International Journal of Research Studies in Electrical and Electronics Engineering (IJRSEEE)
Volume 6, Issue 3, 2020, PP 7-24
ISSN 2454-9436 (Online)
DOI: http://dx.doi.org/10.20431/2454-9436.0603002
www.arcjournals.org

On Approach to Optimize Manufacturing of a Current Source Circuit for Increasing of Integration Rate of Elements

E.L. Pankratov

Nizhny Novgorod State University, 23 Gagarin avenue, Nizhny Novgorod, 603950, Russia

Corresponding Author:** ***E.L. Pankratov, *Nizhny Novgorod State University, 23 Gagarin avenue, Nizhny Novgorod, 603950, Russia*

Abstract: *In this paper we introduce an approach to increase integration rate of elements of a current source. Framework the approach we consider a heterostructure with special configuration. Several specific areas of the heterostructure should be doped by diffusion or ion implantation. Annealing of dopant and/or radiation defects should be optimized.*

Keywords: *current comparator; optimization of manufacturing; analytical approach for modelling.*

1. Introduction

Currently density of elements of integrated circuits and their performance intensively increasing [1-8]. Simultaneously with increasing of the density of the elements of integrated circuit their dimensions decreases. One way to decrease dimensions of these elements of these integrated circuit is manufacturing of these elements in thin-film heterostructures. An alternative approach to decrease dimensions of the elements of integrated circuits is using laser and microwave types annealing [9-17]. Using these types of annealing leads to generation inhomogeneous distribution of temperature. Due to Arrhenius law the inhomogeneity of the diffusion coefficient and other parameters of process [18]. The inhomogeneity gives us possibility to decrease dimensions of elements of integrated circuits. Changing of properties of electronic materials could be obtain by using radiation processing of these materials.

In this paper we consider a heterostructure. The heterostructure includes into itself some epitaxial layers and a substrate. Some sections have been manufactured in the epitaxial layers. Further we consider doping of these sections by diffusion or ion implantation. The doping gives a possibility to manufacture field-effect transistors framework a current source circuit [4] so as it is shown on Figs. 1. After the doping we consider annealing of dopant and/or radiation defects. The annealing should be optimized to manufacture more compact distributions of concentrations of dopant. Framework the paper we determine conditions to increase density of elements of current source [4] and at the same time to increase of homogeneity of distribution of concentration of dopant in enriched area.

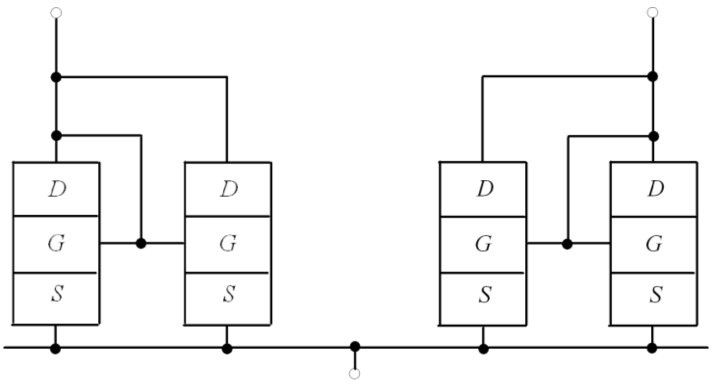

Fig1. *The considered current source [4]*

2. METHOD OF SOLUTION

We calculate distribution of concentration of dopant in space and time as solution of the following boundary problem [1,3,18]

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

Boundary and initial conditions for the equations are

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

$$\left.\frac{\partial C(x,y,z,t)}{\partial z}\right|_{z=0} = 0,\ \left.\frac{\partial C(x,y,z,t)}{\partial z}\right|_{x=L_z} = 0,\ C(x,y,z,0)=f(x,y,z). \tag{2}$$

Function $C(x,y,z,t)$ describes distribution of dopant concentration in space and time; parameter T describes the annealing temperature; parameter D_C describes the diffusion coefficient of dopant. Dopant diffusion coefficient will be changed with changing materials of heterostructure. Dopant diffusion coefficient will be also changed with changing speed of heating and cooling of heterostructure (with account Arrhenius law). Dependences of dopant diffusion coefficient on concentrations of dopant and radiation defects [20-22]

$$D_C = D_L(x,y,z,T)\left[1+\xi\frac{C^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\right]\left[1+\varsigma_1\frac{V(x,y,z,t)}{V^*}+\varsigma_2\frac{V^2(x,y,z,t)}{(V^*)^2}\right]. \tag{3}$$

Here the function $D_L(x,y,z,T)$ describes the spatial (in heterostructure) and temperature (due to Arrhenius law) dependences of diffusion coefficient of dopant. Function $P(x,y,z,T)$ describes spatial and temperature dependence of limit of solubility of dopant. Parameter $\gamma \in [1,3]$ is different in different materials [10]. Function $V(x,y,z,t)$ describes distribution of concentration of radiation vacancies in space and time with equilibrium distribution of concentration of vacancies V^*. The considered concentrational dependence of dopant diffusion coefficient has been described in details in [20]. Using diffusion type of doping gives a possibility to organize technological process without radiation defects. In this situation $\zeta_1 = \zeta_2 = 0$. We determine spatio-temporal distributions of concentrations of radiation defects by solving the following system of equations [21,22]

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

$$+\frac{\partial}{\partial z}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial z}\right] - k_{I,V}(x,y,z,T)\, I(x,y,z,t)\, V(x,y,z,t) - k_{I,I}(x,y,z,T)\, I^2(x,y,z,t) \tag{4}$$

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

$$+\frac{\partial}{\partial z}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial z}\right] - k_{I,V}(x,y,z,T)\, I(x,y,z,t)\, V(x,y,z,t) + k_{V,V}(x,y,z,T)\, V^2(x,y,z,t).$$

Boundary and initial conditions for these equations are

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

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

Here $\rho=I,V$. Function $I(x,y,z,t)$ describes distribution of concentration of radiation interstitials in space and time. Function $D_\rho(x,y,z,T)$ describes dependence of diffusion coefficients of point radiation defects on coordinate and temperature. Terms $V^2(x,y,z,t)$ and $I^2(x,y,z,t)$ correspond to generation divacancies and diinterstitials. Function $k_{I,V}(x,y,z,T)$ describes dependence of parameter of recombination of point radiation defects on coordinate and temperature. Functions $k_{I,I}(x,y,z,T)$ and $k_{V,V}(x,y,z,T)$ describe dependences of the parameters of generation of simplest complexes of point radiation defects on coordinate and temperature.

