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Changing of Charge Carriers Concentration in a Diffusion-Junction Rectifier with Variation of Radiation Processing of Materials

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Abstract

In this paper we analyzed changing of dynamics of redistribution of dopant during manufacturing of diffusion-junction rectifier in a heterostructure due to radiation processing. In this situation concentration of charge carriers will be also changed. We also introduce an analytical approach to analyze mass transport with account nonline-arity, space and time variation of parameters of the transport.

Keywords: Diffusion-Junction Heterorectifier; Radiation Processing; Charge Carriers

Introduction

One of the actual questions in the present time is elaboration of new devices of solid state electronic. Another one is refinement of traditional devices of solid state electronic [1-5]. In this situation both technological processes to manu-facture the devices and characteristics of the devices attracted an interest. Recently (see, for example, [6-10]) we intro-duced an approach to increase sharpness of *p*-*n*-junctions, which were manufactured in a heterostructure by diffusion or implantation. The approach based on using inhomogeneity of doped structure and optimization of annealing time of dopant or radiation defects. In this paper we consider a heterostructure, which consist of substrate and epitaxial layer. The structure is presented in (Figure 1) Let us consider infusion of dopant in epitaxial layer. Farther we consider radiation processing of the doped material. After the radiation processing generated radiation defects have been annealed. It should be noted, that spatio-temporal distribution of temperature has two components: one (smaller) of them has been generated during radiation processing of materials of heterostructure (interaction between ions and materials of heterostructure), another (larger) part of heat has been generated during annealing of radiation defects. Spatio-temporal distribution of temperature could be determined by solving of the second Fourier low by the considered approach of solution of the second Fick's law or by another approach. In this paper we neglect relaxation process of temperature because the relaxation is not principle for our case. In this situation we consider temperature as temperature of annealing. One can obtained spreading of dopant distribution during this annealing. If dopant did not achieved the interface between layers of heterostructure due to the spreading during the annealing one can use additional annealing of dopant. Main aim of the present paper is analysis of changing of dynamics of redistribution of dopant in heterostructure due to radiation processing. The second aim of the present paper is analysis of changing of mobility of charge carriers due to radiation processing of materials.

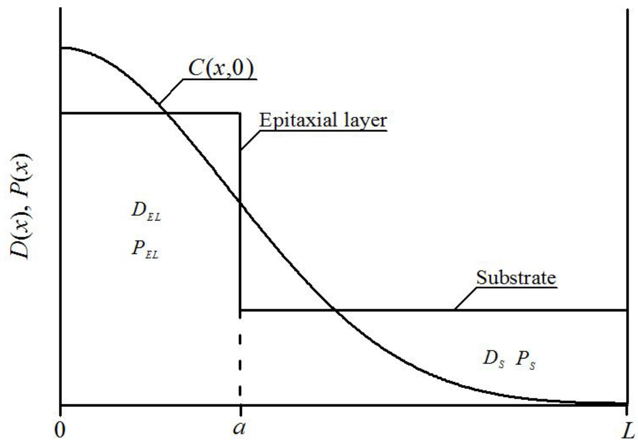


Figure 1: Heterostructure with an epitaxial layer and a substrate

Method of solution

We analyzed redistribution of dopant by solution of the second Fick's law in the following form [1,2]

$$\frac{\partial C(x,t)}{\partial t} = \frac{\partial}{\partial x}\left[D_C \frac{\partial C(x,t)}{\partial x}\right] \tag{1}$$

Here $C(x,t)$ is the spatiotemporal distribution of dopant concentration, D_C is the dopant diffusion coefficient. The Equa-tion. (1) is complemented by the following boundary conditions (the condition correspond to absents of flow through external boundary of the considered heterostructure)

$$\left.\frac{\partial C(x,t)}{\partial x}\right|_{x=0} = 0 \quad \left.\frac{\partial C(x,t)}{\partial x}\right|_{x=L} = 0 \tag{2a}$$

and initial condition (the condition correspond to distribution of concentration of dopant after ion implantation before annealing of radiation defects)

$$C(x,0)=f_C(x). \tag{2b}$$

Value of diffusion coefficient D_C depends on property of materials, velocities of heating and cooling (with account Arrhenius law) of the materials, spatio-temporal distributions of dopant and radiation defects concentrations. Two last dependences of dopant diffusion coefficient could be approximated by the following relation [12-14]

$$D_C = \beta(x,t) D_L(x,T)\left[1+\xi\frac{C^\gamma(x,t)}{P^\gamma(x,T)}\right] \tag{3}$$

Here $D_L(x,T)$ is the spatial (due to inhomogeneity of heterostructure) and temperature (due to Arrhenius law) depend-ences of dopant diffusion coefficient; T is the temperature; Function $\beta(x,t)$ in the relation (3) described by the following relation $\beta(x,t) = 1+\zeta[V(x,t)/V^*]+\zeta^2[V(x,t)/V^*]^2$; $V(x,t)$ is the spatiotemporal distribution of radiation vacancies; V^* is the equilibrium distribution of vacancies; $P(x,T)$ is the limit of solubility of dopant; parameter γ depends on properties of materials and could be integer in the following interval $\gamma \in [1,3]$ [12]. Concentrational dependence of diffusion coef-ficient is discussed in details in [12]. Spatio-temporal distributions of point radiation defects we determine by solution the following system of equations [14-16]

$$\begin{cases} \dfrac{\partial I(x,t)}{\partial t} = \dfrac{\partial}{\partial x}\left[D_I(x,T)\dfrac{\partial I(x,t)}{\partial x}\right] - \\ \qquad -k_{I,V}(x,T)I(x,t)V(x,t) - k_{I,I}(x,T)I^2(x,t) + k_I(x,T)I(x,t) \\ \dfrac{\partial V(x,t)}{\partial t} = \dfrac{\partial}{\partial x}\left[D_V(x,T)\dfrac{\partial V(x,t)}{\partial x}\right] - \\ \qquad -k_{I,V}(x,T)I(x,t)V(x,t) - k_{V,V}(x,T)V^2(x,t) + k_V(x,T)V(x,t) \end{cases} \tag{4}$$

Here $\rho = I,V$; $I(x,t)$ is the spatio-temporal distribution of concentration of radiation interstitials; $D_\rho(x,T)$ are diffusion coefficient of radiation interstitials and radiation vacancies; $k_{I,V}(x,T)$ is the parameter of recombination of radiation defects; terms $V^2(x,t)$ and $I^2(x,t)$ correspond to generation of radiation divacancies and radiation diinterstitials (see, for example, [15] and appropriate references in this book); $k_{I,V}(x,T)$, $k_{I,I}(x,T)$ and $k_{V,V}(x,T)$ are parameters of recombination of point radiation defects and generation of their complexes, respectively; $k_I(x,T)$ are $k_V(x,T)$ are parameters of decay of complexes of radiation defects. System of equations (4) has been complemented by the following boundary and initial conditions

$$\left.\frac{\partial \rho(x,y,z,t)}{\partial x}\right|_{x=0} = 0, \left.\frac{\partial \rho(x,y,z,t)}{\partial x}\right|_{x=L} = 0 \quad \rho(x,0)=f\rho(x). \tag{5}$$

