) of metal (gold) is sprayed on to the silicon structure surface in vacuum which serves a role of electrodes (Fig.1,2).

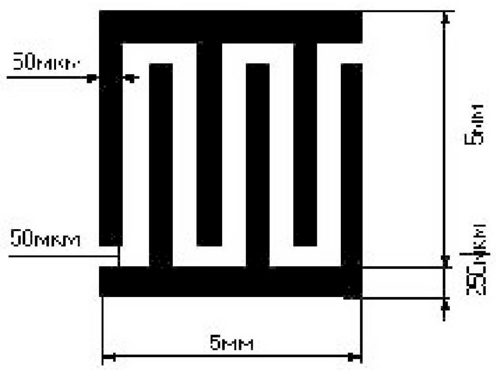


Figure 1.The geometry contacts put.

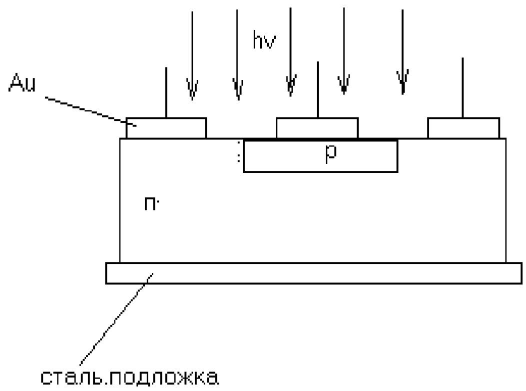


Figure 2. The structure.

The suggested variant allows to reduce an interelectrode gap up to 10 mkm. and to receive flying times of carriers in subnanosecond range with using of a photolithographys technic. The constructive using of detector allows receiving the maximal sensitivity across drift of carriers of falling radiation of high coefficient of absorption.

3. THE CALCULATIONS

The principle of action of the given semiconductor detector is based on generation of electron-hole pairs in a layer of volumetric charge and their collecting at the enclosed pressure of back displacement. As it is known [1], that in most of detectors the coefficient of collecting of charge carriers complicates work of these detectors at high pressure (100-500 V). For elimination of these lacks, complex configuration of electrodes are used. In this case the efficiency of collecting of charge carriers depends on geometrical parameters of structure and size of the enclosed pressure. There is a problem about revealing dependence of a signal from design parameters of structure. The distributions of the electron-hole pairs generated charge by light and values of coefficient of carriers collecting, collected under action of the enclosed displacement has been calculated. The value of parameters are $n_0= 10^{10}$ sm^{-3}; $D_p\tau_p=10^{-4}$ sm; $p_0= 10^{18}$ sm^{-3}. The photoconductivity has been calculated for a case when the electric field is perpendicular to a direction of a light falling on the sample. The density of a photocurrent at pressure U is equal to a difference of a current at an irradiation and darkness [1], i.e.

$$I_\Phi = \frac{U}{R} - \frac{U\delta_0}{d} \qquad (1)$$

Where d- is the thickness of the sample, and δ_0 –is the dark conductivity of the semiconductor, R- is the resistance of a crystal at an irradiation:

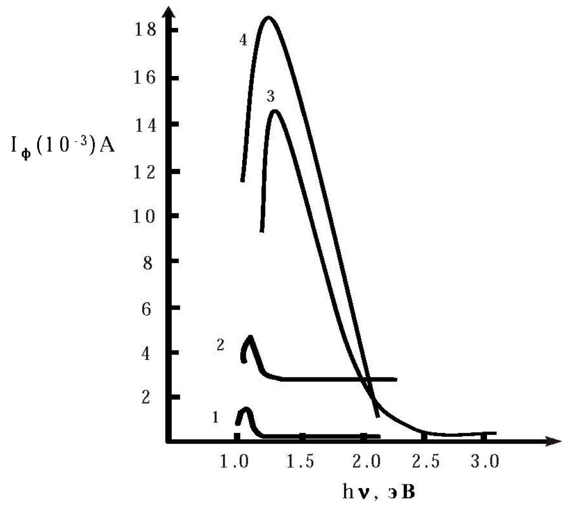
$$R(\alpha,U) = \int_0^d \frac{dx}{e\mu\Delta n + \delta_0} \qquad (2)$$

$$\Delta n(x,\alpha) = Ce^{-\alpha x} \qquad (3)$$

$$C = \frac{\alpha\Phi\tau}{1+\alpha L_{d2} - \alpha^2 L_n^2} \qquad (4)$$

Here Δn- is the superfluous concentration, Φ- is the count of photons, $L_{dr} = \mu F\tau$ - is the length of drift, $L_n = (Д_n\tau)^{1/2}$- is the diffusion length of electrons.