Distributions of concentrations of concentrations of divacancies $\Phi_V(x,y,z,t)$ and dinterstitials $\Phi_I(x,y,z,t)$ in space and time have been determined by solving the following system of equations [21,22]

$$\frac{\partial \Phi_I(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi I}(x,y,z,T)\frac{\partial \Phi_I(x,y,z,t)}{\partial z}\right]+k_{I,I}(x,y,z,T)I^2(x,y,z,t)-k_I(x,y,z,T)I(x,y,z,t) \tag{6}$$

$$\frac{\partial \Phi_V(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_{\Phi V}(x,y,z,T)\frac{\partial \Phi_V(x,y,z,t)}{\partial z}\right]+k_{V,V}(x,y,z,T)V^2(x,y,z,t)-k_V(x,y,z,T)V(x,y,z,t)$$

Boundary and initial conditions for these equations are

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

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

$$\Phi_I(x,y,z,0)=f_{\Phi I}(x,y,z),\ \Phi_V(x,y,z,0)=f_{\Phi V}(x,y,z). \tag{7}$$

Functions $D_{\Phi\rho}(x,y,z,T)$ describe dependences of the diffusion coefficients of the above complexes of radiation defects on coordinate and temperature. Functions $k_I(x,y,z,T)$ and $k_V(x,y,z,T)$ describe dependences of the parameters of decay of these complexes on coordinate and temperature.

Now let us calculate spatio-temporal distributions of point radiation defects concentrations by approach, which has been recently elaborated [18]. The approach based on transformation of approximations of diffusion coefficients in the following form: $D_\rho(x,y,z,T)=D_{0\rho}[1+\varepsilon_\rho\, g_\rho(x,y,z,T)]$, where $D_{0\rho}$ are the average values of diffusion coefficients, $0\le\varepsilon_\rho<1$, $|g_\rho(x,y,z,T)|\le1$, $\rho=I,V$. We also used analogous transformation of approximations of parameters of recombination of point defects and parameters of generation of their complexes: $k_{I,V}(x,y,z,T)=k_{0I,V}[1+\varepsilon_{I,V}\, g_{I,V}(x,y,z,T)]$, $k_{I,I}(x,y,z,T)=k_{0I,I}[1+\varepsilon_{I,I}\, g_{I,I}(x,y,z,T)]$ and $k_{V,V}(x,y,z,T)=k_{0V,V}[1+\varepsilon_{V,V}\, g_{V,V}(x,y,z,T)]$, where $k_{0\rho1,\rho2}$ are the their average values, $0\le\varepsilon_{I,V}<1$, $0\le\varepsilon_{I,I}<1$, $0\le\varepsilon_{V,V}<1$, $|g_{I,V}(x,y,z,T)|\le1$, $|g_{I,I}(x,y,z,T)|\le1$, $|g_{V,V}(x,y,z,T)|\le1$. Let us introduce the following dimensionless variables: $\chi=x/L_x$, $\eta=y/L_y$, $\tilde{I}(x,y,z,t)=I(x,y,z,t)/I^*$, $\tilde{V}(x,y,z,t)=V(x,y,z,t)/V^*$, $\omega=L^2k_{0I,V}\big/\sqrt{D_{0I}D_{0V}}$, $\phi=z/L_z$, $\Omega_\rho=L^2k_{0\rho,\rho}\big/\sqrt{D_{0I}D_{0V}}$, $\vartheta=\sqrt{D_{0I}D_{0V}}\,t/L^2$. The introduction leads to transformation of Eqs.(4) and conditions (5) to the following form

$$\frac{\partial \tilde{I}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\frac{D_{0I}}{\sqrt{D_{0I}D_{0V}}}\frac{\partial}{\partial \chi}\left\{[1+\varepsilon_I g_I(\chi,\eta,\phi,T)]\frac{\partial \tilde{I}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right\}+\frac{\partial}{\partial \eta}\{[1+\varepsilon_I g_I(\chi,\eta,\phi,T)]\times$$
$$\times\frac{\partial \tilde{I}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\Big\}\frac{D_{0I}}{\sqrt{D_{0I}D_{0V}}}+\frac{D_{0I}}{\sqrt{D_{0I}D_{0V}}}\frac{\partial}{\partial \phi}\left\{[1+\varepsilon_I g_I(\chi,\eta,\phi,T)]\frac{\partial \tilde{I}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right\}-\tilde{I}(\chi,\eta,\phi,\vartheta)\times$$
$$\times\omega\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\tilde{V}(\chi,\eta,\phi,\vartheta)-\Omega_I\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]\tilde{I}^2(\chi,\eta,\phi,\vartheta) \quad (8)$$

$$\frac{\partial \tilde{V}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\frac{D_{0V}}{\sqrt{D_{0I}D_{0V}}}\frac{\partial}{\partial \chi}\left\{[1+\varepsilon_V g_V(\chi,\eta,\phi,T)]\frac{\partial \tilde{V}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right\}+\frac{\partial}{\partial \eta}\{[1+\varepsilon_V g_V(\chi,\eta,\phi,T)]\times$$
$$\times\frac{\partial \tilde{V}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\Big\}\frac{D_{0V}}{\sqrt{D_{0I}D_{0V}}}+\frac{D_{0V}}{\sqrt{D_{0I}D_{0V}}}\frac{\partial}{\partial \phi}\left\{[1+\varepsilon_V g_V(\chi,\eta,\phi,T)]\frac{\partial \tilde{V}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right\}-\tilde{I}(\chi,\eta,\phi,\vartheta)\times$$
$$\times\omega\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\tilde{V}(\chi,\eta,\phi,\vartheta)-\Omega_V\left[1+\varepsilon_{V,V}g_{V,V}(\chi,\eta,\phi,T)\right]\tilde{V}^2(\chi,\eta,\phi,\vartheta)$$