Spatiotemporal distribution of concentration of radiation divacancies $\Phi_V(x,t)$ and radiation diinterstitials $\Phi_V(x,t)$ (physical mechanisms of generation of complexes of radiation defects have been described in [15]) we determined by solution the following system of equations

$$\begin{cases} \frac{\partial \Phi_I(x,t)}{\partial t} = \frac{\partial}{\partial x}\left[D_{\Phi I}(x,T)\frac{\partial \Phi_I(x,t)}{\partial x}\right] + k_{I,I}(x,T)\, I^2(x,t) - k_I(x,T) I(x,t) \\ \frac{\partial \Phi_V(x,t)}{\partial t} = \frac{\partial}{\partial x}\left[D_{\Phi V}(x,T)\frac{\partial \Phi_V(x,t)}{\partial x}\right] + k_{V,V}(x,T)\, V^2(x,t) - k_V(x,T) V(x,t) \end{cases} \quad (6)$$

Here $D_{\Phi I}(x,T)$ and $D_{\Phi V}(x,T)$ are diffusion coefficients of complexes of point radiation defects. Boundary and initial con-ditions for the system of Equation 6 in the common case could be written as

$$\left.\frac{\partial \Phi_\rho(x,t)}{\partial x}\right|_{x=0} = 0,\ \left.\frac{\partial \Phi_\rho(x,t)}{\partial x}\right|_{x=L} = 0,\ \Phi_\rho(x,0) = f_{\Phi\rho}(x). \quad (7)$$

To determine spatio-temporal distributions of concentrations of dopant, point radiation defects and complexes of point radiation defects we transform the Equation (1,4,6) to the following integral forms by standard integration on coordinate x and time t. The integral form of differential equations (1,4,6) could be written as for dopant:

$$C(x,t) = C(x,t) + \left\{\int_0^t C(x,\tau)\beta(x,\tau) D_L(x,T)\left[1+\xi\frac{C^\gamma(x,\tau)}{P^\gamma(x,T)}\right]d\tau - \int_0^t\int_0^x C(v,\tau) D_L(v,T)\times\right.$$

$$\times\beta(v,\tau)\frac{\partial}{\partial v}\left[1+\xi\frac{C^\gamma(v,\tau)}{P^\gamma(v,T)}\right]d\,v\,d\,\tau + \int_0^x (x-v) f_C(v)\,d\,v - \int_0^t\int_0^x C(v,\tau)\left[1+\xi\frac{C^\gamma(v,\tau)}{P^\gamma(v,T)}\right]\times$$

$$\times\beta(v,\tau)\frac{\partial D_L(v,T)}{\partial v}d\,v\,d\,\tau - \int_0^t\int_0^x D_L(v,T)\, C(v,\tau)\left[1+\xi\frac{C^\gamma(v,\tau)}{P^\gamma(v,T)}\right]\frac{\partial \beta(v,\tau)}{\partial v}d\,v\,d\,\tau -$$

$$\left. -\int_0^x (x-v) C(v,t)\,d\,v\right\}\frac{1}{L^2} \quad (1a)$$

for point radiation defects:

$$I(x,t) = I(x,t) + \frac{1}{L^2}\left[\int_0^t D_I(x,T) I(x,\tau)\,d\,\tau - \int_0^t\int_0^x I(v,\tau)\frac{\partial D_I(v,T)}{\partial v}d\,v\,d\,\tau - \int_0^t\int_0^x I(v,\tau)\, V(v,\tau)\times\right.$$

$$\times(x-v) k_{I,V}(v,T)\,d\,v\,d\,\tau - \int_0^t\int_0^x (x-v) k_{I,I}(v,T) I^2(v,\tau)\,d\,v\,d\,\tau + \int_0^x (x-v)\, f_I(v)\,d\,v + \int_0^t\int_0^x (x-$$

$$-v) k_I(v,T) I(v,\tau)\,d\,v\,d\,\tau + \int_0^L (L-v) I(v,t)\,d\,v + \int_0^t\int_0^L I(v,\tau)\frac{\partial D_I(v,T)}{\partial v}d\,v\,d\,\tau + \int_0^t\int_0^L (L-v)\times$$

$$\times k_{I,V}(v,T) I(v,\tau) V(v,\tau)\,d\,v\,d\,\tau + \int_0^t\int_0^L (L-v) k_{I,I}(v,T) I^2(v,\tau)\,d\,v\,d\,\tau - \int_0^t\int_0^L (L-v) k_I(v,T)\times$$

$$\left.\times I(v,\tau)\,d\,v\,d\,\tau - \int_0^L (L-v) f_I(v)\,d\,v - \int_0^x (x-v) I(v,t)\,d\,v\right] \quad (4a)$$

$$V(x,t) = V(x,t) + \left[\int_0^t D_V(x,T) V(x,\tau)\,d\,\tau - \int_0^t\int_0^x V(v,\tau)\frac{\partial D_V(v,T)}{\partial v}d\,v\,d\,\tau - \int_0^t\int_0^x I(v,\tau)\, V(v,\tau)\times\right.$$

$$\times\left(x-v\right)k_{I,V}\left(v,T\right)d\,v\,d\,\tau-\int_0^t\int_0^x\left(x-v\right)k_{V,V}\left(v,T\right)V^2\left(v,\tau\right)d\,v\,d\,\tau+\int_0^x\left(x-v\right)\,f_V\left(v\right)d\,v+\int_0^t\int_0^x\left(x-\right.$$

$$\left.-v\right)k_V\left(v,T\right)V\left(v,\tau\right)d\,v\,d\,\tau+\int_0^L\left(L-v\right)V\left(v,t\right)d\,v+\int_0^t\int_0^L V\left(v,\tau\right)\frac{\partial D_V\left(v,T\right)}{\partial v}d\,v\,d\,\tau+\int_0^t\int_0^L\left(L-v\right)\times$$

$$\times k_{I,V}\left(v,T\right)I\left(v,\tau\right)V\left(v,\tau\right)d\,v\,d\,\tau+\int_0^t\int_0^L\left(L-v\right)k_{V,V}\left(v,T\right)V^2\left(v,\tau\right)d\,v\,d\,\tau-\int_0^t\int_0^L\left(L-v\right)k_V\left(v,T\right)\times$$

$$\left.\times V\left(v,\tau\right)d\,v\,d\,\tau-\int_0^L\left(L-v\right)f_V\left(v\right)d\,v-\int_0^x\left(x-v\right)V\left(v,t\right)d\,v\right]\frac{1}{L^2},$$

for complexes of radiation defects:

$$\Phi_I\left(x,t\right)=\Phi_I\left(x,t\right)+\left[\int_0^t D_{\Phi I}\left(x,T\right)\Phi_I\left(x,\tau\right)d\,\tau-\int_0^t\int_0^x\Phi_I\left(v,\tau\right)\frac{\partial D_{\Phi I}\left(v,T\right)}{\partial v}d\,v\,d\,\tau+\int_0^t\int_0^x\left(x-v\right)\times\right.$$

