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RADIATION DOPED SEMICONDUCTORS WITH CERTAIN IMPURITIES

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Abstract- Current fluctuations arise from the presence of external influences. This is the mogutimet place if conductive fluctuation is in an external electric field. In the external electric and magnetic fields and even when there is a temperature gradient in the Wednesday. In semiconductors (electron, electron-type whole type) charge carriers influences are accelerating or slowing down by impurity centers and therefore charge distribution in semiconductor deviates from equilibrium values and while inside a semiconductor appear with different values of the electric field. We shall find some areas of external instability of existence of fluctuation of a current in semiconductors with deep traps with certain concentration. Concentration of deep $(N,N_-)>>(n_+,n_-)$ change a sign on an electric charge at availability recombination and generation of free carriers. Some values of a parity of free carriers of a charge in which are certain, fluctuations of a current appear in-external a circuit. Are certain, that fluctuations of a current very slightly depend on appropriating factors of injection if the inequality $ev_\pm\delta_\pm^{0,L}$<<1 is satisfied. At return an inequality $ev_\pm\delta_\pm^{0,L}$~1 critical value of an external electric field and frequency of fluctuation of a current very strongly change

Keywords: Traps, Frequency, Amplitude, Oscillations, Generation, Recombination.

I. INTRODUCTION

Fluctuations of a current in spending environments arise at availability external influences. It can take place, if the spending environment is in an external electric floor, in external electric and magnetic fields and even at availability of a gradient of temperature in the environment. In semiconductors (electronic type, electronically-hole type) carriers of a charge from external influences are accelerated or slowed down impurity by the centers and consequently distribution of a charge in the semiconductor deviates equilibrium values and thus inside of the semiconductor there are areas with different values of an electric field. These sites (them name domains) move on all image and then there are fluctuations of a current in-external a circuit [2].

In impurity semiconductors recombination and generation of carriers of a current impurity the centers lead to fluctuation of a current in the sample. Availability impurity the centers and their charging conditions causes occurrence of fluctuation of a current in impurity semiconductors.

Some impurity in semiconductors create the centers, capable to be in the several charged conditions (unitary, twice, it is triple positively or negatively charged). For example, atoms of gold in Germany to the order a neutral condition, can be unitary positive also charged or unitary, twice and is triple the negative charged centers; atoms of copper in Germany to the order a neutral condition, can be also unitary, twice and is triple the negative charged centers; atoms of copper in Germany to the order a neutral condition, can be also unitary, twice and is triple the negative charged centers.

These impurities have different power levels in the forbidden zone. In dependence of removal of these levels on a valent zone (or from a bottom of a zone of conductivity) them name deep levels. These deep traps are capable to grasp electrons and holes depending on their charging conditions. Variations of concentration of electrons in a zone of conductivity and holes in a valent zone lead to variation of the general electrical conductivity the semiconductor. Depending on an experimental situation these deep traps possess a different degree of activity. In electric floor E electrons (as well as holes) receive energy eEl (where, e is positive elementary charge, and l is length of free run of electron). Therefore, electrons can overcome Columbic a barrier of unitary charged center and to be grasped, i.e. recombine it. Also generating electrons in deep traps of a zone of conductivity is possible. Besides electrons mightily to be generated from deep traps in a zone of conductivity. At capture of electrons by deep traps in a valent zone, the quantity of holes increases. At capture of electrons from deep traps holes, the quantity of holes decreases.

In the presented theoretical work, we shall construct the theory of external instability in semiconductors with two types of carriers of a charge (electrons and holes) and the certain deep traps at availability of a constant external electric field. The theory of fluctuations in view of a relaxation of carriers of a charge is constructed in work.

In further we shall have to a type of semiconductor possesses carriers of both signs (electrons and holes), with concentration accordingly equal and n_-, n_+.

Concentration of negatively charged traps we shall designate N_0. Let concentration of unitary negatively charged traps equally N and twice negatively charged traps N_-. Total of negatively charged traps N_0 we shall designate it is defined as the sum and N, N_-:

$$N_0 = N + N_- \quad (1)$$

In the model of the semiconductor chosen by us at availability of external constant electric field E_0, there is an electric field inside of the sample

$$\vec{E} = \vec{E}_0 + \vec{E}' \quad (2)$$

Thus concentration of carriers of a charge are defined under formulas

$$n_- = n_0 + n' ;\ n_+ = n_+^0 + n_+' \quad (3)$$

In the semiconductor described in the above-stated parameters occurs fluctuations of carriers of a charge and an electric current. If thus in an external circuit the full current is equal

$$I = I_+ + I_- = \text{const} \quad (4)$$

That fluctuations inside of the sample can grow (because of availability of internal instability).

