USING POROSITY OF EPITAXIAL LAYER TO DECREASE QUANTITY OF RADIATION DEFECTS GENERATED DURING RADIATION PROCESSING OF A MULTILAYER STRUCTURE

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ABSTRACT

In this paper we consider redistribution of radiation defects, which were generated during radiation processing, in a multilayer structure with porous epitaxial layer. It has been shown, that porosity of epitaxial layer gives a possibility to decrease quantity of radiation defects.

KEYWORDS

Multilayer structure; porous epitaxial layer; radiation processing; decreasing of quantity of radiation defects.

1. INTRODUCTION

One of actual questions of solid state electronics is increasing of radiation resistance. Several methods are using to increase the radiation resistance of devices of solid state electronics [1-5]. One way to decrease quantity of radiation defects, generated during radiation processing of materials, we present in our paper. Framework the approach we consider a heterostructure, which consist of a substrate and porous epitaxial layer (see Fig. 1). We assume, that the substrate was under influence of radiation processing (ion implantation, effects of cosmic radiation et al) through the epitaxial layer. Radiation processing of materials leads to generation of radiation defects. In this paper we analyzed influence of porosity of material on distribution of concentration of radiation defects in the considered material.

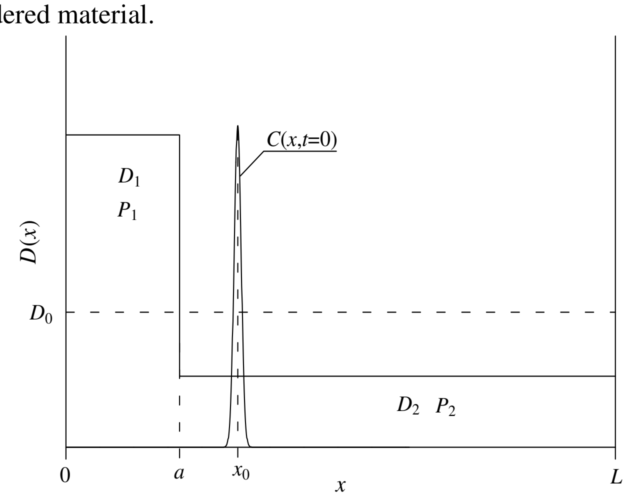

Fig. 1. Heterostructure, which includes into itself a substrate and an epitaxial layer. The figure also shows distribution of concentration of implanted dopant

2. METHOD OF SOLUTION

We solve our aim by analysis of distributions of concentrations of radiation defects in space and time in the considered heterostructure. We determine the above distributions by solving the following system of equations [6-11]

$$\frac{\partial I(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)\,I(x,y,z,t)\,V(x,y,z,t)-k_{I,I}(x,y,z,T)\times$$
$$\times I^2(x,y,z,t)+\frac{\partial}{\partial x}\left[\frac{D_{IS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{IS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{IS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]$$
$$\frac{\partial V(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial y}\right]+ \quad (1)$$
$$+\frac{\partial}{\partial z}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)\,I(x,y,z,t)\,V(x,y,z,t)-k_{V,V}(x,y,z,T)\times$$
$$\times V^2(x,y,z,t)+\frac{\partial}{\partial x}\left[\frac{D_{VS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{VS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{VS}}{\bar V kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]$$

with boundary and initial conditions

$$\left.\frac{\partial I(x,y,z,t)}{\partial x}\right|_{x=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial x}\right|_{x=L_x}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial y}\right|_{y=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial y}\right|_{y=L_y}=0,$$
$$\left.\frac{\partial I(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial x}\right|_{x=0}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial x}\right|_{x=L_x}=0,$$
$$\left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=0}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=L_y}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,$$
$$I(x,y,z,0)=f_I(x,y,z),\ V(x,y,z,0)=f_V(x,y,z),\ V(x_1+V_nt,y_1+V_nt,z_1+V_nt,t)=V^*\left(1+\frac{2\ell\omega}{kT\sqrt{x_1^2+y_1^2+z_1^2}}\right). \quad (2)$$