$$\times k_{I,I}\left(v,T\right)I^2\left(v,\tau\right)d\,v\,d\,\tau+\int_0^t\int_0^L\Phi_I\left(v,\tau\right)\frac{\partial D_{\Phi I}\left(v,T\right)}{\partial v}d\,v\,d\,\tau+\int_0^L\left(L-v\right)\Phi_I\left(v,t\right)d\,v+\int_0^t\int_0^L\left(L-\right.$$

$$-\text{üiüiü(üiü,üiü)üiü(üiü,}\tau)\qquad\tau-\int_0^t\int_0^x(\ \ -\ \ )\ _I(\ \ ,\ \ )\ \ (\ \ ,\tau)\qquad\tau-\int_0^x(\ \ -\ \ )\Phi_I(\ \ ,\ \ )\qquad-$$

$$\left.-\int_0^t\int_0^L\left(L-v\right)k_{I,I}\left(v,T\right)I^2\left(v,\tau\right)d\,v\,d\,\tau\right]\frac{1}{L^2}\qquad(4a)$$

$$\Phi_V\left(x,t\right)=\Phi_V\left(x,t\right)+\left[\int_0^t D_{\Phi V}\left(x,T\right)\Phi_V\left(x,\tau\right)d\,\tau-\int_0^t\int_0^x\Phi_V\left(v,\tau\right)\frac{\partial D_{\Phi V}\left(v,T\right)}{\partial v}d\,v\,d\,\tau+\int_0^t\int_0^x\left(x-v\right)\times\right.$$

$$\times k_{V,V}\left(v,T\right)V^2\left(v,\tau\right)d\,v\,d\,\tau+\int_0^t\int_0^L\Phi_V\left(v,\tau\right)\frac{\partial D_{\Phi V}\left(v,T\right)}{\partial v}d\,v\,d\,\tau+\int_0^L\left(L-v\right)\Phi_V\left(v,t\right)d\,v+\int_0^t\int_0^L\left(L-\right.$$

$$\left.-v\right)k_V\left(v,T\right)V\left(v,\tau\right)d\,v\,d\,\tau-\int_0^t\int_0^x\left(x-v\right)k_V\left(v,T\right)V\left(v,\tau\right)d\,v\,d\,\tau-\int_0^x\left(x-v\right)\Phi_V\left(v,t\right)d\,v-$$

$$\left.-\int_0^t\int_0^L\left(L-v\right)k_{V,V}\left(v,T\right)V^2\left(v,\tau\right)d\,v\,d\,\tau\right]\frac{1}{L^2}.$$

Let us determine solutions of the equations by using method of averaging of functional corrections [17-20]. Framework the approach we shall replace all considered concentrations in right sides of Eqation ($1a$, $4a$, $6a$) on their average values α_{1C}, $\alpha_{1\rho}$ and $\alpha_{1\Phi\rho}$, respectively. After the replacement we obtain the first-order approximations of the considered concentrations in the following form

$$C_1\left(x,t\right)=\alpha_{1C}+\frac{1}{L^2}\left\{\alpha_{1C}\int_0^t\beta\left(x,\tau\right)D_L\left(x,T\right)\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}\left(x,T\right)}\right]d\,\tau-\alpha_{1C}\frac{x^2}{2}-\alpha_{1C}\int_0^t\int_0^x D_L\left(v,T\right)\times\right.$$

$$\times\beta\left(v,\tau\right)\frac{\partial}{\partial\,v}\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}\left(x,T\right)}\right]d\,v\,d\,\tau-\alpha_{1C}\int_0^t\int_0^x\beta\left(v,\tau\right)\frac{\partial D_L\left(v,T\right)}{\partial\,v}\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}\left(v,T\right)}\right]d\,v\,d\,\tau-$$

$$\left.-\alpha_{1C}\int_0^t\int_0^x D_L\left(v,T\right)-\alpha_{1C}\int_0^t\int_0^x D_L\left(v,T\right)\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}\left(v,T\right)}\right]\frac{\partial\beta\left(v,\tau\right)}{\partial\,v}d\,v\,d\,\tau+\int_0^x\left(x-v\right)f_C\left(v\right)d\,v\right\},$$

$$I_1(x,t)=\alpha_{1I}+\frac{1}{L^2}\left\{\alpha_{1I}\int_0^t D_I(x,T)\,d\,\tau-\alpha_{1I}\int_0^t\left[D_I(x,T)-D_I(0,T)\right]\,d\,\tau-\alpha_{1I}\alpha_{1V}\int_0^t\int_0^x(x-v)\times\right.$$

$$\times k_{I,V}(v,T)\,d\,v\,d\,\tau+\alpha_{1I}\int_0^t\int_0^x(x-v)\,k_I(v,T)\,d\,v\,d\,\tau+\alpha_{1I}\int_0^t\left[D_I(L,T)-D_I(0,T)\right]\,d\,\tau+\alpha_{1I}\frac{L^2}{2}-$$

$$-\alpha_{1I}^2\int_0^t\int_0^x(x-v)\,k_{I,I}(v,T)\,d\,v\,d\,\tau+\int_0^x(x-v)\,f_I(v)\,d\,v+\alpha_{1I}\alpha_{1V}\int_0^t\int_0^L(L-v)\,k_{I,V}(v,T)\,d\,v\,d\,\tau+$$

$$\left.+\alpha_{1I}^2\int_0^t\int_0^L(L-v)\,k_{I,I}(v,T)\,d\,v\,d\,\tau-\alpha_{1I}\int_0^t\int_0^L(L-v)\,k_I(v,T)\,d\,v\,d\,\tau-\int_0^L(L-v)\,f_I(v)\,d\,v-\alpha_{1I}\frac{x^2}{2}\right\},$$

$$V_1(x,t)=\alpha_{1V}+\frac{1}{L^2}\left\{\alpha_{1V}\int_0^t D_V(x,T)\,d\,\tau-\alpha_{1V}\int_0^t\left[D_V(x,T)-D_V(0,T)\right]\,d\,\tau-\alpha_{1I}\alpha_{1V}\int_0^t\int_0^x(x-v)\times\right.$$

$$\times k_{I,V}(v,T)\,d\,v\,d\,\tau+\alpha_{1V}\int_0^t\int_0^x(x-v)\,k_V(v,T)\,d\,v\,d\,\tau+\alpha_{1V}\int_0^t\left[D_V(L,T)-D_V(0,T)\right]\,d\,\tau+\alpha_{1V}\frac{L^2}{2}-$$

$$-\alpha_{1V}^2\int_0^t\int_0^x(x-v)\,k_{V,V}(v,T)\,d\,v\,d\,\tau+\int_0^x(x-v)\,f_V(v)\,d\,v+\alpha_{1I}\alpha_{1V}\int_0^t\int_0^L(L-v)\,k_{I,V}(v,T)\,d\,v\,d\,\tau+$$

