*ISSN 2455-4863 (Online)* **www.ijisset.org** *Volume: 4 Issue: 11 | 2018*

# Theoretical Ground of Creation of Highly Sensitivity Photodetector on the Basis of Multistable Semiconductor Structure

**Ruben Asatryan, Hamlet Karayan**

[1]*Prof., Department of theoretical Metrology, National Institute of Metrology, Yerevan Armenia*

[2]*Prof., Department of physics, Yerevan State University, Yerevan, Armenia*

**Abstract:** **M***ethods of treatment of measuring information with participation the fields of radiation lately intensively extend the application area. These expansions are caused by many tasks of metrology, automatic systems of control and recognition, optoelectronic systems of reception, transmission and treatment of information etc. Thus often there is a necessity of division of useful information from informative mixture, selection of signal from noise in a stochastic environment, renewal of the distored information with veyvlet characters etc.*

*The most high achievements in the decision of the tasks indicated and similar to them, are attained at application of information treatment digital methods.*

**Keywords:** *Multistable semiconductor structure, infrared photodetectors, optical windows, highly sensitive devices, division "signal-noise".*

## 1. INTRODUCTION

The use of computers allowed to build the interference picture of two waves registered independent of each other, and even in different time. However, the receipt of sufficient information in a comfortable form remains a very thorny problem. Not always it is succeeded to set the terms of informative plenitude of measuring, therefore there is a necessity of simultaneous realization of the independent frequent measuring. It belongs, first of all, to the receipt of information of the fields of radiation of a few sources, especially in the wave range from 0.5 to 5 mkm (in optical and IR range).

However, sometimes carrier of information, in particular, field of radiation, in mixture can carry information of unknown, or even indefinite nature also. The question is not about noise, hindrance or casual distored information, and about some information nature of that is also subject to determination. In other words, there is a necessity of formation of some knowledge about an object. While by an only method in such cases there is neuron treatment of information without a teacher, on the basis of the multiple-valued (mainly unclear) logic [1,2]. Naturally, in this case the use of the multiple-valued photodetectors can appear more effective.

In this connection, with the purpose of development of the multiple-valued semiconductor receivers, the problem of research of simultaneous influence of a few optical fields is set on conductivity of multistable electron-hole plasma (EHP).

## 2. SEMICONDUCTOR BIPOLAR STRUCTURES

Multistable EHP in semiconductor bipolar structures is one of pretenders for physical realization of the put aim, namely, for creation of receiver of information of two fields of radiation. We will consider that the field information appears modulation of him some macroscopic parameter, say, intensities.

Then the chaotic field (or chaotic components of the field) is without informative in sense of organization. In particular, the noise field is such and points difficulties the intensity in the process of receipt by the receiver of useful information. Therefore, physical influence of the noise field on the receiver is too subject to the account and without an useful signal.

Then we will get additional possibility of division of signal from mixture "signal + noise". Actually, let on a receiver simultaneously two streams of radiation fall with intensities $g_1$ and $g_2$, accordingly, and their united action is described by a function $f_1(g_1, g_2)$. Further, let in parallel the second receiver works with $f_2(g_1, g_2)$. Then differentiate $f_1$ and $f_2$ enough even if, then on their measuring it is possible exactly enough to define $g_1$ and $g_2$.

Effective difference between functions $f_1$ and $f_2$ it easily to provide, if in one of receivers streams $g_1$ and $g_2$ bring in the opposite holding, for example:

$$\begin{aligned} f_1(g_1, g_2) &= f_{11}(g_1) + f_{12}(g_2) \\ f_2(g_1, g_2) &= f_{21}(g_1) - f_{22}(g_2) \end{aligned} \qquad (1)$$

where all functions $f_{ik} > 0$. Signs show in right part of correlation (1), that the second entrance channel (managements) in the second sensor has negative weight. From the point of view of physical realization non-trivial is only a case of negative weight.

 

*ISSN 2455-4863 (Online)* **www.ijisset.org** *Volume: 4 Issue: 11 | 2018*

In semiconductor EHP on behavior of aleak in her kinetic processes it is possible to influence also structural methods. Therefore, it is possible to make an effort provide the negativity of weight of one channel by a structural method.