Here $I(x,y,z,t)$ and $V(x,y,z,t)$ are the spatio-temporal distributions of concentrations of interstitials and vacancies; I^* and V^* are the equilibrium distributions of concentrations of interstitials and vacancies; diffusion coefficients of interstitials and vacancies have been described by the following functions $D_I(x,y,z,T)$ and $D_V(x,y,z,T)$; terms with squares of concentrations of interstitials and vacancies ($V^2(x,y,z,t)$ and $I^2(x,y,z,t)$, respectively) correspond to generation divacancies and analogous complexes of interstitials (see, for example, [10] and appropriate references in this work); $k_{I,V}(x,y,z,T)$ is the parameter of recombination of point defects; $k_{I,I}(x,y,z,T)$ and $k_{V,V}(x,y,z,T)$ are the parameters of generation of complexes of point defects and generation; k, V^*, ℓ and a are the Boltzmann constant, the equilibrium distribution of vacancies, the atomic spacing and the specific surface energy, respectively. $\omega=a^3$. Framework taking into account porosity we assume, that at initial stage porous are approximately cylindrical with average dimensions $r=\sqrt{x_1^2+y_1^2}$ and z_1 [12]. With time small pores decomposing into vacancies. The vacancies are absorbed by large pores [8]. The large pores takes spherical form during the absorbtion [8]. We determine distribution of concentration of vacancies, which was formed due to porosity, by summing over all pores, i.e.

$$V(x,y,z,t)=\sum_{i=0}^{l}\sum_{j=0}^{m}\sum_{k=0}^{n}V_p(x+i\,\alpha,y+j\,\beta,z+k\,\chi,t),\ R=\sqrt{x^2+y^2+z^2}\ .$$

Averaged distances between centers of pores are equal to α, β and χ in x, y and z directions, respectively. Quantities of pores in x, y and z directions are equal to i, j and k.

Distributions of concentrations of divacancies $\Phi_V(x,y,z,t)$ and diinterstitials $\Phi_I(x,y,z,t)$ in space and time have been calculated by solving the following system of equations [9-11]

$$\begin{aligned}\frac{\partial\Phi_I(x,y,z,t)}{\partial t}&=\frac{\partial}{\partial x}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_I(x,y,z,t)}{\partial y}\right]+\\&+\frac{\partial}{\partial z}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_I(x,y,z,t)}{\partial z}\right]+k_I(x,y,z,T)I(x,y,z,t)+k_{I,I}(x,y,z,T)I^2(x,y,z,t)+\\&+\frac{\partial}{\partial x}\left[\frac{D_{\Phi IS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi IS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi IS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]\end{aligned}\qquad(3)$$

$$\begin{aligned}\frac{\partial\Phi_V(x,y,z,t)}{\partial t}&=\frac{\partial}{\partial x}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_V(x,y,z,t)}{\partial y}\right]+\\&+\frac{\partial}{\partial z}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_V(x,y,z,t)}{\partial z}\right]+k_V(x,y,z,T)V(x,y,z,t)+k_{V,V}(x,y,z,T)V^2(x,y,z,t)+\\&+\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi VS}}{\bar V kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]\end{aligned}$$

with boundary and initial conditions

$$\left.\frac{\partial\Phi_I(x,y,z,t)}{\partial x}\right|_{x=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial x}\right|_{x=L_x}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial y}\right|_{y=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial y}\right|_{y=L_y}=0,$$

$$\left.\frac{\partial\Phi_I(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial I(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,\ \left.\frac{\partial\Phi_V(x,y,z,t)}{\partial x}\right|_{x=0}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial x}\right|_{x=L_x}=0,$$

$$\left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=0}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=L_y}=0,\ \left.\frac{\partial V(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial\Phi_V(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,$$

$\Phi_I(x,y,z,0)=f_{\Phi I}(x,y,z)$, $\Phi_V(x,y,z,0)=f_{\Phi V}(x,y,z)$. (4)

Functions $D_{\Phi I}(x,y,z,T)$ and $D_{\Phi V}(x,y,z,T)$ describe spatial and temperature dependences of the diffusion coefficients of complexes of radiation defects; $k_I(x,y,z,T)$ and $k_V(x,y,z,T)$ are the parameters of decay of the above complexes.