$$\left.+\alpha_{1V}\int_0^t\int_0^L(L-v)\,k_{V,V}(v,T)\,d\,v\,d\,\tau-\alpha_{1V}\int_0^t\int_0^L(L-v)\,k_V(v,T)\,d\,v\,d\,\tau-\int_0^L(L-v)\,f_V(v)\,d\,v-\alpha_{1V}\,\text{—}\right\},$$

$$\Phi_{1I}(x,t)=\alpha_{1\Phi I}+\frac{1}{L^2}\left\{\int_0^t\int_0^x(x-v)\,k_{I,I}(v,T)\,I^2(v,\tau)\,d\,v\,d\,\tau-\alpha_{1\Phi I}\int_0^t\left[D_{\Phi I}(x,T)-D_{\Phi I}(0,T)\right]\,d\,\tau+\right.$$

$$+\alpha_{1\Phi I}\int_0^t D_{\Phi I}(x,T)\,d\,\tau+\int_0^t\int_0^L(L-v)\,k_I(v,T)\,I(v,\tau)\,d\,v\,d\,\tau-\int_0^t\int_0^x(x-v)\,k_I(v,T)\,I(v,\tau)\,d\,v\,d\,\tau+$$

$$\left.+\alpha_{1\Phi I}\int_0^t\left[D_{\Phi I}(L,T)-D_{\Phi I}(0,T)\right]\,d\,\tau-\int_0^t\int_0^L(L-v)\,k_{I,I}(v,T)\,I^2(v,\tau)\,d\,v\,d\,\tau+\alpha_{1\Phi I}\frac{L^2-x^2}{2}\right\},$$

$$\Phi_{1V}(x,t)=\alpha_{1\Phi V}+\frac{1}{L^2}\left\{\int_0^t\int_0^x(x-v)\,k_{V,V}(v,T)\,V^2(v,\tau)\,d\,v\,d\,\tau-\alpha_{1\Phi V}\int_0^t\left[D_{\Phi V}(x,T)-D_{\Phi V}(0,T)\right]\,d\,\tau+\right.$$

$$+\alpha_{1\Phi V}\int_0^t D_{\Phi V}(x,T)\,d\,\tau+\int_0^t\int_0^L(L-v)\,k_V(v,T)\,V(v,\tau)\,d\,v\,d\,\tau-\int_0^t\int_0^x(x-v)\,k_V(v,T)\,V(v,\tau)\,d\,v\,d\,\tau+$$

$$\left.+\alpha_{1\Phi V}\int_0^t\left[D_{\Phi V}(L,T)-D_{\Phi V}(0,T)\right]\,d\,\tau-\int_0^t\int_0^L(L-v)\,k_{V,V}(v,T)\,V^2(v,\tau)\,d\,v\,d\,\tau+\alpha_{1\Phi V}\frac{L^2-x^2}{2}\right\}.$$

Average values of computable concentrations α_{1C}, $\alpha_{1\rho}$ and $\alpha_{1\Phi\rho}$ could be determined as [17-20]

$$\alpha_{1C}=\frac{1}{\Theta L}\int_0^\Theta\int_0^L C_1(x,t)\,d\,x\,d\,t\,,\quad \alpha_{1\rho}=\frac{1}{\Theta L}\int_0^\Theta\int_0^L \rho_1(x,t)\,d\,x\,d\,t\,,\quad \alpha_{1\Phi\rho}=\frac{1}{\Theta L}\int_0^\Theta\int_0^L \Phi_{1\rho}(x,t)\,d\,x\,d\,t \tag{8}$$

where Θ is the annealing time.

Substitution of the first-order approximations of considered concentrations into relations (8) gives us possibility to calculate following relations to the average values

$$\alpha_{1I}=\frac{1}{2}\left[L\tilde{S}_{1I0101}-\Theta^2\frac{L^2}{2}D_I\left(0,T\right)-LQ_{I010}-\alpha_{1V}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)-\frac{1}{2}S_{2I0101}-\Theta\frac{L^3}{3}\right]+$$

$$+\frac{1}{2}\left\{\left[LS_{1I0101}-LQ_{I010}-\alpha_{1V}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)-\Theta^2\frac{L^2}{2}D_I\left(0,T\right)-\frac{1}{2}S_{2I0101}-\Theta\frac{L^3}{3}\right]^2-\right.$$

$$\left.-4\,\Theta\,F\left(S_{1I,I0101}-\frac{1}{2}S_{2I,I0101}\right)\right\}^{\frac{1}{2}},\;\alpha_{1V}=\sqrt{\left(\frac{a_3+a_1A}{2a_1}\right)^2-4\frac{a_3}{a_1}}-\frac{a_3+a_1A}{4a_1}.$$

where $S_{i\rho,\rho jklm}=\int\limits_0^{\Theta}\left(\Theta-t\right)\int\limits_0^{L}\left(L-x\right)^i k_{\rho,\rho}\left(x,T\right)I_k^j\left(x,t\right)V_m^l\left(x,t\right)d\,x\,d\,t$, $\tilde{S}_{i\rho jk}=\int\limits_0^{\Theta}\left(\Theta-t\right)\int\limits_0^{L}k_\rho\left(x,T\right)\times$

$$\times\left(L-x\right)^i I_k^j\left(x,t\right)d\,x\,d\,t,\;Q_{\rho ijk}=\int\limits_0^{\Theta}\left(\Theta-t\right)\int\limits_0^{L}\left(L-x\right)^i\rho_j^k\left(x,t\right)\frac{\partial D_\rho\left(x,T\right)}{\partial x}d\,x\,d\,t,\;F_\rho=\int\limits_0^{L}f_\rho\left(x\right)\left(x^2-\right.$$

$$\left.-x^2\right)d\,x,\;a_1=\frac{1}{16}\left(LS_{1I,V}-\frac{1}{2}S_{2I,V}\right)^4,\;a_2=\frac{1}{8}\left(LS_{1I,V}-\frac{1}{2}S_{2I,V}\right)^3\left[LS_{1I}-\Theta\frac{L^3}{3}-LQ_{I010}-\Theta^2\times\right.$$

$$\left.\times\frac{L}{2}D_I\left(0,T\right)-\frac{1}{2}S_{2I}\right],\;a_3=\frac{1}{16}\left\{LS_{1I}-L\int\limits_0^{\Theta}\left(\Theta-t\right)\left[D_I\left(L,T\right)-D_I\left(0,T\right)\right]d\,t-D_I\left(0,T\right)\Theta^2\times\right.$$

$$\left.\times\frac{L}{2}-\Theta\frac{L^3}{3}-\frac{1}{2}S_{2I}\right\}\left(LS_{1I,V}-\frac{1}{2}S_{2I,V}\right)^2-4\,\Theta\,F_V+\left(LS_{1I,V}-\frac{1}{2}S_{2I,V}\right)^2\left(S_{1I,I}-\frac{1}{2}S_{2I,I}\right)-\left(S_{1V,V}-\right.$$

$$\left.-\frac{1}{2}S_{2V,V}\right)\left(\frac{1}{2}S_{2I,V}-LS_{1I,V}\right)^2\frac{1}{2},\;a_4=\frac{1}{2}\left[LS_{1I}-\frac{1}{2}S_{2I}-\Theta^2\frac{L^2}{2}D_I\left(0,T\right)-LQ_{I010}-\Theta\frac{L^3}{3}\right]\times$$