$$\left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right|_{\chi=0}=0,\ \left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right|_{\chi=1}=0,\ \left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\right|_{\eta=0}=0,\ \left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\right|_{\eta=1}=0,$$
$$\left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right|_{\phi=0}=0,\ \left.\frac{\partial \tilde{\rho}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right|_{\phi=1}=0,\ \tilde{\rho}(\chi,\eta,\phi,\vartheta)=\frac{f_\rho(\chi,\eta,\phi,\vartheta)}{\rho^*}. \quad (9)$$

We determine solutions of Eqs.(8) with conditions (9) framework recently introduced approach [18], i.e. as the power series

$$\tilde{\rho}(\chi,\eta,\phi,\vartheta)=\sum_{i=0}^{\infty}\varepsilon_\rho^i\sum_{j=0}^{\infty}\omega^j\sum_{k=0}^{\infty}\Omega_\rho^k\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta). \quad (10)$$

Substitution of the series (10) into Eqs.(8) and conditions (9) gives us possibility to obtain equations for initial-order approximations of concentration of point defects $\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)$ and $\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)$ and corrections for them $\tilde{I}_{ijk}(\chi,\eta,\phi,\vartheta)$ and $\tilde{V}_{ijk}(\chi,\eta,\phi,\vartheta)$, $i \ge 1$, $j \ge 1$, $k \ge 1$. The equations are presented in the Appendix. Solutions of the equations could be obtained by standard Fourier approach [24,25]. The solutions are presented in the Appendix.

Now we calculate distributions of concentrations of simplest complexes of point radiation defects in space and time. To determine the distributions we transform approximations of diffusion coefficients in the following form: $D_{\Phi\rho}(x,y,z,T)=D_{0\Phi\rho}[1+\varepsilon_{\Phi\rho}g_{\Phi\rho}(x,y,z,T)]$, where $D_{0\Phi\rho}$ are the average values of diffusion coefficients. In this situation the Eqs.(6) could be written as

$$\frac{\partial \Phi_I(x,y,z,t)}{\partial t}=D_{0\Phi I}\frac{\partial}{\partial x}\left\{[1+\varepsilon_{\Phi I}g_{\Phi I}(x,y,z,T)]\frac{\partial \Phi_I(x,y,z,t)}{\partial x}\right\}+k_{I,I}(x,y,z,T)\,I^2(x,y,z,t)+$$
$$+D_{0\Phi I}\frac{\partial}{\partial y}\left\{[1+\varepsilon_{\Phi I}g_{\Phi I}(x,y,z,T)]\frac{\partial \Phi_I(x,y,z,t)}{\partial y}\right\}+D_{0\Phi I}\frac{\partial}{\partial z}\left\{[1+\varepsilon_{\Phi I}g_{\Phi I}(x,y,z,T)]\frac{\partial \Phi_I(x,y,z,t)}{\partial z}\right\}-$$
$$-k_I(x,y,z,T)I(x,y,z,t)$$

$$\frac{\partial \Phi_V(x,y,z,t)}{\partial t}=D_{0\Phi V}\frac{\partial}{\partial x}\left\{[1+\varepsilon_{\Phi V}g_{\Phi V}(x,y,z,T)]\frac{\partial \Phi_V(x,y,z,t)}{\partial x}\right\}+k_{I,I}(x,y,z,T)\,I^2(x,y,z,t)+$$
$$+D_{0\Phi V}\frac{\partial}{\partial y}\left\{[1+\varepsilon_{\Phi V}g_{\Phi V}(x,y,z,T)]\frac{\partial \Phi_V(x,y,z,t)}{\partial y}\right\}+D_{0\Phi V}\frac{\partial}{\partial z}\left\{[1+\varepsilon_{\Phi V}g_{\Phi V}(x,y,z,T)]\frac{\partial \Phi_V(x,y,z,t)}{\partial z}\right\}-$$
$$-k_I(x,y,z,T)\,I(x,y,z,t).$$

Farther we determine solutions of above equations as the following power series

$$\Phi_\rho(x,y,z,t)=\sum_{i=0}^{\infty}\varepsilon_{\Phi\rho}^i\Phi_{\rho i}(x,y,z,t). \quad (11)$$

Now we used the series (11) into Eqs.(6) and appropriate boundary and initial conditions. The using gives the possibility to obtain equations for initial-order approximations of concentrations of complexes of defects $\Phi_{\rho 0}(x,y,z,t)$, corrections for them $\Phi_{\rho i}(x,y,z,t)$ (for them $i \geq 1$) and boundary and initial conditions for them. We remove equations and conditions to the Appendix. Solutions of the equations have been calculated by standard approaches [24,25] and presented in the Appendix.

Now we calculate distribution of concentration of dopant in space and time by using the approach, which was used for analysis of radiation defects. To use the approach we consider following transformation of approximation of dopant diffusion coefficient: $D_L(x,y,z,T)=D_{0L}[1+ \varepsilon_L g_L(x,y,z,T)]$, where D_{0L} is the average value of dopant diffusion coefficient, $0\leq\varepsilon_L< 1$, $|g_L(x,y,z,T)|\leq 1$. Farther we consider solution of Eq.(1) as the following series:

$$C(x,y,z,t)=\sum_{i=0}^{\infty}\varepsilon_L^i\sum_{j=1}^{\infty}\xi^j C_{ij}(x,y,z,t).$$

Using the relation into Eq.(1) and conditions (2) leads to obtaining equations for the functions $C_{ij}(x,y,z,t)$ ($i \geq 1$, $j \geq 1$), boundary and initial conditions for them. The equations are presented in the Appendix. Solutions of the equations have been calculated by standard approaches (see, for example, [24,25]). The solutions are presented in the Appendix.