We calculate distributions of concentrations of radiation defects in space and time by method of averaging of function corrections [13]. To use the approach we write the Eqs. (1) and (3) with account initial distributions of defects, i.e.

$$\frac{\partial I(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)I(x,y,z,t)V(x,y,z,t)+f_I(x,y,z)\delta(t)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]-$$
$$-k_{I,I}(x,y,z,T)I^2(x,y,z,t)$$

(1*a*)

$$\frac{\partial V(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,T)I(x,y,z,t)V(x,y,z,t)+f_V(x,y,z)\delta(t)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]-$$
$$-k_{V,V}(x,y,z,T)V^2(x,y,z,t)$$

$$\frac{\partial \Phi_I(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial z}\right]+k_I(x,y,z,T)I(x,y,z,t)+k_{I,I}(x,y,z,T)I^2(x,y,z,t)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]+$$
$$+f_{\Phi I}(x,y,z)\delta(t)$$

(3*a*)

$$\frac{\partial \Phi_V(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial z}\right]+k_V(x,y,z,T)V(x,y,z,t)+k_{V,V}(x,y,z,T)V^2(x,y,z,t)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]+$$
$$+f_{\Phi I}(x,y,z)\delta(t).$$

Now we use not yet known average values $\alpha_{1\rho}$ of the required concentrations in right sides of the Eqs. (1*a*) and (3*a*) instead of the concentrations. The replacement gives us possibility to obtain following equations for determination the first-order approximations of concentrations of radiation defects in the following form

$$\frac{\partial I_1(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+f_I(x,y,z)\delta(t)+$$

$$+\frac{\partial}{\partial z}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]-\alpha_{1I}^2 k_{I,I}(x,y,z,T)-\alpha_{1I}\alpha_{1V}k_{I,V}(x,y,z,T) \tag{1b}$$

$$\frac{\partial V_1(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+f_V(x,y,z)\delta(t)+$$
$$+\frac{\partial}{\partial z}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]-\alpha_{1V}^2 k_{V,V}(x,y,z,T)-\alpha_{1I}\alpha_{1V}k_{I,V}(x,y,z,T)$$

$$\frac{\partial \Phi_{1I}(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+f_{\Phi I}(x,y,z)\delta(t)+$$
$$+\frac{\partial}{\partial z}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]+k_I(x,y,z,T)I(x,y,z,t)+k_{I,I}(x,y,z,T)I^2(x,y,z,t) \tag{3b}$$

$$\frac{\partial \Phi_{1V}(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+f_{\Phi V}(x,y,z)\delta(t)+$$
$$+\frac{\partial}{\partial z}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]+k_V(x,y,z,T)V(x,y,z,t)+k_{V,V}(x,y,z,T)V^2(x,y,z,t).$$

Integration of the both sides of Eqs. (1*b*) and (3*b*) on time gives a possibility to obtain first-order approximations of concentrations of radiation defects in the final form

$$I_1(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}d\tau+f_I(x,y,z)+$$
$$+\frac{\partial}{\partial z}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}d\tau-\alpha_{1I}^2\int_0^t k_{I,I}(x,y,z,T)d\tau-\alpha_{1I}\alpha_{1V}\int_0^t k_{I,V}(x,y,z,T)\,d\tau \tag{1c}$$

$$V_1(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}d\tau+f_V(x,y,z)+$$
$$+\frac{\partial}{\partial z}\int_0^t\frac{D_{VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}d\tau-\alpha_{1V}^2\int_0^t k_{V,V}(x,y,z,T)d\tau-\alpha_{1I}\alpha_{1V}\int_0^t k_{I,V}(x,y,z,T)\,d\tau$$

$$\Phi_{1I}(x,y,z,t)=f_{\Phi I}(x,y,z)+\int_0^t k_I(x,y,z,T)I(x,y,z,\tau)d\tau+\int_0^t k_{I,I}(x,y,z,T)I^2(x,y,z,\tau)d\tau+$$
$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial z}d\tau$$
$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial z}d\tau \tag{3c}$$

$$\Phi_{1V}(x,y,z,t)=f_{\Phi V}(x,y,z)+\int_0^t k_V(x,y,z,T)V(x,y,z,\tau)\,d\tau+\int_0^t k_{V,V}(x,y,z,T)V^2(x,y,z,\tau)d\tau+$$
$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,\tau)}{\partial z}d\tau.$$

We calculate average values of the required approximations by the following relation [13]

$$\alpha_{1\rho} = \frac{1}{\Theta L_x L_y L_z} \int_0^{\Theta} \int_0^{L_x} \int_0^{L_y} \int_0^{L_z} \rho_1(x, y, z, t)\, d\,z\, d\, y\, d\, x\, d\, t\,. \tag{5}$$