$$\times\left(\frac{1}{2}S_{2I,V}-LS_{1I,V}\right)^2+LS_{1V}-\Theta\frac{L^3}{3}-\frac{1}{2}S_{2V}-LQ_{I010}-D_V\left(0,T\right)\Theta^2\frac{L}{2},\;A=\sqrt{8y+\frac{a_2^2}{a_1^2}-4\frac{a_3}{a_1}}$$

$$y=\sqrt[3]{\sqrt{q^2+p^3}-q}-\sqrt[3]{\sqrt{q^2+p^3}+q}+\frac{a_3}{6a_1},\;q=\frac{a_3\left(a_2a_4-16\,\Theta\,F_Va_1\right)}{48a_1^3}+\frac{\Theta\,F_V}{8a_1}\left(4\frac{a_3}{a_1}-\frac{a_2^2}{a_1^2}\right)-$$

$$-\frac{a_4^2}{16\,a_1^2}+\frac{a_3^3}{108a_1^3},\;p=\frac{a_2a_4-16\,\Theta\,F_Va_1}{24\,a_1^2}-\frac{a_3^2}{18\,a_1^2}$$

$$\alpha_{1\Phi I}=\left(\frac{1}{2}\tilde{S}_{2I11}+LS_{1I,I2101}-\frac{1}{2}S_{2I,I2101}-L\tilde{S}_{1I11}\right)\left\{L\int\limits_0^{\Theta}\left(\Theta-t\right)\left[D_{\Phi I}\left(L,T\right)-D_{\Phi I}\left(0,T\right)\right]d\,t+\right.$$

$$\left.+\int\limits_0^{\Theta}\left(\Theta-t\right)\int\limits_0^{L}D_{\Phi I}\left(x,T\right)d\,x\,d\,t-\int\limits_0^{\Theta}\left(\Theta-t\right)\int\limits_0^{L}\left[D_{\Phi I}\left(x,T\right)-D_{\Phi I}\left(0,T\right)\right]d\,x\,d\,t+\Theta\frac{L^3}{3}\right\}^{-1}$$

$$\alpha_{1\Phi V}=\left(\frac{1}{2}\tilde{S}_{2V11}+LS_{1V,V2101}-\frac{1}{2}S_{2V,V2101}-L\tilde{S}_{1V11}\right)\left\{L\int\limits_0^{\Theta}\left(\Theta-t\right)\left[D_{\Phi V}\left(L,T\right)-D_{\Phi V}\left(0,T\right)\right]d\,t+\right.$$

$$+\int_0^{\Theta}(\Theta-t)\int_0^{L}D_{\Phi V}(x,T)\,d\,x\,d\,t-\int_0^{\Theta}(\Theta-t)\int_0^{L}\left[D_{\Phi V}(x,T)-D_{\Phi V}(0,T)\right]d\,x\,d\,t+\Theta L^3/3\Bigg\}^{-1}$$

Average value α_{1C} could be determined by solution of the following equation. The equation depends on parameter γ and could be written as

$$\alpha_{1C}\int_0^{\Theta}(\Theta-t)\int_0^{L}\beta(x,t)D_L(x,T)\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}(x,T)}\right]d\,x\,d\,t-\int_0^{\Theta}(\Theta-t)\int_0^{L}(L-x)\frac{\partial}{\partial\,x}\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}(x,T)}\right]\times$$

$$\times\alpha_{1C}\,\beta(x,t)D_L(x,T)\,d\,x\,d\,t-\int_0^{\Theta}(\Theta-t)\int_0^{L}(L-x)\beta(x,t)\frac{\partial D_L(x,T)}{\partial\,x}\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}(x,T)}\right]d\,x\,d\,t\times$$

$$\times\alpha_{1C}-\alpha_{1C}\int_0^{\Theta}(\Theta-t)\int_0^{L}D_L(L,T)\frac{\partial\beta(x,t)}{\partial\,x}\left[1+\frac{\xi\,\alpha_{1C}^{\gamma}}{P^{\gamma}(x,T)}\right]d\,x\,d\,t+\frac{\Theta}{2}\int_0^{L}(L-x)^2 f_C(x)\,d\,x-$$

$$-\alpha_{1C}\Theta L^3/6=0$$

The second-order approximations of concentrations of dopant and radiation defects could be obtained by the standard iterative procedure of the method of average of function corrections, i.e. by replacement of computable concentrations in the right sides of Equations (1*a*, 4*a*, 6*a*) on the sum of average value of computable approximation and approximation with previous order. After the replacement we obtain the second-order approximations of computable concentrations in the following form

$$C_2(x,t)=C_1(x,t)+\frac{1}{L^2}\Bigg(\int_0^{t}\left[\alpha_{2C}+C_1(x,\tau)\right]\beta(x,\tau)D_L(x,T)\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(x,\tau)\right]^{\gamma}}{P^{\gamma}(x,T)}\right\}d\,\tau-$$

$$-\int_0^{t}\int_0^{x}\beta(v,\tau)\left[\alpha_{2C}+C_1(v,\tau)\right]D_L(v,T)\frac{\partial}{\partial\,v}\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(v,\tau)\right]^{\gamma}}{P^{\gamma}(v,T)}\right\}d\,v\,d\,\tau-\int_0^{t}\int_0^{x}\frac{\partial D_L(v,T)}{\partial\,v}\times$$

$$\times\left[\alpha_{2C}+C_1(v,\tau)\right]\beta(v,\tau)\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(v,\tau)\right]^{\gamma}}{P^{\gamma}(v,T)}\right\}d\,v\,d\,\tau\;-\int_0^{t}\int_0^{x}\left[\alpha_{2C}+C_1(v,\tau)\right]D_L(v,T)\times$$

$$\times\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(v,\tau)\right]^{\gamma}}{P^{\gamma}(v,T)}\right\}\frac{\partial\beta(v,\tau)}{\partial\,v}d\,v\,d\,\tau-\int_0^{x}(x-v)\left[\alpha_{2C}+C_1(v,t)\right]d\,v+\int_0^{x}f_C(v)(x-$$

$$-v)\,d\,v\Bigg)+\alpha_{2C}$$

$$I_2(x,t)=\alpha_{2I}+\frac{1}{L^2}\Bigg\{\int_0^{t}D_I(x,T)\left[\alpha_{2I}+I_1(x,\tau)\right]d\,\tau-\int_0^{t}\int_0^{x}\left[\alpha_{2I}+I_1(v,\tau)\right]\frac{\partial D_I(v,T)}{\partial v}d\,v\,d\,\tau-$$

$$-\int_0^{t}\int_0^{x}(x-v)k_{I,V}(v,T)\left[\alpha_{2I}+I_1(v,\tau)\right]\left[\alpha_{2V}+V_1(v,\tau)\right]d\,v\,d\,\tau-\int_0^{t}\int_0^{x}(x-v)\left[\alpha_{2I}+I_1(v,\tau)\right]^2(x-$$