We analyzed distributions of concentrations of dopant and radiation defects in space and time analytically by using the second-order approximations on all parameters, which have been used in appropriate series. Usually the second-order approximations are enough good approximations to make qualitative analysis and to obtain quantitative results. All analytical results have been checked by numerical simulation.

3. Discussion

In this section we analyzed spatio-temporal distributions of concentrations of dopants. Figs. 2 shows typical spatial distributions of concentrations of dopants in neighborhood of interfaces of heterostructures. We calculate these distributions of concentrations of dopants under the following condition: value of dopant diffusion coefficient in doped area is larger, than value of dopant diffusion coefficient in nearest areas. In this situation one can find increasing of compactness of field-effect transistors with increasing of homogeneity of distribution of concentration of dopant at one time. Changing relation between values of dopant diffusion coefficients leads to opposite result (see Figs. 3).

It should be noted, that framework the considered approach one shall optimize annealing of dopant and/or radiation defects. To do the optimization we used recently introduced criterion [26-34]. The optimization based on approximation real distribution by step-wise function $\psi(x,y,z)$ (see Figs. 4). Farther the required values of optimal annealing time have been calculated by minimization the following mean-squared error

$$U=\frac{1}{L_xL_yL_z}\int_0^{L_x}\int_0^{L_y}\int_0^{L_z}[C(x,y,z,\Theta)-\psi(x,y,z)]\,d\,z\,d\,y\,d\,x. \tag{12}$$

We show optimal values of annealing time as functions of parameters on Figs. 5. It is known, that standard step of manufactured ion-doped structures is annealing of radiation defects. In the ideal case after finishing the annealing dopant achieves interface between layers of heterostructure. If the dopant has no enough time to achieve the interface, it is practicably to anneal the dopant additionally. The Fig. 5*b* shows the described dependences of optimal values of additional annealing time for the same parameters as for Fig. 5*a*. Necessity to anneal radiation defects leads to smaller values of optimal annealing of implanted dopant in comparison with optimal annealing time of infused dopant.

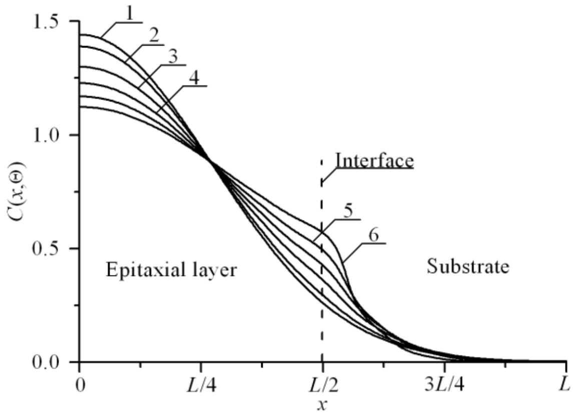

Fig2*a*. *Dependences of concentration of dopant, infused in heterostructure from Figs. 1, on coordinate in direction, which is perpendicular to interface between epitaxial layer substrate. Difference between values of dopant diffusion coefficient in layers of heterostructure increases with increasing of number of curves. Value of dopant diffusion coefficient in the epitaxial layer is larger, than value of dopant diffusion coefficient in the substrate*

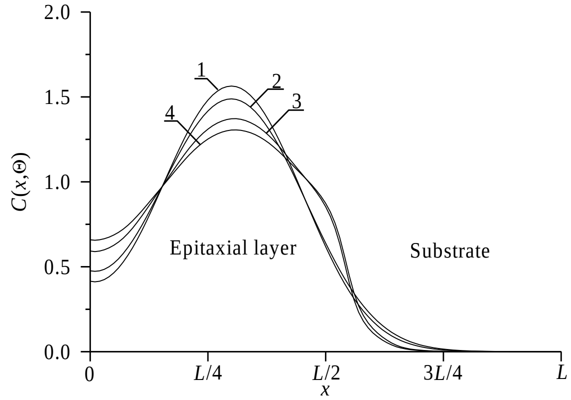

Fig2*b*. *Dependences of concentration of dopant, implanted in heterostructure from Figs. 1, on coordinate in direction, which is perpendicular to interface between epitaxial layer substrate.*

Difference between values of dopant diffusion coefficient in layers of heterostructure increases with increasing of number of curves. Value of dopant diffusion coefficient in the epitaxial layer is larger, than value of dopant diffusion coefficient in the substrate. Curve 1 corresponds to homogenous sample and annealing time $\Theta = 0.0048\ (L_x^2+L_y^2+L_z^2)/D_0$. Curve 2 corresponds to homogenous sample and annealing time $\Theta = 0.0057\ (L_x^2+L_y^2+L_z^2)/D_0$. Curves 3 and 4 correspond to heterostructure from Figs. 1; annealing times $\Theta = 0.0048\ (L_x^2+L_y^2+L_z^2)/D_0$ and $\Theta = 0.0057\ (L_x^2+L_y^2+L_z^2)/D_0$, respectively

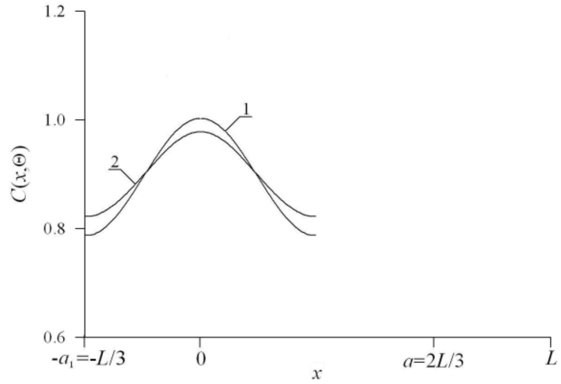

Fig3*a*. *Distributions of concentration of dopant, infused in average section of epitaxial layer of heterostructure from Figs. 1 in direction parallel to interface between epitaxial layer and substrate of heterostructure. Difference between values of dopant diffusion coefficients increases with increasing of number of curves. Value of dopant diffusion coefficient in this section is smaller, than value of dopant diffusion coefficient in nearest sections*