Substitution of the relations (1c) and (3c) into the relation (5) gives a possibility to calculate the required average values in the following form

$$\alpha_{1I} = \sqrt{\frac{(a_3 + A)^2}{4a_4^2} - 4\left(B + \frac{\Theta a_3 B + \Theta^2 L_x L_y L_z a_1}{a_4}\right)} - \frac{a_3 + A}{4a_4},\ \alpha_{1V} = \left[\int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_I\,(x, y, z)\; d\,z\,d\;y\,d\;x \times\right.$$

$$\left.\times \frac{\Theta}{\alpha_{1I}} - \alpha_{1I} S_{II\,00} - \Theta\, L_x L_y L_z\right] \frac{1}{S_{IV\,00}},\ \alpha_{1\Phi I} = \frac{R_{I1}}{\Theta L_x L_y L_z} + \frac{1}{L_x L_y L_z} \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_{\Phi I}\,(x, y, z)\; d\,z\,d\;y\,d\;x +$$

$$+ \frac{S_{II\,20}}{\Theta L_x L_y L_z},\ \alpha_{1\Phi V} = \frac{1}{L_x L_y L_z} \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_{\Phi V}\,(x, y, z)\; d\,z\,d\;y\,d\;x + \frac{R_{V1} + S_{VV\,20}}{\Theta L_x L_y L_z}.$$

Here $S_{\rho\rho\, ij} = \int_0^{\Theta} (\Theta - t) \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} k_{\rho,\rho}(x, y, z, T) I_1^i(x, y, z, t) V_1^j(x, y, z, t)\, d\,z\, d\,y\, d\,x\, d\,t$, $a_4 = \left(S_{IV\,00}^2 - S_{II\,00} S_{VV\,00}\right)\times$ $\times\, S_{II\,00}$, $a_3 = S_{IV\,00} S_{II\,00} + S_{IV\,00}^2 - S_{II\,00} S_{VV\,00}$, $a_2 = S_{IV\,00} S_{IV\,00}^2 \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_V\,(x, y, z)\,d\,z\,d\;y\,d\;x + 2\,S_{VV\,00} \times$ $\times S_{II\,00} \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_I\,(x, y, z)\,d\,z\,d\;y\,d\;x - S_{IV\,00}^2 \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_I\,(x, y, z)\,d\,z\,d\;y\,d\;x + S_{IV\,00}\Theta L_x^2 L_y^2 L_z^2 - L_x^2 L_y^2 L_z^2 \times$ $\times\, \Theta S_{VV00}$, $a_1 = S_{IV\,00} \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_I\,(x, y, z)\,d\,z\,d\;y\,d\;x$, $a_0 = S_{VV00}\left[\int_0^{L_x}\int_0^{L_y}\int_0^{L_z} f_I\,(x, y, z)\,d\,z\,d\,y\,d\,x\right]^2$, $q = \frac{\Theta^3 a_2}{24\,a_4^2}\times$ $\times\left(4a_0 - \Theta L_x L_y L_z \frac{a_1 a_3}{a_4}\right) - \Theta^2 \frac{a_0}{8a_4^2}\left(4\Theta a_2 - \Theta^2 \frac{a_3^2}{a_4}\right) - \frac{\Theta^3 a_2^3}{54 a_4^3} - L_x^2 L_y^2 L_z^2 \frac{\Theta^4 a_1^2}{8 a_4^2}$, $A = \sqrt{8y + \Theta^2 \frac{a_3^2}{a_4^2} - 4\Theta \frac{a_2}{a_4}}$, $R_{\rho\, i} = \int_0^{\Theta} (\Theta - t) \int_0^{L_x}\int_0^{L_y}\int_0^{L_z} k_I(x, y, z, T) I_1^i(x, y, z, t)\; d\,z\,d\,y\,d\,x\,d\,t$, $p = \Theta^2 \frac{4a_0 a_4}{12 a_4^2} - \frac{\Theta\, a_2}{18\, a_4} - L_x L_y L_z \frac{\Theta\, a_1 a_3}{12\, a_4^2}$, $B = \frac{\Theta\, a_2}{6\, a_4} + \sqrt[3]{\sqrt{q^2 + p^3} - q} - \sqrt[3]{\sqrt{q^2 + p^3} + q}$.