First briefly we will consider physical basis of multistability of EHP and managements these states. Exactly in heterogeneous EHP with an action in her effect of the plasma-field cooperation (EPFC) a management comes true by the states [3]. Essence of EPFC briefly consists in the following: In default of in some area of EHP with the internal (pin) fields consilient to direction with the external fields, there is an informative exchange between plasma and fields for maxwell's time of relaxation. In this case plasma and fields become the intrasystem vections of information and in this area set the certain informative field (field of order). In accordance with the last due to energy-entropy of outsourcing distributions of particles of plasma and fields are set in the system. By the Structurally-technological set of impedimental barriers (back displaced p - n transitions) and by turn taking away the different purviews of EPFC get their way of indemnification of by volume charges. Each of these areas determines some state of conductivity. It is possible to manage the purviews of EPFC external electric, optical, temperature and mechanical influences.

## 3. MODEL SCHEME of SEMICONDUCTOR DEVICE OF SIGNAL- NOISE DIVISION

We will consider the certain case of optical dual-link management with windows in the second quasineutral area of EHP. Such choice is conditioned by comforts for digital treatment of information and based on the phenomenon of internal photoeffect in semiconductors.

The photoborn carriers of current in a base partly compensate the by volume charges of joining p – n transition the analogical input of electrons by the electric field. To have a management with negative weight, it is needed input of carriers of current in a base to replace them a conclusion from a base, in other words, to shunt straight displaced (emitter) p – n transition. This aim can be obtained by adding to the second base two p – n transitions so that together with the first transition they made a four layers structure. Then photoborn carriers of current in the bases of additional structure can induce the conclusion of carriers from the second base of basic structure.

General model structure and closenesses of currents management $j_A, j_B, j_c$ presented on a fig. 1.

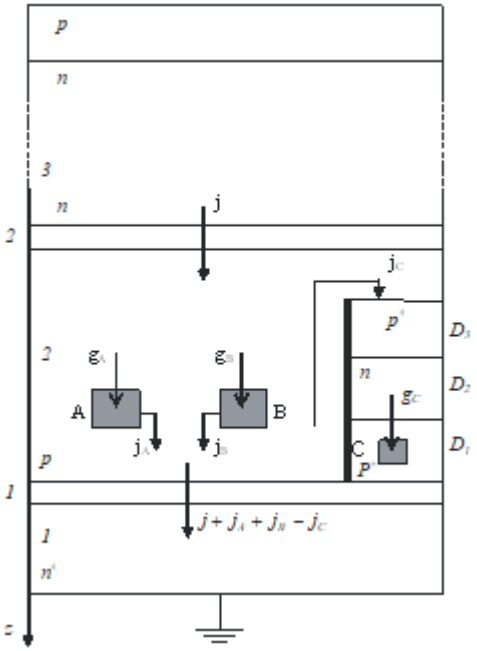


**Fig. 1.** *Model bipolar structure with much channel management.*

Now let on the first receiver an additional structure is absent with an optical window. Then windows A and B determine functions $f_{11}$ and $f_{12}$ in a formula (1). And let there is a windows C of type A or B, in the second receiver (see a fig. 2.). Then C will determine a function $f_{22}$ on condition that she is negative, monotonous and unambigiuous. Last most easy to provide the choice of technological parameters of additional structure so that falling of external tension on revers displacement p – n transition, was negative, i.e. that the sum of coefficients of transfer of unbasic carriers on bases excelled unit.

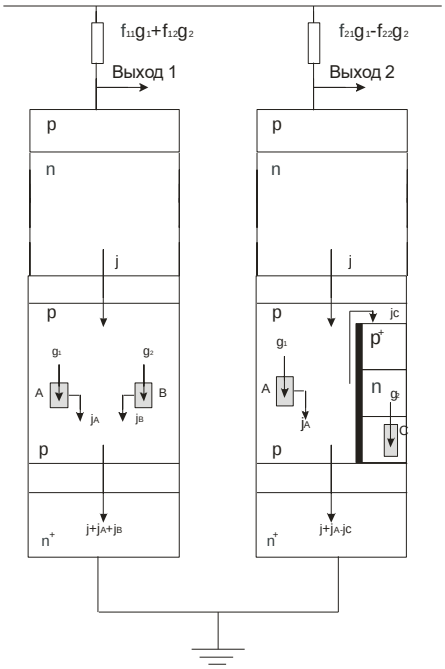


**Fig. 2.** *A model structure of s/c device of division signal-noise.*

 

*ISSN 2455-4863 (Online)* **www.ijisset.org** *Volume: 4 Issue: 11 | 2018*

Consideration of methods of technological realizability two photopolistors receivers with the optical windows of input of radiation is the article of separate research.