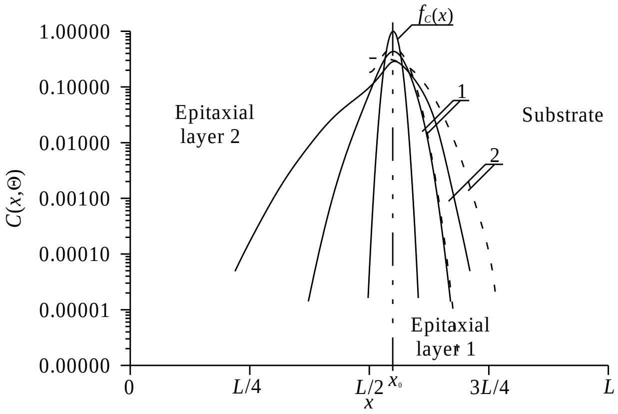

Fig3*b*. *Calculated distributions of implanted dopant in epitaxial layers of heterostructure. Solid lines are spatial distributions of implanted dopant in system of two epitaxial layers. Dushed lines are spatial distributions of implanted dopant in one epitaxial layer. Annealing time increases with increasing of number of curves*

4. Conclusion

In this paper we introduce an approach to increase integration rate of element of a current source. The approach gives us possibility to decrease area of the elements with smaller increasing of the element's thickness.

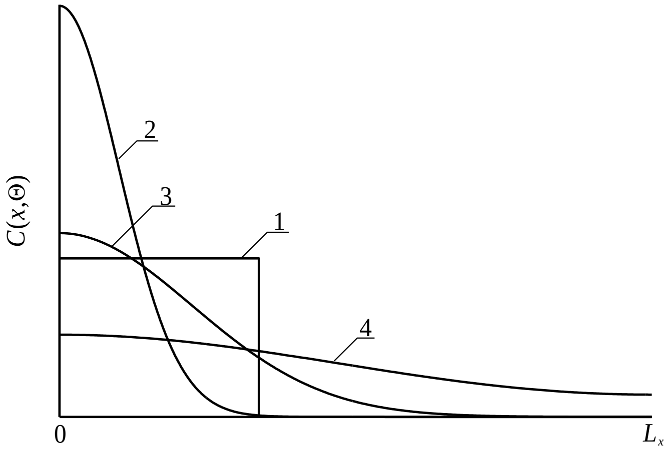

Fig4*a*. *Distributions of concentration of infused dopant in depth of heterostructure from Fig. 1 for different values of annealing time (curves 2-4) and idealized step-wise approximation (curve 1). Increasing of number of curve corresponds to increasing of annealing time*

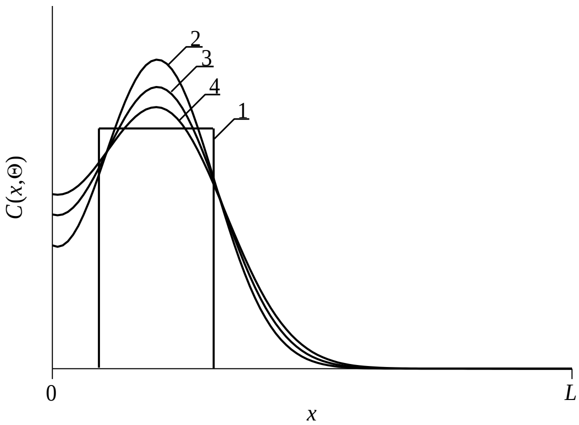

Fig4*b*. *Distributions of concentration of implanted dopant in depth of heterostructure from Fig. 1 for different values of annealing time (curves 2-4) and idealized step-wise approximation (curve 1). Increasing of number of curve corresponds to increasing of annealing time*

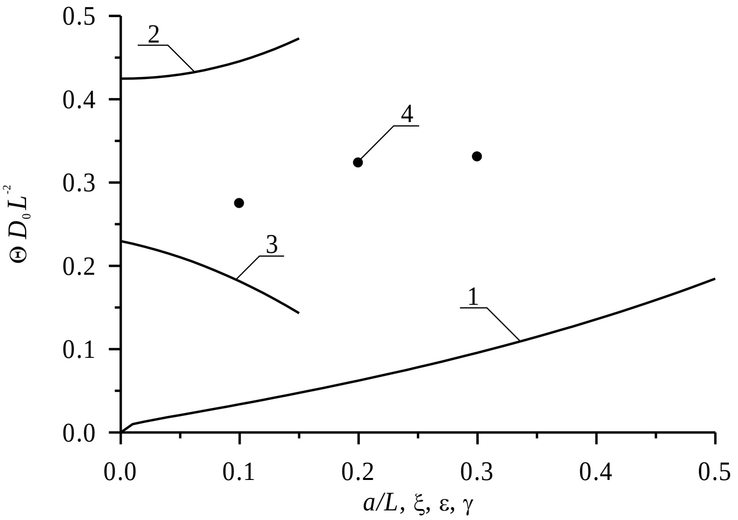

Fig5*a*. *Dimensionless optimal annealing time of infused dopant as a function of several parameters*

Curve 1 describes the dependence of the annealing time on the relation *a/L* and $\xi = \gamma = 0$ for equal to each other values of dopant diffusion coefficient in all parts of heterostructure. Curve 2 describes the dependence of the annealing time on value of parameter ε for *a/L*=1/2 and $\xi = \gamma = 0$. Curve 3 describes the dependence of the annealing time on value of parameter ξ for *a/L*=1/2 and $\varepsilon = \gamma = 0$. Curve 4 describes the dependence of the annealing time on value of parameter γ for *a/L*=1/2 and $\varepsilon = \xi = 0$