Approximations of concentrations of radiations defects with the second and higher orders have been calculated framework standard iterative procedure of method of averaging of function corrections [13]. Framework the procedure we determine the approximation of the n-th order by replacement of the concentrations of radiation defects $I\,(x,y,z,\ t)$, $V\,(x,y,z,t)$, $\Phi_I\,(x,y,z,t)$ and Φ_V (x,y,z,t) in right sides of the Eqs.(1b) and (3b) on the following sums $\alpha_{n\rho}+\rho_{\ n-1}(x,y,z,t)$. The replacement gives a possibility to obtain the second-order approximations of concentrations of radiation defects

$$\frac{\partial\, I_2(x, y, z, t)}{\partial\, t} = \frac{\partial}{\partial\, x}\left[D_I(x, y, z, T)\frac{\partial\, I_1(x, y, z, t)}{\partial x}\right] + \frac{\partial}{\partial\, y}\left[D_I(x, y, z, T)\frac{\partial\, I_1(x, y, z, t)}{\partial\, y}\right] +$$

$$+ \frac{\partial}{\partial\, z}\left[D_I(x, y, z, T)\frac{\partial\, I_1(x, y, z, t)}{\partial\, z}\right] - k_{I,V}(x, y, z, T)\left[\alpha_{1I} + I_1(x, y, z, t)\right]\left[\alpha_{1V} + V_1(x, y, z, t)\right] +$$

$$+ \frac{\partial}{\partial\, x}\int_0^t \frac{D_{IS}}{\bar{V}\,kT}\frac{\partial \mu_2(x, y, z, t)}{\partial\, x}\, d\,\tau + \frac{\partial}{\partial\, y}\int_0^t \frac{D_{IS}}{\bar{V}\,kT}\frac{\partial \mu_2(x, y, z, t)}{\partial\, y}\, d\,\tau + \frac{\partial}{\partial\, z}\int_0^t \frac{D_{IS}}{\bar{V}\,kT}\frac{\partial \mu_2(x, y, z, t)}{\partial\, z}\, d\,\tau -$$

$$- k_{I,I}(x, y, z, T)\left[\alpha_{1I} + I_1(x, y, z, t)\right]^2 \tag{1d}$$

$$\frac{\partial V_2(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_V(x,y,z,T)\frac{\partial V_1(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_V(x,y,z,T)\frac{\partial V_1(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_V(x,y,z,T)\frac{\partial V_1(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)[\alpha_{1I}+I_1(x,y,z,t)][\alpha_{1V}+V_1(x,y,z,t)]+$$
$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}d\tau-$$
$$-k_{V,V}(x,y,z,T)[\alpha_{1I}+V_1(x,y,z,t)]^2$$

$$\frac{\partial\Phi_{2I}(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_{1I}(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_{1I}(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_{1I}(x,y,z,t)}{\partial z}\right]+k_{I,I}(x,y,z,T)I^2(x,y,z,t)+f_{\Phi I}(x,y,z)\delta(t)+k_I(x,y,z,T)\times$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]\quad(3d)$$

$$\frac{\partial\Phi_{2V}(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_{1V}(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_{1V}(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi V}(x,y,z,T)\frac{\partial\Phi_{1I}(x,y,z,t)}{\partial z}\right]+k_{V,V}(x,y,z,T)V^2(x,y,z,t)+k_V(x,y,z,T)\,V(x,y,z,t)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right].$$

Integration of the both sides of Eqs. (1*d*) and (3*d*) gives a possibility to obtain relations for the second-order approximations of the required concentrations of radiation defects in the following form

$$I_2(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t D_I(x,y,z,T)\frac{\partial I_1(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t D_I(x,y,z,T)\frac{\partial I_1(x,y,z,\tau)}{\partial y}d\tau+$$
$$+\frac{\partial}{\partial z}\int_0^t D_I(x,y,z,T)\frac{\partial I_1(x,y,z,\tau)}{\partial z}d\tau-\int_0^t k_{I,I}(x,y,z,T)\,[\alpha_{2I}+I_1(x,y,z,\tau)]^2d\tau-$$
$$-\int_0^t k_{I,V}(x,y,z,T)[\alpha_{2I}+I_1(x,y,z,\tau)][\alpha_{2V}+V_1(x,y,z,\tau)]\,d\tau+f_I(x,y,z)+$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]$$
$$+\frac{\partial}{\partial x}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{IS}}{\bar{V}kT}\frac{\partial\mu_2(x,y,z,t)}{\partial z}\right]\quad(1e)$$