However, the present level of semiconductor technology allows execution actually of any necessary structure, if the values of initial structural parameters are only known. Thus a topology, sizes, location and material of optical windows, is determined by descriptions of radiation : by the method of input (by a light-pipe, bunch etc.), long waves, by modulation of bunch etc. [4,5]. In order to avoid the effects of asymmetry in polistor with the one-sided dual-link management of window located consistently.

Thus, influences of two optical fields for polistors of both types are modelled as additive currents of management, i.e., functions $f_{ik}^{\pm}(g_1, g_2)$ are found, where signs $\pm$ correspond polistors with positive and negative scales. Namely:

$$f_{ik}^{+} = \begin{pmatrix} \alpha_{11}^{+} g_1; & \alpha_{12}^{+} g_2 \\ -\alpha_{21}^{+} g_1; & -\alpha_{22}^{+} g_2 \end{pmatrix},$$

$$f_{ik}^{-} = \begin{pmatrix} \alpha_{11}^{-} g_1; & -j^{s}(g_2) \\ -\alpha_{21}^{-}; & 0 \end{pmatrix}, \quad i,k = 1,2. \qquad (2)$$

We will complete the scheme of design of polistors receiver with the terms of organization of the states of conductivity in an external chain.

$$E = \sum_1^p V_i \left[ j(j_1^c, j_2^c), j_1^c, j_2^c \right] + R_H j(j_1^c; j_2^c), \qquad (3)$$

where E and e.m.f. and resistance of loading, and $j_1^c$ and $j_2^c$ sum of elements first and second lines in matrices (2), i.e.VAC of polistors appears in a kind

$$j_k = j_k^T - j_k^c \qquad (4)$$

For basis for this purpose we will accept a requirement, that polistor in the i - th state is compared in the $\Delta j_{(i)}^c \equiv j_{(i+1)}^c - j_{(i)}^c$ interval of values . The last is the decision of the system (3) and (4), that it is undifficult to find by numeral method (and also analytically on the basis of properties of EPFC).

Regional values of interval, $\Delta j_i^c$, $j_{(i+1)}^c$ and $j_i^c$ we find accordingly from the terms of crossing of trajectories of $(i+1)$-th maximum and i – th minimum of VAC with a loadline (3).

Measuring of the polistor's state parameters, i.e., the closeness of current $j$, tension V on basis (3) to define the value of the summed current of management $j_k^c$ . It should be noted that by virtue of denotations [6], for this polistor by independent information about streams $g_1$ and $g_2$ possesses only one of $j_k^c$, we will say $j_1^c$ . Therefore, if both polistors of receiver the identical type and differ in only the structural parameters of optical windows $S_{ik}$ (areas of windows on structures), then as a result of measuring of electric data-outs we will get the system of equalizations in relation to streams and : electric parameters we will get the system of equalizations in relation to streams $g_1$ and $g_2$:

$$\begin{cases} S_{11} g_1 + S_{12} g_2 = G_1 \\ S_{21} g_1 + S_{22} g_2 = G_2 \end{cases}, \qquad (5)$$

that has an only decision subject to condition :

$$S_{11} S_{22} - S_{12} S_{21} \neq 0.$$

However, difference of right parts of correlation (5) $G_1 - G_2$ in the real cases near to the zero, therefore this device appears comfortable only for treatment of discrete information. For polistors with opposite scales takes place :

$$\begin{aligned} S_{11} g_1 + S_{12} g_2 &= j(\nu) - j^T(\nu) \\ S_{21} g_1 - S_{22} j^c g_2 &= j(\mu) - j^T(\mu) \end{aligned}, \qquad (6)$$

Where $\det(S_{ik}) \neq 0,$

and arguments $\nu$ and $\mu$ in right parts (6) show the states of polistors (i.e. points of crossing of VAC of polistors with a loadline fig. 5.7 in [6].