The photocurrent depending on coefficient of absorption and pressure of displacement U has been calculated. Using a curve of absorption and α(hv) for Si have received the spectral characteristics of photoconductivity. In Fig.3 and 4 are represents the calculated curves of photoconductivity I_Φ (hv) for Si (curves 1 and 2) and experimental curves (curves 3 and 4) for structure Au - Si at various pressure of displacement a course. Comparison of the calculated and experimental curves shows, that dependences I_Φ from hv are agree. It is shown from figure, that the sensitivity of structure Si-Au is more than for Si. It is connected that in Si the length of drift L_{dr} is less than thickness of a crystal d i.e. if optical coefficient of absorption α is enough big and L_{dr} <d, absorption of photons occurs in a thin layer adjoining to an irradiated surface. To put to crystal voltage the picture is changes. If the lighed surface is charged negatively the excited electrons will be delayed from a surface to volume, its resistance decreases, and photoconductivity of a sample increases as a whole. At opposite polarity



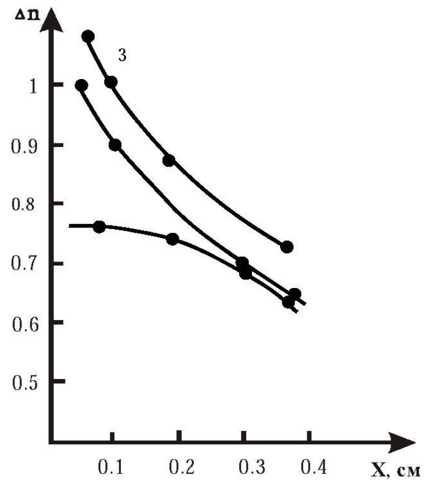


Fig.3. Spectral characteristics of photoconductivity: curves 1,2 – the calculated for Si; curves 3,4 –the experimental for structure Au - Si

Fig.4.Electrons distribution of nonequilibrium electrons at V=20V (curve.1); V=0 (curve.2); V =-10V (curve3)

electrons will be pushed out by an electric field from a crystal and photoconductivity of the sample decreases. In the second case in a volumetric part of a crystal holes will be extended. In structure the intensity of a field increases a field existing between Si and Au due to that sensitivity increases. In fig. 4 results of calculations of electrons distribution Δn at their excitation near the front of surface of crystal are presented. Life time of electrons is equal to 10^{-6} sec. with, i.e. the sizes, typical for Si, used in detectors γ- radiations. The thickness of crystal is equal to 4 mm.

At V=0 photogenerated electrons are concentrated near the surface of crystal. At U =-10V area of distribution and Δn (x) extends some times in depth of crystal, electrons in a crystal there is all less at the further increase of voltage, at V> 20 V is very few. That's, all generated electrons reach an opposite electrode.

We also calculated relative power sanctions σ (E/E_0) of the silicon counter for γ quantum with energy 1,33 MeV which makes 1.56 10^{-4} -1.95 10^{-4} at the factor F=0.09-0.14.

4. RESULTS

That's the avalanche multiplication raises the sensivity of the detecting system. The advantage of the silicon p-n detectors are their simple technology making, the high voltage in depletion layer (10^6V/sm), a few value of detectors' capacity (2-10 pf), the high sensivity.

Thus, we develop and create the detector for γ-quanta and x-ray radiation on the basis of Au-Si. It has been defined, that at γ irradiation there is a generation of electron- hole pairs on structure Au-Si, thus speed of accumulation of charges on contact depends on intensity of electric field.

5. REFERENCES

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