$$V_2(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t D_V(x,y,z,T)\frac{\partial V_1(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t D_V(x,y,z,T)\frac{\partial V_1(x,y,z,\tau)}{\partial y}d\tau+$$
$$+\frac{\partial}{\partial z}\int_0^t D_V(x,y,z,T)\frac{\partial V_1(x,y,z,\tau)}{\partial z}d\tau-\int_0^t k_{V,V}(x,y,z,T)\,[\alpha_{2V}+V_1(x,y,z,\tau)]^2d\tau-$$
$$-\int_0^t k_{I,V}(x,y,z,T)[\alpha_{VI}+I_1(x,y,z,\tau)][\alpha_{2V}+V_1(x,y,z,\tau)]\,d\tau+f_V(x,y,z)+$$

$$+\frac{\partial}{\partial x}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[\frac{D_{VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,t)}{\partial z}\right]$$

$$\Phi_{2I}(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{1I}(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{1I}(x,y,z,\tau)}{\partial y}d\tau+$$

$$+\frac{\partial}{\partial z}\int_0^t D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{1I}(x,y,z,\tau)}{\partial z}d\tau+\int_0^t k_{I,I}(x,y,z,T)I^2(x,y,z,\tau)\,d\tau+f_{\Phi I}(x,y,z)+$$

$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{\Phi IS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial z}d\tau+$$

$$+\int_0^t k_I(x,y,z,T)I(x,y,z,\tau)\,d\tau \qquad (3e)$$

$$\Phi_{2V}(x,y,z,t)=\frac{\partial}{\partial x}\int_0^t D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_{1V}(x,y,z,\tau)}{\partial x}d\tau+f_{\Phi V}(x,y,z)+\frac{\partial}{\partial y}\int_0^t D_{\Phi V}(x,y,z,T)+$$

$$+\frac{\partial}{\partial z}\int_0^t D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_{1V}(x,y,z,\tau)}{\partial z}d\tau+f_{\Phi V}(x,y,z)+\int_0^t k_V(x,y,z,T)V(x,y,z,\tau)\,d\tau+$$

$$+\frac{\partial}{\partial x}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial x}d\tau+\frac{\partial}{\partial y}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial y}d\tau+\frac{\partial}{\partial z}\int_0^t\frac{D_{\Phi VS}}{\bar{V}kT}\frac{\partial \mu_2(x,y,z,\tau)}{\partial z}d\tau+$$

$$+\int_0^t k_{V,V}(x,y,z,T)V^2(x,y,z,\tau)\,d\tau.$$

We determine average values of the second-order approximations by the standard relation [13]

$$\alpha_{2\rho}=\frac{1}{\Theta L_xL_yL_z}\int_0^\Theta\int_0^{L_x}\int_0^{L_y}\int_0^{L_z}\left[\rho_2(x,y,z,t)-\rho_1(x,y,z,t)\right]dz\,dy\,dx\,dt. \qquad (6)$$

Substitution of the relations (1*e*) and (3*e*) in the relation (6) gives a possibility to obtain relations for the required values $\alpha_{2\rho}$

$$\alpha_{2C}=0,\ \alpha_{2\Phi I}=0,\ \alpha_{2\Phi V}=0,\ \alpha_{2V}=\sqrt{\frac{(b_3+E)^2}{4b_4^2}-4\left(F+\frac{\Theta a_3F+\Theta^2L_xL_yL_zb_1}{b_4}\right)}-\frac{b_3+E}{4b_4},$$

$$\alpha_{2I}=\frac{C_V-\alpha_{2V}^2S_{VV00}-\alpha_{2V}\left(2S_{VV01}+S_{IV10}+\Theta L_xL_yL_z\right)-S_{VV02}-S_{IV11}}{S_{IV01}+\alpha_{2V}S_{IV00}},$$

where $b_4=\frac{1}{\Theta L_xL_yL_z}S_{IV00}^2S_{VV00}-\frac{1}{\Theta L_xL_yL_z}S_{VV00}^2S_{II00}$, $b_3=-\left(2S_{VV01}+S_{IV10}+\Theta L_xL_yL_z\right)\frac{S_{II00}S_{VV00}}{\Theta L_xL_yL_z}+$