From formulas (5.32), (5.33) and (5.36) in [6], it easily to set that the trajectories of different points of VAC of polistors do not intersect, every trajectory intersects with a loadline only in one point,

This statement it is possible to reformulation so: if that is known $j(\nu)$ (it is measured), known (recovered by calculations) also $j^T(\nu), j(\nu) - j^T(\nu)$ etc., or, that the same, in force (5-39) in [6], on measuring $j(\nu)$ and $j(\mu)$ it is possible to recover the values of parameters, $g_{1,2}\left[j(\nu), j(\mu)\right]$ i.e. to try to execute "computer" calibration $g_1$ and $g_2$ .

The system of equations (5.39) in [6], differs in that a the same stream $g_2$ renders the opposite operating on polistor of receiver, that assists a sensitisation and lowering of threshold of receiver.

In particular, if, for example, $S_{11} = S_{12}$ and $g_2$ does not carry information (i.e. is a base-line signal or noise), then his scale can be calibrated in accordance with equation:

$$S_{12}g_2 + S_{22}j^c(g_2) = \left[j(\nu) - j(\mu)\right] - \left[j^T(\nu) - j^T(\mu)\right].$$

$j^c(g_2)$ in the left part of this formula in force (5-33) in [6], is nonlinear, therefore, in practical applications for the current of management it is expedient to produce the computer calibrating of area of his values, i.e. to make, so-called, computer scale $g_1$. Right part can appear small, but this non-linearity, however, this non-linearity is inherent also to the scale . As be obvious from a fig.2. it is possible to carry out the division of signal addition of output signals of in parallel operating two structures from noise.

## 4. CONCLUSION

Theoreticaly it is shown , that on the basis of results of researches of changes of volt-ampere descriptions (VAC) of multistable bipolar semiconductor structures under act of optical (including IR) radiation on different quasineutral (base) areas creation is possible on their element base qualitatively new highly sensitive photoreceiver devices IR range for application in the measuring systems of distant monitoring of the atmosphere's optical-physical parameters.

Theoretical bases of creation of new device of division are worked out signal-noise on the base of multistable semiconductor structure. It is shown that task of division of useful signal from noise it is possible to decide application two in parallel working s/c multistable structures with two optical windows for the reception of falling radiant stream, output signals of that well-known functions from sizes "signal+noise" and "signal-noise".

## REFERENCES

[1] Ruben Asatryan, Optical-Electronic Methods and Apparatus for Research of Atmosphere's and Infrared Sources Parameters, Doctoral Theses, Yerevan, NPUA, 2013, pp. 226.

[2] Rijov A.P. .Elements of theory of fuzzy sets and her applications. - M.: World. - 2003. - 252 p.

[3] Karayan H.S., Makaryan A.H., Yolchyan R.A., Martirosyan Sh.J., Khudabashyan M.A. About Multi-Stable Bipolar Structure Approximation by System of Virtual Bi-Stable Semiconductor Elements // 1st IEEE Intern, Conf. on Circuits and Communications. – 2002. - Proceed. St. Petersburg. - P. 392-395.

[4] Karayan H.S, Manukyan A.G., Proshyan V.P., Asatryan R.S., Technology and Topology of Construction of Co-planar Multilevel Semiconductor Element of micro and optoelectronics // Thes. Reports. II Republ. Scient. Techn. Confer. The "modern systems are an automat. justices. and their element base". Yerevan. - 1986. – pp.103-104. Yerevan. – 1986.

[5] Karayan H.S., , Jerejyan A.A., Manukyan A.G., Makaryan A.A., Asatryan R.S. Khachatryan A.L., Method of including of semiconductor device // ACE of the USSR №1448970. - 1988.

[6] Ruben Asatryan, Hamlet Karayan, Modelling of Ecoprocesses and Atmosphere's Optical-Electronic Researchs, Palmarium Academic Publishing, ISBN: 978-3-639-72229-1, Saarbrucken, Deutschland, 2015, pp.184.