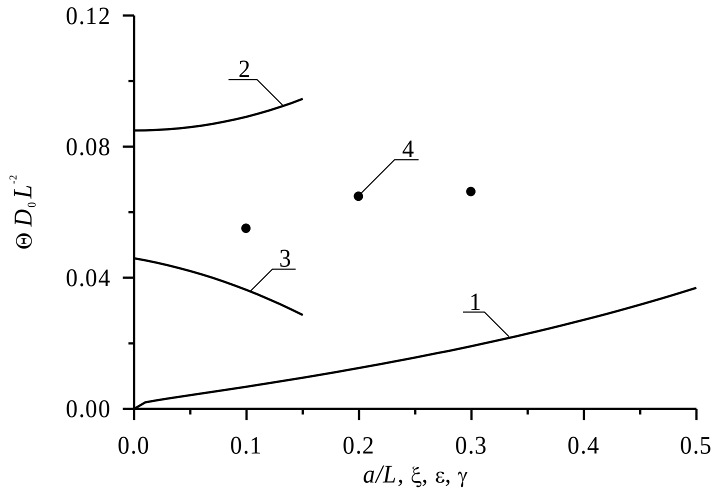

Fig5*b*. *Dimensionless optimal annealing time of implanted dopant as a function of several parameters*

Curve 1 describes the dependence of the annealing time on the relation *a/L* and $\xi = \gamma = 0$ for equal to each other values of dopant diffusion coefficient in all parts of heterostructure. Curve 2 describes the dependence of the annealing time on value of parameter ε for *a/L*=1/2 and $\xi = \gamma = 0$. Curve 3 describes the dependence of the annealing time on value of parameter ξ for *a/L*=1/2 and $\varepsilon = \gamma = 0$. Curve 4 describes the dependence of the annealing time on value of parameter γ for *a/L*=1/2 and $\varepsilon = \xi = 0$

REFERENCES

[1] V.I. Lachin, N.S. Savelov. *Electronics* (Phoenix, Rostov-na-Donu, 2001).

[2] A.G. Alexenko, I.I. Shagurin. *Microcircuitry* (Radio and communication, Moscow, 1990).

[3] N.A. Avaev, Yu.E. Naumov, V.T. Frolkin. *Basis of microelectronics* (Radio and communication, Moscow, 1991).

[4] A. Baradaranrezaeii, O. Shino, K. Hadidi, A. Khoei. Analog. Integr. Circ. Sig. Process. **Vol. 85**. P. 181-192 (2015).

[5] D. Fathi, B. Forouzandeh, N. Masoumi. Nano. **Vol. 4** (4). P. 233-238 (2009).

[6] S.A. Chachuli, P.N.A. Fasyar, N. Soin, N.M. Kar, N. Yusop. Mat. Sci. Sem. Proc. **Vol. 24**. P. 9-14 (2014).

[7] A.O. Ageev, A.E. Belyaev, N.S. Boltovets, V.N. Ivanov, R.V. Konakova, Ya.Ya. Kudrik, P.M. Litvin, V.V. Milenin, A.V. Sachenko. Semiconductors. **Vol. 43** (7). P. 897-903 (2009).

[8] Z. Li, J. Waldron, T. Detchprohm, C. Wetzel, R.F. Karlicek, Jr.T.P. Chow. Appl. Phys. Lett. **Vol. 102** (19). P. 192107-192109 (2013).

[9] Jung-Hui Tsai, Shao-Yen Chiu, Wen-Shiung Lour, Der-Feng Guo. Semiconductors. **Vol. 43** (7). P. 971-974 (2009).

[10] O.V. Alexandrov, A.O. Zakhar'in, N.A. Sobolev, E.I. Shek, M.M. Makoviychuk, E.O. Parshin. Semiconductors. **Vol. 32** (9). P. 1029-1032 (1998).

[11] M.J. Kumar, T.V. Singh. Int. J. Nanoscience. **Vol. 7** (2-3). P. 81-84 (2008).

[12] P. Sinsermsuksakul, K. Hartman, S.B. Kim, J. Heo, L. Sun, H.H. Park, R. Chakraborty, T. Buonassisi, R.G. Gordon. Appl. Phys. Lett. **Vol. 102** (5). P. 053901-053905 (2013).

[13] J.G. Reynolds, C.L. Reynolds, Jr.A. Mohanta, J.F. Muth, J.E. Rowe, H.O. Everitt, D.E. Aspnes. Appl. Phys. Lett. **Vol. 102** (15). P. 152114-152118 (2013).

[14] K.K. Ong, K.L. Pey, P.S. Lee, A.T.S. Wee, X.C. Wang, Y.F. Chong. Appl. Phys. Lett. **Vol. 89** (17). P. 172111-172114 (2006).

[15] H.T. Wang, L.S. Tan, E. F. Chor. J. Appl. Phys. **Vol. 98** (9). P. 094901-094905 (2006).

[16] S.T. Shishiyanu, T.S. Shishiyanu, S.K. Railyan. Semiconductors. **Vol. 36** (5). P. 611-617 (2002).

[17] Yu.V. Bykov, A.G. Yeremeev, N.A. Zharova, I.V. Plotnikov, K.I. Rybakov, M.N. Drozdov, Yu.N. Drozdov, V.D. Skupov. Radiophysics and Quantum Electronics. **Vol. 43** (3). P. 836-843 (2003).

[18] E.L. Pankratov, E.A. Bulaeva. Reviews in Theoretical Science. **Vol. 1** (1). P. 58-82 (2013).

[19] Yu.N. Erofeev. *Pulse devices* (Higher School, Moscow, 1989).

[20] V.V. Kozlivsky. *Modification of semiconductors by proton beams* (Science, Sant-Peterburg, 2003).

[21] Z.Yu. Gotra. *Technology of microelectronic devices* (Radio and communication, Moscow, 1991).

[22] V.L. Vinetskiy, G.A. Kholodar', *Radiative physics of semiconductors*. ("Naukova Dumka", Kiev, 1979).