$$+\frac{S_{IV00}S_{VV00}}{\Theta L_xL_yL_z}\left(S_{IV01}+2S_{II10}+S_{IV01}+\Theta L_xL_yL_z\right)+\left(2S_{VV01}+S_{IV10}+\Theta L_xL_yL_z\right)\frac{S_{IV00}^2}{\Theta L_xL_yL_z}-\frac{S_{IV00}^2S_{IV10}}{\Theta^3L_x^3L_y^3L_z^3},$$

$$b_2=\frac{S_{II00}S_{VV00}}{\Theta L_xL_yL_z}\left(S_{VV02}+S_{IV11}+C_V\right)-\left(\Theta L_xL_yL_z-2S_{VV01}+S_{IV10}\right)^2+\left(\Theta L_xL_yL_z+2S_{II10}+S_{IV01}\right)\times$$

$$\times\frac{S_{IV01}S_{VV00}}{\Theta L_xL_yL_z}+\frac{S_{IV00}}{\Theta L_xL_yL_z}\left(\Theta L_xL_yL_z+S_{IV01}+2S_{II10}+2S_{IV01}\right)\left(\Theta L_xL_yL_z+2S_{VV01}+S_{IV10}\right)-S_{IV00}^2\times$$

$$\times\frac{C_V-S_{VV02}-S_{IV11}}{\Theta L_xL_yL_z}+\frac{C_IS_{IV00}^2}{\Theta^2L_x^2L_y^2L_z^2}-2S_{IV10}\frac{S_{IV00}S_{IV01}}{\Theta L_xL_yL_z},\ b_1=S_{II00}\left(2S_{VV01}+S_{IV10}+\Theta L_xL_yL_z\right)\times$$

$$\times\frac{S_{IV11}+S_{VV02}+C_V}{\Theta L_x L_y L_z}+S_{IV01}\frac{\Theta L_x L_y L_z+2S_{II10}+S_{IV01}}{\Theta L_x L_y L_z}\left(2S_{VV01}+S_{IV10}+\Theta L_x L_y L_z\right)-\frac{S_{IV00}}{\Theta L_x L_y L_z}\times$$

$$\times\left(3S_{IV01}+2S_{II10}+\Theta L_x L_y L_z\right)\left(C_V-S_{VV02}-S_{IV11}\right)+2C_I S_{IV00}S_{IV01}-\frac{S_{IV10}S_{IV01}^2}{\Theta L_x L_y L_z},\ b_0=\frac{S_{II00}}{\Theta L_x L_y L_z}\times$$

$$\times\left(S_{IV00}+S_{VV02}\right)^2-S_{IV01}\frac{C_V-S_{VV02}-S_{IV11}}{\Theta L_x L_y L_z}\left(\Theta L_x L_y L_z+2S_{II10}+S_{IV01}\right)-\frac{C_V-S_{VV02}-S_{IV11}}{\Theta L_x L_y L_z}S_{IV01}\times$$

$$\times\left(\Theta L_x L_y L_z+2S_{II10}+S_{IV01}\right)+2C_I S_{IV01}^2,\ C_I=\frac{\alpha_{1I}\alpha_{1V}}{\Theta L_x L_y L_z}S_{IV00}+\frac{\alpha_{1I}^2 S_{II00}}{\Theta L_x L_y L_z}-\frac{S_{II20}}{\Theta L_x L_y L_z}-\frac{S_{IV11}}{\Theta L_x L_y L_z},$$

$$C_V=\alpha_{1I}\alpha_{1V}S_{IV00}+\alpha_{1V}^2 S_{VV00}-S_{VV02}-S_{IV11},\ F=\frac{\Theta a_2}{6a_4}+\sqrt[3]{\sqrt{r^2+s^3}-r}-\sqrt[3]{\sqrt{r^2+s^3}+r},\ r=\frac{\Theta^3 b_2}{24b_4^2}\times$$

$$\times\left(4b_0-\Theta L_x L_y L_z\frac{b_1 b_3}{b_4}\right)-b_0\frac{\Theta^2}{8b_4^2}\left(4\Theta b_2-\Theta^2\frac{b_3^2}{b_4}\right)-\frac{\Theta^3 b_2^3}{54b_4^3}-L_x^2 L_y^2 L_z^2\frac{\Theta^4 b_1^2}{8b_4^2},\ E=\sqrt{8y+\Theta^2\frac{a_3^2}{a_4^2}-4\Theta\frac{a_2}{a_4}},$$

$$s=\frac{\Theta^2}{12b_4^2}\left(4b_0 b_4-\Theta L_x L_y L_z b_1 b_3\right)-\frac{\Theta b_2}{18b_4}.$$