With occurrence in an external circuit of a part of a current

$$I' \neq 0 \quad (5)$$

There is an external instability. Available instability frequency and a wave vector of fluctuation have a following appearance.

$$k = \frac{2\pi}{L} m \quad , \quad m = 0, \pm 1, \pm 2, \dots \quad (6)$$

$$\omega = \omega_0 + i\omega_1 \quad (7)$$

where, L is the size of the sample, ω_0 and ω_1 real and imaginary parts of frequency of fluctuation inside of the sample, respectively.

At external instability of a conditions (6) and (7) as

$$\omega = \omega_0 \quad , \quad k = k_0 + ik_1 \quad (8)$$

We analyzed conditions of external instability (i.e. conditions of fluctuation of a current in an external circuit) in the above-stated semiconductor in a constant external electric floor.

At the theoretical analysis of external instability, it is necessary to calculate an impedance of the sample. Volt-Ampere the characteristic of the sample in conditions of external instability has a falling site and consequently the actual part of an impedance Z is negative. From the equation

$$\text{Re}\, Z + R = 0 \quad (9)$$

Frequency of fluctuation of a current or value of an electric field in conditions of external instability is defined. In the Equation (9), R is ohmic resistance in the circuit.

The imaginary part of an impedance in a falling site can have a positive or negative sign. Then from the equation

$$\text{Im}\, Z + R_1 = 0 \quad (10)$$

It is defined either frequency, or an electric field. In the given equation R_1 is resistance of capacitor or inductive character.

The basic equation of indissolubility for electrons in the semiconductor with the above-stated types of traps looks like [1]:

$$\frac{\partial n}{\partial t} + \text{div} j_- = \gamma_-(0) n_{1-} N_- - \gamma_-(E) n_- N = \left(\frac{\partial n_-}{\partial t}\right)_{rek} \quad (11)$$

where, j_- is density of a stream of electrons:

$$j_- = -n_- \mu_-(E) - D_- \nabla n_- \quad (12)$$

as well as $\gamma_-(0)$ is factor of emission of electrons twice negatively charged traps in absence of an electric field (it can be named factor of thermal generation). In non-degenerate the semiconductor the given factor from an electric field does not depend [2] and $\gamma_-(E)$ is factor of capture of electrons unitary negatively charged traps at availability of an electric field. Concentration n_{1-} is defined from condition $\left(\frac{\partial n_-}{\partial t}\right)_{rek} = 0$ [3].

$$n_{1-} = \frac{n^0 N_0}{N_-^0} \quad (13)$$

where, $\mu_-(E)$ is the mobility of electrons depending on an electric field, and D_- factor of diffusion of electrons.

The equation of indissolubility for holes will look like [2, 3, 4]:

$$\frac{\partial n_+}{\partial t} + div j_+ = \gamma_+(E) n_{1+} N - \gamma_+(0) n_+ N = \left(\frac{\partial n_+}{\partial t}\right)_{rek} \quad (14)$$

$$j_+ = n_+ \mu_+(E) \vec{E} - D_+ \nabla n_+ \quad (15)$$

$$n_{1+} = \frac{n_+^0 N_-^0}{N_0} \quad (16)$$

Owing to recombination and generation the number twice and unitary negatively charged traps (thus the total of traps remains constant) changes. The equation defining variation of traps in due course looks like [2, 3]:

$$\frac{\partial N_-}{\partial t} = \left(\frac{\partial n_+}{\partial t}\right)_{rek} + \left(\frac{\partial n_-}{\partial t}\right)_{rek} \quad (17)$$

Based on these equations it is necessary to add a condition Gaussian neutrality

$$\text{div} j = e \cdot \text{div}\left(j_+ - j_-\right) \quad (18)$$

According to the expression (18), the full current does not depend on coordinates, but depends on time.