$$-v)k_{I,I}(v,T)\,d\,v\,d\,\tau+\int_0^{t}\int_0^{x}(x-v)k_I(v,T)\left[\alpha_{2I}+I_1(v,\tau)\right]d\,v\,d\,\tau+\int_0^{t}\int_0^{L}\frac{\partial D_I(v,T)}{\partial v}\left[I_1(v,\tau)+\right.$$

$$\left.+\alpha_{2I}\right]d\,v\,d\,\tau+\int_0^{t}\int_0^{L}(L-v)\,k_{I,V}(v,T)\left[\alpha_{2I}+I_1(v,\tau)\right]\left[\alpha_{2V}+V_1(v,\tau)\right]d\,v\,d\,\tau+\int_0^{L}(L-v)\left[\alpha_{2I}+\right.$$

$$+I_1(v,t)\big]dv+\int_0^t\int_0^L(L-v)k_{I,I}(v,T)\big[\alpha_{2I}+I_1(v,\tau)\big]^2dvd\tau-\int_0^x(x-v)\big[\alpha_{2I}+I_1(v,t)\big]dv+$$

$$+\int_0^x(x-v)\,f_I(v)dv+\int_0^t\int_0^L(L-v)k_{I,I}(v,T)\big[\alpha_{2I}+I_1(v,\tau)\big]^2dvd\tau-\int_0^L(L-x)\,f_I(x)dx-$$

$$-\int_0^t\int_0^L(L-v)k_I(v,T)\big[\alpha_{2I}+I_1(v,\tau)\big]dvd\tau\Bigg\}+I_1(x,t)$$

$$V_2(x,t)=\alpha_{2V}+\frac{1}{L^2}\Bigg\{\int_0^t D_V(x,T)\big[\alpha_{2V}+V_1(x,\tau)\big]d\tau-\int_0^t\int_0^x\big[\alpha_{2V}+V_1(v,\tau)\big]\frac{\partial D_V(v,T)}{\partial v}dvd\tau-$$

$$-\int_0^t\int_0^x(x-v)k_{I,V}(v,T)\big[\alpha_{2I}+I_1(v,\tau)\big]\big[\alpha_{2V}+V_1(v,\tau)\big]dvd\tau-\int_0^t\int_0^x(x-v)\big[\alpha_{2V}+V_1(v,\tau)\big]^2(x-$$

$$-v)k_{V,V}(v,T)dvd\tau+\int_0^t\int_0^x(x-v)k_V(v,T)\big[\alpha_{2V}+V_1(v,\tau)\big]dvd\tau+\int_0^t\int_0^L\frac{\partial D_V(v,T)}{\partial v}\big[V_1(v,\tau)+$$

$$+\alpha_{2V}\big]dvd\tau+\int_0^t\int_0^L(L-v)\,k_{I,V}(v,T)\big[\alpha_{2I}+I_1(v,\tau)\big]\big[\alpha_{2V}+V_1(v,\tau)\big]dvd\tau+\int_0^L(L-v)\big[\alpha_{2V}+$$

$$+V_1(v,t)\big]dv+\int_0^t\int_0^L(L-v)k_{V,V}(v,T)\big[\alpha_{2V}+V_1(v,\tau)\big]^2dvd\tau-\int_0^x(x-v)\big[\alpha_{2V}+V_1(v,t)\big]dv+$$

$$+\int_0^x(x-v)\,f_V(v)dv+\int_0^t\int_0^L(L-v)k_{V,V}(v,T)\big[\alpha_{2V}+V_1(v,\tau)\big]^2dvd\tau-\int_0^L(L-x)\,f_V(x)dx-$$

$$-\int_0^t\int_0^L(L-v)k_V(v,T)\big[\alpha_{2V}+V_1(v,\tau)\big]dvd\tau\Bigg\}+V_1(x,t)$$

$$\Phi_{2I}(x,t)=\frac{1}{L^2}\Bigg\{\int_0^t D_{\Phi I}(x,T)\big[\alpha_{2\Phi I}+\Phi_{1I}(x,\tau)\big]d\tau-\int_0^t\int_0^x\big[\alpha_{2\Phi I}+\Phi_{1I}(v,\tau)\big]\frac{\partial D_{\Phi I}(v,T)}{\partial v}dvd\tau+$$

$$+\int_0^t\int_0^x(x-v)k_{I,I}(v,T)I^2(v,\tau)dvd\tau+\int_0^t\int_0^L\big[\alpha_{2\Phi I}+\Phi_{1I}(x,\tau)\big]\frac{\partial D_{\Phi I}(x,T)}{\partial x}dxd\tau+\int_0^t\int_0^L k_I(x,T)\times$$

$$\times(L-x)I(x,\tau)dxd\tau-\int_0^t\int_0^x(x-v)k_I(v,T)I(v,\tau)dvd\tau+\int_0^L(L-x)\big[\alpha_{2\Phi I}+\Phi_{1I}(x,\tau)\big]dx-$$

$$-\int_0^t\int_0^L(L-x)k_{I,I}(x,T)I^2(x,\tau)dxd\tau-\int_0^x(x-v)\big[\alpha_{2\Phi I}+\Phi_{1I}(v,t)\big]dv\Bigg\}+\alpha_{2\Phi I}+\Phi_{1I}(x,t)$$

$$\Phi_{2V}(x,t)=\frac{1}{L^2}\Bigg\{\int_0^t D_{\Phi V}(x,T)\big[\alpha_{2\Phi V}+\Phi_{1V}(x,\tau)\big]d\tau-\int_0^t\int_0^x\big[\alpha_{2\Phi V}+\Phi_{1V}(v,\tau)\big]\frac{\partial D_{\Phi V}(v,T)}{\partial v}dvd\tau+$$

$$+\int_0^t\int_0^x(x-v)k_{V,V}(v,T)V^2(v,\tau)dvd\tau+\int_0^t\int_0^L\big[\alpha_{2\Phi V}+\Phi_{1V}(x,\tau)\big]\frac{\partial D_{\Phi V}(x,T)}{\partial x}dxd\tau+\int_0^t\int_0^L k_V(x,T)\times$$

$$\times(L-x)V(x,\tau)dxd\tau-\int_0^t\int_0^x(x-v)k_V(v,T)V(v,\tau)dvd\tau+\int_0^L(L-x)\big[\alpha_{2\Phi V}+\Phi_{1V}(x,\tau)\big]dx-$$

$$-\int_0^t\int_0^L (L-x)k_{V,V}(x,T)V^2(x,\tau)\,d\,x\,d\,\tau-\int_0^x (x-v)\left[\alpha_{2\Phi V}+\Phi_{1V}(v,t)\right]d\,v\Bigg\}+\alpha_{2\Phi V}+\Phi_{1V}(x,t)$$