[23] P.M. Fahey, P.B. Griffin, J.D. Plummer. Rev. Mod. Phys. **Vol. 61** (2). P. 289-388 (1989).

[24] A.N. Tikhonov, A.A. Samarskii. *The mathematical physics equations* (Moscow, Nauka 1972).

[25] H.S. Carslaw, J.C. Jaeger. *Conduction of heat in solids* (Oxford University Press, 1964).

[26] E.L. Pankratov. Russian Microelectronics. **Vol. 36** (1). P. 33-39 (2007).

[27] E.L. Pankratov. Int. J. Nanoscience. **Vol. 7** (4-5). P. 187–197 (2008).

[28] E.L. Pankratov. J. Comp. Theor. Nanoscience. **Vol. 14** (10). P.4885-4899 (2017).

[29] E.L. Pankratov. Advanced science, engineering and medicine. **Vol. 9** (9). P. 787 - 801 (2017).

[30] E.L. Pankratov, E.A. Bulaeva. Multidiscipline Modeling in Materials and Structures. **Vol. 13** (4). P. 664-677 (2017).

[31] E.L. Pankratov, E.A. Bulaeva. Int. J. Micro-Nano Scale Transp. **Vol. 4** (1). P. 17-31 (2014).

[32] E.L. Pankratov, E.A. Bulaeva. Multidiscipline Modeling in Materials and Structures. **Vol. 12** (4). P. 578-604 (2016).

[33] E.L. Pankratov, E.A. Bulaeva. Materials science in semiconductor processing. **Vol. 34**. P. 260-268 (2015).

APPENDIX

Equations for the functions $\tilde{I}_{ijk}(\chi,\eta,\phi,\vartheta)$ and $\tilde{V}_{ijk}(\chi,\eta,\phi,\vartheta)$, $i \geq 0$, $j \geq 0$, $k \geq 0$ and conditions for them

$$\frac{\partial \tilde{I}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta} = \sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2} + \frac{\partial^2 \tilde{I}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2} + \frac{\partial^2 \tilde{I}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]$$

$$\frac{\partial \tilde{V}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta} = \sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2 \tilde{V}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2} + \frac{\partial^2 \tilde{V}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2} + \frac{\partial^2 \tilde{V}_{000}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right];$$

$$\frac{\partial \tilde{I}_{i00}(\chi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{I}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{I}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]+\sqrt{\frac{D_{0I}}{D_{0V}}}\times$$

$$\times\left\{\frac{\partial}{\partial \chi}\left[g_I(\chi,\eta,\phi,T)\frac{\partial \tilde{I}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right]+\frac{\partial}{\partial \eta}\left[g_I(\chi,\eta,\phi,T)\frac{\partial \tilde{I}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\right]++\frac{\partial}{\partial \phi}\left[g_I(\chi,\eta,\phi,T)\frac{\partial \tilde{I}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right]\right\},\ i\geq 1,$$

$$\frac{\partial \tilde{V}_{i00}(\chi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2 \tilde{V}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{V}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{V}_{i00}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]+\frac{\partial}{\partial \chi}\left[g_V(\chi,\eta,\phi,T)\times\right.$$

$$\left.\times\frac{\partial \tilde{V}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right]\sqrt{\frac{D_{0V}}{D_{0I}}}+\sqrt{\frac{D_{0V}}{D_{0I}}}\frac{\partial}{\partial \eta}\left[g_V(\chi,\eta,\phi,T)\frac{\partial \tilde{V}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\right]+\frac{\partial}{\partial \phi}\left[g_V(\chi,\eta,\phi,T)\times\right.$$

$$\left.\times\frac{\partial \tilde{V}_{i-100}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right]\sqrt{\frac{D_{0V}}{D_{0I}}},\ i\geq 1,$$

$$\frac{\partial \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]-$$

$$-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)$$

$$\frac{\partial \tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2 \tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]-$$

$$-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta);$$

$$\frac{\partial \tilde{I}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{I}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{I}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]-$$

$$-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\left[\tilde{I}_{010}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)+\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)\right]$$

$$\frac{\partial \tilde{V}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{V}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{V}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{V}_{020}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]-$$

$$-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\left[\tilde{I}_{010}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)+\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)\right];$$

$$\frac{\partial \tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]--\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]\tilde{I}^2_{000}(\chi,\eta,\phi,\vartheta)$$

$$\frac{\partial \tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2 \tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]--\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]\tilde{V}^2_{000}(\chi,\eta,\phi,\vartheta);$$

$$\frac{\partial \tilde{I}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2 \tilde{I}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{I}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{I}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]+\sqrt{\frac{D_{0I}}{D_{0V}}}\times$$

$$\times\left\{\frac{\partial}{\partial \chi}\left[g_I(\chi,\eta,\phi,T)\frac{\partial \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \chi}\right]+\frac{\partial}{\partial \eta}\left[g_I(\chi,\eta,\phi,T)\frac{\partial \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \eta}\right]+\frac{\partial}{\partial \phi}\left[g_I(\chi,\eta,\phi,T)\times\right.\right.$$

$$\left.\left.\times\frac{\partial \tilde{I}_{010}(\chi,\eta,\phi,\vartheta)}{\partial \phi}\right]\right\}-\left[\tilde{I}_{100}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)+\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{100}(\chi,\eta,\phi,\vartheta)\right]\times\times\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]$$

$$\frac{\partial \tilde{V}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2 \tilde{V}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \chi^2}+\frac{\partial^2 \tilde{V}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \eta^2}+\frac{\partial^2 \tilde{V}_{110}(\chi,\eta,\phi,\vartheta)}{\partial \phi^2}\right]+$$

$$+\sqrt{\frac{D_{0V}}{D_{0I}}}\left\{\frac{\partial}{\partial\chi}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial\chi}\right]+\frac{\partial}{\partial\eta}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial\eta}\right]+\right.$$