II. EXPERIMENTAL PROCEDURE

A. Theory

The Equations (11), (14), (17) and (18) should be solved in common. At linear approximation and from formulas $E' << E_0, n_\pm' << n_\pm^0$ (11), (14), (17), (18), we shall easily receive:

$$\begin{cases} \left(\nu_- - i\omega - ik\upsilon_- + \frac{T}{e}\mu_- k^2\right)\Delta n''_- + \left(\frac{n\nu_-\beta_-}{E_0} - ik\mu_- n\right)\Delta E'' - \\ -\nu''_-\Delta N''_- = 0 \\ \left(\nu_+ - i\omega - ik\upsilon_+ + \frac{T}{e}\mu_+ k^2\right)\Delta n''_+ + \left(ik\mu_+ n_+ + \frac{n_{1+}\nu_+^E\beta_+}{E_0}\right)\Delta E'' + \\ +\nu'_+\Delta N'_- = 0 \\ \Delta N''_- = \frac{1}{\nu - i\omega}\left[\nu_-\Delta n''_- - \nu_+\Delta n''_+ + \left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\frac{\Delta E''}{E_0}\right] \\ \Delta E'' = \frac{e}{\sigma}\left(-\upsilon_-\Delta n''_- - \upsilon_+\Delta n''_+ + ik\frac{T}{e}\mu_+\Delta n''_+ - ik\frac{T}{e}\mu_-\Delta n''_-\right) \end{cases} \quad (19)$$

$$\begin{cases} \left(\nu_- - i\omega\right)\Delta n'_- + n_-\nu_- - i\omega\beta_-\frac{\Delta E'}{E_0} - \nu'_-\Delta N'_- = 0 \\ \left(\nu_+ - i\omega\right)\Delta n'_+ + n_{1+}\nu_+^E\beta_+\frac{\Delta E'}{E_0} + \nu'_+\Delta N'_- = 0 \\ \Delta N'_- = \frac{1}{\nu_- - i\omega}\left[\nu_-\Delta n'_- - \nu_+\Delta n'_+ + (n'_{1+}\nu_+^E\beta_+ + \right. \\ \left. + n_-\nu_-\beta_-)\frac{\Delta E'}{E_0}\right] \\ \Delta E' = \frac{1}{\sigma}\left(\Delta\upsilon - e\upsilon_-\Delta n'_- - e\upsilon_+\Delta n'_+\right) \end{cases} \quad (20)$$

At reception of Equations (19) and (20) the following designations have been entered:

$$\Delta n_\pm = \Delta n'_\pm e^{-i\omega t} + \Delta n''_\pm e^{i(kx-\omega t)} \quad , \quad E' = \Delta E' + \Delta E'' \quad (21)$$

where, $\nu_- = \gamma_-\left(E_0\right)N_0$ is frequency of capture of electrons unitary charged traps, $\nu_+^E = \gamma_+\left(E_0\right)N_0$ is frequency of emission of holes unitary charged traps, $\nu_+ = \gamma_+\left(0\right)N_-^0$ is Frequency of capture of holes twice charged traps, $\nu'_+ = \gamma_+\left(0\right)n_+^0 + \gamma_+\left(E_0\right)n_{1+}$ is the combined frequency of capture and emission of holes by non-equilibrium traps and $\nu'_- = \gamma_-\left(0\right)n_{1-} + \gamma_-\left(E_0\right)n_-^0$ is the combined frequency of capture and emission of electrons by non-equilibrium traps

$$\nu = \nu'_+ + \nu'_- \quad , \quad \beta_\pm = 2\frac{d\ln\gamma_+\left(E_0\right)}{d\ln\left(E_0^2\right)}$$

Except for these designations which are used $D_\pm = \frac{T}{e}\mu_\pm$ as Einstein's parity.