Average values of computable concentrations α_{2C}, $\alpha_{2\rho}$ and $\alpha_{2\Phi\rho}$ could be determined by standard relations, which analogous to relations (8). Order of approximation is changed in the relations only. Calculation of computable average values $\alpha_{2\rho}$ and $\alpha_{2\Phi\rho}$ by using appropriate relations gives us possibility to obtain the following result

$$\alpha_{2V}=\sqrt{b_2^2-4b_1b_3}-b_2$$

$$\alpha_{2I}=\Bigg\{\Bigg[\alpha_{2V}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)+R_{I10}-Q_{I110}-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}+LQ_{I010}-$$

$$-\tilde{S}_{1I0101}+\Theta^2\frac{L}{2}D_I(0,T)+LS_{1I,V0111}+2S_{1I,I1101}-L^3\frac{\Theta}{6}\Bigg]^2-4\left(S_{1I,V0101}-\frac{1}{2}S_{2I,I0101}\right)\left[\frac{\tilde{S}_{2I1101}}{2}-\right.$$

$$-\frac{1}{2}S_{2I,V1111}-Q_{I111}-\frac{1}{2}S_{2I,I2101}-\frac{1}{2}\int_0^\Theta\int_0^L(L-x)^2I_1(x,t)\,d\,x\,d\,t+L\int_0^\Theta\int_0^L(L-x)I_1(x,t)\,d\,x\,d\,t-$$

$$-\tilde{S}_{1I1101}+R_{I11}+S_{1I,I2101}+LQ_{I011}+\alpha_{2V}\left(LS_{1I,V1101}-\frac{1}{2}S_{2I,V1101}\right)+LS_{1I,V1111}-\Theta L\tilde{F}_{I1}+\tilde{F}_{I2}\times$$

$$\left.\times\frac{\Theta}{2}\right\}^{\frac{1}{2}}-\frac{1}{2}\Bigg[\alpha_{2V}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)+R_{I10}-Q_{I110}-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}+$$

$$+\Theta^2\frac{L^2}{2}+LQ_{I010}-\tilde{S}_{1I0101}+LS_{1I,V0111}+2S_{1I,I1101}-L^3\frac{\Theta}{6}\Bigg]$$

where $R_{\rho ij}=\int_0^\Theta(\Theta-t)\int_0^L D_\rho(x,T)\rho_i^j(x,t)\,d\,x\,d\,t$, $b_1=\frac{3}{4}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)^2+LS_{1I,V0101}-$

$$-1-\frac{1}{2}S_{2I,V0101},\quad b_2=\left[\frac{3}{4}\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)-1\right]\Bigg[R_{I10}-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}-$$

$$-Q_{I110}+\Theta^2\frac{L^2}{2}+LQ_{I010}+LS_{1I,V0111}-\tilde{S}_{1I0101}+2S_{1I,I1101}-L^3\frac{\Theta}{6}\Bigg]-\left(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\right)\times$$

$$\times\frac{1}{4}\Bigg[R_{I10}+LQ_{I010}+\Theta^2\frac{L^2}{2}-L^3\frac{\Theta}{6}D_I(0,T)-Q_{I110}-\tilde{S}_{1I0101}+LS_{1I,V0111}+2S_{1I,I110}-S_{2I,I1101}-$$

$$-\frac{1}{2}S_{2I,V0111}+\frac{1}{2}\tilde{S}_{2I0101}\Bigg]-2\left(S_{1I,V0101}-\frac{1}{2}S_{2I,I0101}\right)\left(LS_{1I,V1101}-\frac{1}{2}S_{2I,V1101}\right),\quad b_3=\Big[R_{I10}-Q_{I110}-$$

$$-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}+\Theta^2\frac{L^2}{2}+LQ_{I010}-\tilde{S}_{1I0101}+LS_{1I,V0111}+2S_{1I,I1101}-L^3\frac{\Theta}{6}\Bigg]^2-$$

$$-4\left(S_{1I,V0101}-\frac{1}{2}S_{2I,I0101}\right)\Bigg[\frac{1}{2}\int_0^\Theta\int_0^L\left(L^2-x^2\right)I_1(x,t)\,d\,x\,d\,t+\frac{1}{2}\tilde{S}_{2I1101}-\frac{1}{2}S_{2I,V1111}-\frac{1}{2}S_{2I,I2101}+$$

$$+S_{1I,I2101}+LQ_{I011}-Q_{I111}+R_{I11}-\tilde{S}_{1I1101}+\frac{\Theta}{2}\tilde{F}_{I2}+LS_{1I,V1111}-\Theta L\tilde{F}_{I1}\Bigg]-\frac{1}{4}\Bigg[\Theta^2\frac{L^2}{2}-Q_{I110}+$$

$$+R_{I10}-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}+LQ_{I010}-\tilde{S}_{1I0101}+LS_{1I,V0111}+2S_{1I,I1101}-L^3\frac{\Theta}{6}\Bigg]^2$$

$$\tilde{F}_{\rho i}=\int_0^L(L-x)^i f_\rho(x)\,d\,x$$

$$\alpha_{2\Phi I}=\Bigg[\int_0^\Theta(\Theta-t)\int_0^L(L-x)\Phi_{1I}(x,t)\frac{\partial D_{\Phi I}(x,T)}{\partial x}d\,x\,d\,t-L\int_0^\Theta\int_0^L(L-x)\Phi_{1I}(x,t)\,d\,x\,d\,t-L\times$$

$$\times\int_0^\Theta(\Theta-t)\int_0^L\Phi_{1I}(x,t)\frac{\partial D_{\Phi I}(x,T)}{\partial x}d\,x\,d\,t-\int_0^\Theta(\Theta-t)\int_0^L\Phi_{1I}(x,t)D_{\Phi I}(x,T)\,d\,x\,d\,t-\frac{1}{2}\int_0^\Theta(\Theta-$$

$$-t)\int_0^L(L-x)^2k_{I,I}(x,T)I^2(x,t)\,d\,x\,d\,t+\frac{1}{2}\int_0^\Theta(\Theta-t)\int_0^L(L-x)^2k_I(x,T)I(x,t)\,d\,x\,d\,t-L\times$$

$$\times\int_0^\Theta(\Theta-t)\int_0^L(L-x)k_I(x,T)I(x,t)\,d\,x\,d\,t+L\int_0^\Theta(\Theta-t)\int_0^L(L-x)k_{I,I}(x,T)I^2(x,t)\,d\,x\,d\,t+$$

$$b_2=\Bigg[\frac{3}{4}\bigg(LS_{1I,V0101}-\frac{1}{2}S_{2I,V0101}\bigg)-1\Bigg]\Bigg[R_{I10}-\frac{1}{2}S_{2I,V0111}-S_{2I,I1101}+\frac{1}{2}\tilde{S}_{2I0101}-$$

$$\times\int_0^L D_{\Phi I}(x,T)\,d\,x\,d\,t-\int_0^\Theta(\Theta-t)\int_0^L\big[D_{\Phi I}(x,T)-D_{\Phi I}(0,T)\big]\,d\,x\,d\,t\Bigg\}$$

$$\alpha_{2\Phi V}=\Bigg[\int_0^\Theta(\Theta-t)\int_0^L(L-x)\Phi_{1V}(x,t)\frac{\partial D_{\Phi V}(x,T)}{\partial x}d\,x\,d\,t-L\int_0^\Theta\int_0^L\Phi_{1V}(x,t)\frac{\partial D_{\Phi V}(x,T)}{\partial x}d\,x\times$$