Framework this paper the required spatio-temporal distributions of concentrations of radiations defects have been determined by using the second-order approximations by using method of averaging of function corrections. The approximations give enough good qualitative and some quantitative results. We check all analytical results by comparison with numerical one.

3. DISCUSSION

In the previous section we analytically take into account porosity of materials in comparison with cited similar works. In this situation we obtain decreasing quantity of radiation defects (one can find decreasing both types of accounted defects: point defects and their simplest complexes) in comparison with nonporous materials. Probably this effect could be obtained due to drain of these defects to pores.

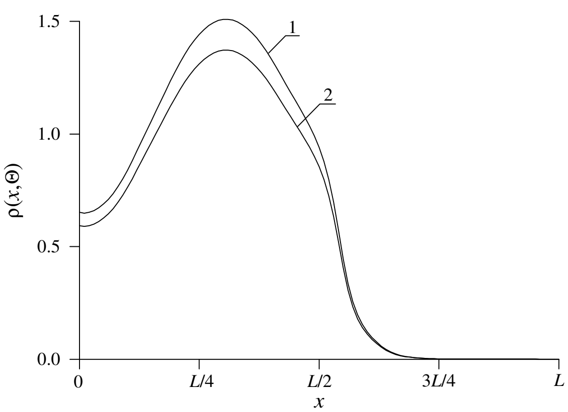

Fig. 2. Distributions of concentrations of point radiation defects for fixed value of annealing time.

Curve 1 corresponds to implantation of ions of dopant through nonporous epitaxial layer. Curve 2 corresponds to implantation of ions of dopant through porous epitaxial layer

Typical distributions of concentrations of point radiation defects and their simplest complexes are presented on Figs. 2 and 3, respectively. In this situation using overlayer over device area gives a possibility to increase radiation resistance of the devices during radiation processing. Using porous overlayer gives a possibility to obtain larger increasing of radiation resistance. The Figs. 2 and 3 also shows, that quantity of point defects is larger, than quantity of simplest complexes of point defects. This effect could be find because only part of point defects could generate their complexes. It should be also noted, that we analyzed relaxation of concentrations of radiation defects analytically and in more common case in comparison with similar results in literature. The figures show, that porosity of materials of epitaxial layer gives a possibility to decrease quantity of radiation defects. In this situation porous overlayer over device area gives a possibility to increase safety during radiation processing. Analogous situation could be find during using nonporous overlayer over device area. However pores probably became drains of radiation defects. In this situation porosity of overlayer leads to higher safety of device area.

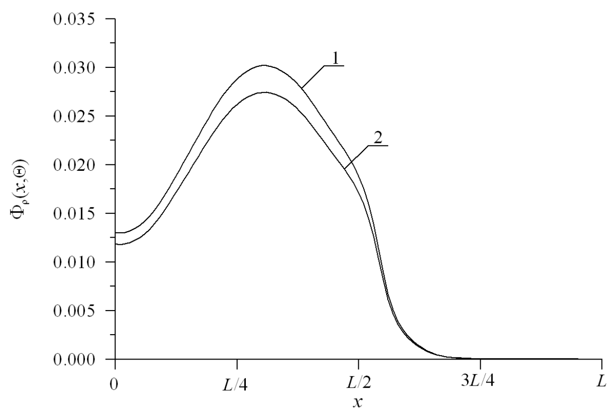

Fig. 3. Distributions of concentrations of simplest complexes of point radiation defects for fixed value of annealing time.

Curve 1 corresponds to implantation of ions of dopant through nonporous epitaxial layer. Curve 2 corresponds to implantation of ions of dopant through porous epitaxial layer

4. CONCLUSIONS

In the present paper we analyzed redistributions of radiations defects in material with porous and nonporous overlayer after radiation processing. We show, that presents of porous overlayer gives a possibility to decrease quantity of radiation defects.

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