$n_\pm^0 << N_0, N_-^0 \quad ; \quad \upsilon_\pm^0 = \mu_\pm^0 E_0 = \upsilon_\pm \quad ; \quad n_\pm^0 = n_\pm$

Excepting $\Delta N', \Delta N''_-, \Delta E', \Delta E''$ from the Equations (19) and (20), we shall receive following systems of the equations for definition and a wave vector to:

$$\begin{cases} U_-\left(k\right)\Delta n''_- + U_+(k)\Delta n''_+ = 0 \\ \Phi_-\left(k\right)\Delta n''_- + \Phi_+(k)\Delta n''_+ = 0 \end{cases} \quad (22)$$

$$\begin{cases} U_-\left(0\right)\Delta n'_- + U_+(0)\Delta n'_+ + U\Delta I = 0 \\ \Phi_-\left(0\right)\Delta n'_- + \Phi_+(0)\Delta n'_+ + \Phi\Delta I = 0 \end{cases} \quad (23)$$

The expressions $U_\pm(k)$, $U_\pm(0)$, $\Phi_\pm(k)$ and $\Phi_\pm(0)$ easily turn out from Equations (19) and (20). Therefore, their expressions it is not written out. Solving (23) it is $\Delta n'_\pm$ defined in a following type:

$$\begin{cases} \Delta n'_- = \frac{\Phi_-(0)U - U_+(0)\Phi}{U_-(0)\Phi_+(0) - U_+(0)\Phi_-(0)} = c_-\Delta j \\ \Delta n'_+ = \frac{U_-(0)\Phi - \Phi_-(0)U}{U_-(0)\Phi_+(0) - U_+(0)\Phi_-(0)} = c_+\Delta j \end{cases} \quad (24)$$

For definition of a wave vector, we should solve the dispersive equation received from a determinant, made of factors $U_\pm(k)$ and $\Phi_\pm(k)$:

$$U_-(k)\Phi_+(k) - U_+\left(k\right)\Phi_-(k) = 0 \quad (25)$$

However, the dispersive equation in the form of (25) is too bulky and consequently we shall consider its decision in two limiting cases after

1) High-frequency case, i.e.

$$\sigma = \sigma_+ + \sigma_-$$

$$\frac{\nu'_\pm}{\nu_\pm} << 1, \quad \frac{T\nu_\pm}{eE_0\upsilon_\pm} << 1, \quad \frac{T}{eE_0 l} << 1$$

At the decision of the dispersive Equation (25) we used small parameters, where l is length of a crystal.

2) Low-frequency case, i.e.

$$\begin{cases} k_1 = \frac{\sigma\omega\left[n_-\nu_-{}^2 - n_+\nu_+{}^2 - \left(\nu_- + \nu_+\right)\left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\right] -}{e\mu_-\mu_+E_0\left(n_+\nu_+ - n_-\nu_- + n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)^2} \\ \underline{-i\sigma\nu_-\nu''_+\left(n_+\nu_+ - n_-\nu_- + n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)} \end{cases} \quad (26)$$

$$k_2 = \frac{1}{\left[\left(\sigma_- - \sigma_+\right)\left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right) - \sigma\left(n_+\nu_+ + n_-\nu_-\right)\right]^2}\cdot$$
$$\cdot\left\{\sigma^2\omega\cdot\left[\left(2n_-n_+\left(\nu_- - \nu_+\right) - \left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\left(n_- + n_+\right) + \right.\right.\right.$$
$$+\sigma\omega\left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\left(n_- - n_+\right)\left(\sigma_- - \sigma_+\right) - i\sigma. \quad (27)$$
$$\cdot\left(n_+\nu_+ + n_-\nu_- + n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\cdot$$
$$\cdot\left[\left(n_-\nu_-\beta_- + n_{1+}\nu_+^E\beta_+\right)\left(\sigma_- - \sigma_+\right) - \sigma\left(n_-\nu_- + n_+\nu_+\right)\right]$$

After finding of expression of wave vectors k_1 and k_2 by means of the Equation (27), it is possible to calculate an impedance of a crystal, representing expression catch.

B. Impedance Expression

For definition of constants we should use boundary conditions of deviations from equilibrium conditions. In dependence by-pass directions of both contacts it is possible to distinguish two types of boundary conditions:

1. In both contacts particles of an identical sign are injected

$$\begin{cases} \Delta E\left(x,t\right) = \frac{1}{\sigma}\left(\Delta J - e\upsilon_-\Delta n_- + e\upsilon_+\Delta n_+ + \frac{T}{e}\mu_+\nabla n_+ - \frac{T}{e}\mu_-\nabla n_-\right) \\ \Delta n_+ = c_1^+ e^{ik_1x} + c_2^+ e^{ik_2x} + c^+\Delta J \; u \; \Delta n_+ = c_1^- e^{ik_1x} + c_2^- e^{ik_2x} + c^-\Delta J \end{cases} \quad (28)$$