$$\times(\Theta-t)\,d\,t-\int_0^\Theta(\Theta-t)\int_0^L\Phi_{1V}(x,t)D_{\Phi V}(x,T)\,d\,x\,d\,t-\frac{1}{2}\int_0^\Theta\int_0^L(L-x)^2k_{V,V}(x,T)V^2(x,t)\,d\,x\times$$

$$\times(\Theta-t)\,d\,t-L\int_0^\Theta\int_0^L(L-x)\Phi_{1V}(x,t)\,d\,x\,d\,t+\frac{1}{2}\int_0^\Theta(\Theta-t)\int_0^L(L-x)^2k_V(x,T)V(x,t)\,d\,x\,d\,t-$$

$$-L\int_0^\Theta(\Theta-t)\int_0^L(L-x)k_V(x,T)V(x,t)\,d\,x\,d\,t+\frac{1}{2}\int_0^\Theta\int_0^L(L-x)\Phi_{1V}(x,t)\,d\,x\,d\,t+L\int_0^\Theta(\Theta-t)\times$$

$$\times\int_0^L(L-x)k_{V,V}(x,T)V^2(x,t)\,d\,x\,d\,t\Bigg]\Bigg\{L\int_0^\Theta(\Theta-t)\big[D_{\Phi V}(L,T)-D_{\Phi V}(0,T)\big]\,d\,t+\Theta\frac{L^3}{3}+$$

$$+\int_0^\Theta(\Theta-t)\int_0^L D_{\Phi V}(x,T)\,d\,x\,d\,t-\int_0^\Theta(\Theta-t)\int_0^L\big[D_{\Phi V}(x,T)-D_{\Phi V}(0,T)\big]\,d\,x\,d\,t\Bigg\}$$

Average value α_{2C} could be determined by solution of the following equation, which depends on parameter γ

$$\int_0^{\Theta}(\Theta-t)\int_0^{L}\left[\alpha_{2C}+C_1(x,t)\right]\beta(x,t)D_L(x,T)\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(x,t)\right]^{\gamma}}{P^{\gamma}(x,T)}\right\}d\,x\,d\,t-\int_0^{\Theta}(\Theta-t)\int_0^{L}(L-$$

$$-x)\beta(x,t)\left[\alpha_{2C}+C_1(x,t)\right]D_L(x,T)\frac{\partial}{\partial x}\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(x,t)\right]^{\gamma}}{P^{\gamma}(x,T)}\right\}d\,x\,d\,t-\int_0^{\Theta}(\Theta-t)\int_0^{L}(L-$$

$$-x)\beta(x,t)\left[\alpha_{2C}+C_1(x,t)\right]\frac{\partial D_L(x,T)}{\partial x}\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(x,t)\right]^{\gamma}}{P^{\gamma}(x,T)}\right\}d\,x\,d\,t\;-\int_0^{\Theta}(\Theta-t)\int_0^{L}(L-x)\times$$

$$\times\left[\alpha_{2C}+C_1(x,t)\right]D_L(x,T)\left\{1+\xi\frac{\left[\alpha_{2C}+C_1(x,t)\right]^{\gamma}}{P^{\gamma}(x,T)}\right\}\frac{\partial\beta(x,t)}{\partial x}d\,x\,d\,t+\int_0^{L}(L-x)^2 f_C(x)\,d\,x\times$$

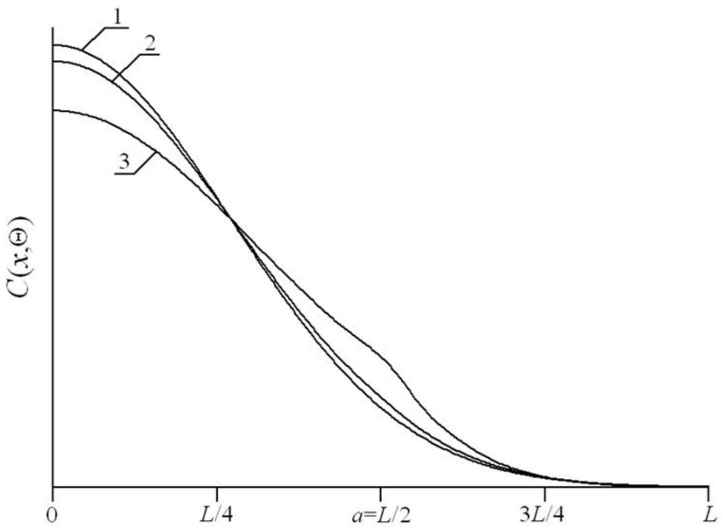
$$\times\frac{\Theta}{2}-\frac{1}{2}\int_0^{\Theta}\int_0^{L}(L-x)^2\left[\alpha_{2C}+C_1(x,t)\right]d\,x\,d\,t=0$$

Analysis of spatiotemporal distributions of concentrations of dopand and radiation defects has been done analytically by using the second-order approximation framework method of averaging of function corrections and has been amended numerically.

Discussion

In this section we analyzed influence of radiation processing of doped materials on dopant distribution. Let us consider some signature distributions in the considered heterostructure before and after radiation processing. Some of these dis-tributions are presented in the (Figure 2). The figure shows, that due to radiation processing dopant distributions became more homogenous in enriched area due to radiation-stimulated diffusion. The second effect of radiation processing is increasing of sharpness of *p-n*-junction. These conclusions are coincides with conclusions, which obtained in [21].

Farther we consider redistribution of charge carriers in the considered *p-n*-junction with account variation of distri-bution of concentration of dopant due to radiation processing. We consider the redistribution framework recently con-sidered in [20] approach. The approach based on solution of standard for the case boundary problem by using method of averaged of function correction. We will not present the solution because the algorithm is standard and bulky. By using the analysis we obtain that concentration of excess charge carriers decreases with decreasing of dopant concentration due to radiation processing. In the area when dopant concentration increases one can find wise versa result for charge carriers concentration. In this situation one can obtain smaller electrical current density in materials of heterostructure after radiation processing near processes external boundary. At the same time one can obtain higher electrical current density in larger depth. Value of the depth depends on value of radiation processing and annealing time of radiation defects.



Curve 1 is dopant distributions in homogenous sample. Curve 2 is the dopant distributions in the heterostructure with-out radiation processing. Curve 3 is the dopant distributions in the heterostructure after radiation processing.

Figure 2: Normalized distribution of concentration of dopant in considered heterostructure

Conclusion

In this paper we consider influence of radiation processing on distribution of concentration of dopant in a diffusion-junction rectifier in a heterostructure. We obtain that radiation processing of materials of the heterostructure could leads to decreasing of sharpness of *p-n*-junction. The decreasing could be explained by diffusion stimulated by diffusion. One can also find analogous variation of concentration of charge carriers. The variation leads to decreasing of electrical current density near processed by radiation external boundary of heterostructure and to increasing electrical current density far from the boundary.

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