2. In both contacts particles of an opposite sign are injected

$$\begin{cases} Z=\frac{1}{\Delta JS'}\int_0^L \Delta E(x,t)dx = Z_0\left[1-\frac{e\left(e^{ik_1L}-1\right)}{\sigma}\left(\frac{\upsilon_- C_1^- + \upsilon_+ C_1^+}{\Delta J i k_1 L}\right)+\right. \\ \left. +\frac{T}{e}\frac{\mu_- C_1^- + \mu_+ C_1^+}{\Delta JL} - \frac{e}{\sigma}(\upsilon_- C^- + \upsilon_+ C^+\right] \end{cases} \quad (29)$$

Considering all four cases we should define constants $C_{1,2}^{\pm}$ and therefore an impedance crystal under the Equation (29). In the meantime, the way of definition of constants is identical in all four cases. Therefore, boundary conditions we shall write in such type

$$\begin{cases} \Delta n_+(0)=\delta_+(0)\Delta J' \ , \ \Delta n_+(L)=\delta_+(L)\Delta J' \\ \Delta n_-(0)=\delta_-(0)\Delta J' \ , \ \Delta n_-(L)=\delta_-(L)\Delta J' \end{cases} \quad (30)$$

Substituting (30) in (28) we shall receive

$$\begin{cases} C_1^+ = \frac{\left[\delta_+(0)-C^+\right]\left(e^{\alpha_2}-e^{\alpha_1}\right)-\left[\delta_+(L)-\delta_+(0)\right]}{\left(e^{\alpha_2}-e^{\alpha_1}\right)}\Delta J' \\ C_2^+ = \frac{\left[\delta_+(L)-\delta_+(0)\right]}{\left(e^{\alpha_2}-e^{\alpha_1}\right)}\Delta J' \\ C_1^- = \frac{\left[\delta_+(0)-C^-\right]\left(e^{\alpha_2}-e^{\alpha_1}\right)-\left[\delta_-(L)-\delta_-(0)\right]}{\left(e^{\alpha_2}-e^{\alpha_1}\right)}\Delta J' \\ C_2^- = \frac{\left[\delta_-(L)-\delta_-(0)\right]}{\left(e^{\alpha_2}-e^{\alpha_1}\right)}\Delta J' \end{cases} \quad (31)$$

Substituting (31) in (29) we shall receive expressions of an impedance as function of an electric field and frequency of fluctuation of a current. However, the received expressions of an impedance are bulky enough. Therefore, they will be analyzed in following limiting cases.

High-frequency case: $\omega >> \nu_+^E, \nu_\pm, \nu'_\pm$

1. $n_- >> n$, gives δ_+^0

$$\begin{cases} \frac{\operatorname{Re} Z}{Z_0} = 2-\frac{E_0}{E_1}\left(\frac{\mu_-}{\mu_+}\sin\theta+\ln\theta\right)- \\ -\frac{E_0^2}{(E_{\delta_+^0})}\left(\frac{\omega}{\nu_+}\sin\theta+\ln\theta\right)=0 \\ \frac{\operatorname{Im} Z}{Z_0} = \frac{E_0}{E_1}\left(\frac{4\omega}{\nu_+}\cos\theta-\frac{\omega}{\nu_+}\right)+ \\ +\frac{E_0^2\omega}{E_{\delta+}^2(\nu_+^E)}\frac{n_-}{n_+}\left(2\sin\theta-\frac{\omega}{\nu_+}\cos\theta\right)+1=0 \\ \frac{1}{E_1}=\frac{n_-\nu_+^2\mu_+ e\beta_+}{L\nu_+^2 n_1} \quad , \quad \frac{1}{E^2(\delta_+^L)}=\frac{\mu_+^2\beta_+ e\delta_+^0}{L\nu_+\mu_-} \end{cases} \quad (32)$$

From (32) at $\theta=\pi/2$:

$$E_0=E_1;\ \omega=2\nu_+\left(\frac{E\delta_+^0}{E_1}\right)^2$$

2. $n_- >> n_+$, gives δ_-^0

$$\begin{cases} \frac{\operatorname{Re} Z}{Z_0} = 2-\frac{\vartheta_+\beta_+}{L\nu_+}+\frac{\vartheta_+\beta_+}{L\nu_+}\left(\frac{3\omega_-}{\nu_+}\sin\theta+\ln\theta\right)- \\ -\frac{E_0^2}{E_{\delta_+^0}}\left(\frac{\omega}{\nu_+}\sin\theta+\ln\theta\right)=0 \\ \frac{\operatorname{Im} Z}{Z_0} = \frac{3\vartheta_+\beta_-\omega}{L\nu_+^2} - \frac{\vartheta_+\beta_+}{L\nu_+}\left(\sin\theta+3\cos\theta\right)+ \\ +\frac{E_0^2}{E_{\delta_+^0}}\left(\sin\theta+\frac{\omega}{\nu_+}\ln\theta\right)+1=0 \\ \frac{1}{E^2(\delta_+^L)}=\frac{\mu_+\mu_-\beta_- e\delta_-^0}{L\nu_+} \end{cases} \quad (33)$$

From the (33) we easily obtain

$$\frac{\omega}{\nu_+}=\frac{1}{6}<<1 \ \ ; \ E_0=\frac{L\nu_+}{6\mu_+\beta_-}$$

3. $n_- << n_+$, gives δ_-^0

$$\begin{cases} \frac{\operatorname{Re} Z}{Z_0} = 2-a-\frac{E_0^2}{E^2(\delta_-^L)}- \\ -\frac{E_0^2}{E^2(\delta_-^L)}\left(\frac{\omega}{\nu_+}\sin\theta-\ln\theta\right)=0 \\ \frac{\operatorname{Im} Z}{Z_0} = b-\frac{E_0^2}{E^2(\delta_-^L)}-\frac{\vartheta_+\beta_+\omega}{L\nu_+\nu_+}+ \\ +\frac{E_0^2}{E^2(\delta_-^L)}\left(\sin\theta+\frac{\omega}{\nu_+}\ln\theta\right)=0 \end{cases} \quad (34)$$

From (34) at $\theta=2\pi$:

$$\frac{\omega}{\nu_+}=\frac{1}{\beta_-\nu_-}\frac{\nu_+^2}{\nu_+^E}<<1 \ \ ; \ E_0=E_\delta\left(\frac{2}{\beta_-}\frac{\nu_+^2}{\nu_-\nu_+^E}\right)^{1/2}$$

4. $n_- << n_+$, gives δ_+^0

$$\begin{cases} \frac{\operatorname{Re} Z}{Z_0} = 2-a-\frac{E_0^2}{E^2(\delta_+^L)}-\frac{E_0^2}{E^2(\delta_+^L)}\left(\sin\theta-\cos\theta\right)+ \\ +\frac{E_0}{E_1}(\sin\theta+\cos\theta)=0 \\ \frac{\operatorname{Im} Z}{Z_0} = b-\frac{E_0^2}{E_1}\left(\sin\theta+\frac{2\omega}{\nu_+}\ln\theta\right)+ \\ +\frac{E_0^2}{E^2(\delta_+^L)}\left(\sin\theta+\frac{\omega}{\nu_+}\ln\theta\right)+1=0 \end{cases} \quad (35)$$

From solving (35) it is given

$$E_0=2E_\delta \quad , \quad \frac{\omega}{\nu_+}=\frac{E_1}{E_\delta}<<1$$

III. CONCLUSIONS

The analysis of all results in a high-frequency limit leads to a following conclusion. In a high-frequency limit (frequency it is much more than fluctuation of a current than all characteristic frequencies entering into theories) is possible supervision of several areas of instability.

These areas essentially depend on value of concentration of carriers of a current, from value of an external electric field, from frequency of fluctuations. Dependence of these observable areas of instability on factors intentions proves only at a high level of injection at $e\upsilon_{\pm}\delta_{\pm}^{0}$, L~1 fluctuations in-external a circuit, both in high-frequency, and in a low-frequency limit.

Conditions of occurrence of these fluctuations depend on different parities of equilibrium concentration of carriers and different values of an external constant electric field and slightly depend on factors of injection. At very greater levels of injection of a condition of occurrence of these fluctuations depend strongly on factors of injection.

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BIOGRAPHIES

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