$$\left.+\frac{\partial}{\partial\phi}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)}{\partial\phi}\right]\right\}-\left[1+\varepsilon_{V,V}g_{V,V}(\chi,\eta,\phi,T)\right]\times\times\left[\tilde{V}_{100}(\chi,\eta,\phi,\vartheta)\,\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)+\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)\tilde{I}_{100}(\chi,\eta,\phi,\vartheta)\right];$$

$$\frac{\partial\tilde{I}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2\tilde{I}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{I}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{I}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]-\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]\tilde{I}_{001}(\chi,\eta,\phi,\vartheta)\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)$$

$$\frac{\partial\tilde{V}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2\tilde{V}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{V}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{V}_{002}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]-\left[1+\varepsilon_{V,V}g_{V,V}(\chi,\eta,\phi,E)\right]\tilde{V}_{001}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta);$$

$$\frac{\partial\tilde{I}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2\tilde{I}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{I}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{I}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]++\sqrt{\frac{D_{0I}}{D_{0V}}}\left\{\frac{\partial}{\partial\chi}\left[g_I(\chi,\eta,\phi,T)\frac{\partial\tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\chi}\right]+\frac{\partial}{\partial\eta}\left[g_I(\chi,\eta,\phi,T)\frac{\partial\tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\eta}\right]+\right.$$

$$\left.+\frac{\partial}{\partial\phi}\left[g_I(\chi,\eta,\phi,T)\frac{\partial\tilde{I}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\phi}\right]\right\}-\left[1+\varepsilon_I g_I(\chi,\eta,\phi,T)\right]\tilde{I}_{100}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)$$

$$\frac{\partial\tilde{V}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2\tilde{V}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{V}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{V}_{101}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]++\sqrt{\frac{D_{0V}}{D_{0I}}}\left\{\frac{\partial}{\partial\chi}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\chi}\right]+\frac{\partial}{\partial\eta}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\eta}\right]+\right.$$

$$\left.+\frac{\partial}{\partial\phi}\left[g_V(\chi,\eta,\phi,T)\frac{\partial\tilde{V}_{001}(\chi,\eta,\phi,\vartheta)}{\partial\phi}\right]\right\}-\left[1+\varepsilon_V g_V(\chi,\eta,\phi,T)\right]\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{100}(\chi,\eta,\phi,\vartheta);$$

$$\frac{\partial\tilde{I}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0I}}{D_{0V}}}\left[\frac{\partial^2\tilde{I}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{I}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{I}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]-\tilde{I}_{010}(\chi,\eta,\phi,\vartheta)\times$$

$$\times\left[1+\varepsilon_{I,I}g_{I,I}(\chi,\eta,\phi,T)\right]\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,T)\right]\tilde{I}_{001}(\chi,\eta,\phi,\vartheta)\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)$$

$$\frac{\partial\tilde{V}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\vartheta}=\sqrt{\frac{D_{0V}}{D_{0I}}}\left[\frac{\partial^2\tilde{V}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\chi^2}+\frac{\partial^2\tilde{V}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\eta^2}+\frac{\partial^2\tilde{V}_{011}(\chi,\eta,\phi,\vartheta)}{\partial\phi^2}\right]-\tilde{V}_{010}(\chi,\eta,\phi,\vartheta)\times$$

$$\times\left[1+\varepsilon_{V,V}g_{V,V}(\chi,\eta,\phi,T)\right]\tilde{V}_{000}(\chi,\eta,\phi,\vartheta)-\left[1+\varepsilon_{I,V}g_{I,V}(\chi,\eta,\phi,t)\right]\tilde{I}_{000}(\chi,\eta,\phi,\vartheta)\tilde{V}_{001}(\chi,\eta,\phi,\vartheta);$$

$$\left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\chi}\right|_{x=0}=0,\ \left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\chi}\right|_{x=1}=0,\ \left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\eta}\right|_{\eta=0}=0,\ \left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\eta}\right|_{\eta=1}=0,$$

$$\left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\phi}\right|_{\phi=0}=0,\ \left.\frac{\partial\tilde{\rho}_{ijk}(\chi,\eta,\phi,\vartheta)}{\partial\phi}\right|_{\phi=1}=0\ (i\geq 0,\ j\geq 0,\ k\geq 0);$$

$$\tilde{\rho}_{000}(\chi,\eta,\phi,0)=f_\rho(\chi,\eta,\phi)/\rho^*,\ \tilde{\rho}_{ijk}(\chi,\eta,\phi,0)=0\ (i\geq 1,\ j\geq 1,\ k\geq 1).$$

Solutions of the above equations could be written as

$$\tilde{\rho}_{000}(\chi,\eta,\phi,\vartheta)=\frac{1}{L}+\frac{2}{L}\sum_{n=1}^{\infty}F_{n\rho}c(\chi)c(\eta)c(\phi)e_{n\rho}(\vartheta),$$

where $F_{n\rho}=\frac{1}{\rho^*}\int_0^1 cos(\pi n u)\int_0^1 cos(\pi n v)\int_0^1 cos(\pi n w)f_{n\rho}(u,v,w)\,d\,w\,d\,v\,d\,u$, $c_n(\chi) = cos(\pi n \chi)$,

$$e_{nI}(\vartheta)=exp\left(-\pi^2 n^2\vartheta\sqrt{D_{0V}/D_{0I}}\right),\ e_{nV}(\vartheta)=exp\left(-\pi^2 n^2\vartheta\sqrt{D_{0I}/D_{0V}}\right);$$

$$\tilde{I}_{i00}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n c_n(\chi)c(\eta)c(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial u}\times$$

$$\times c_n(w)g_I(u,v,w,T)\,d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n c_n(\chi)c(\eta)c(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 s_n(v)\times$$

$$\times\int_0^1 c_n(w)g_I(u,v,w,T)\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n c_n(\chi)c(\eta)c(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\times$$

$$\times\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(w)g_I(u,v,w,T)\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau,\ i\geq 1,$$

$$\tilde{V}_{i00}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c(\eta)c(\phi)e_{nV}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1 g_V(u,v,w,T)\times$$
$$\times c_n(w)\frac{\partial\tilde{V}_{i-100}(u,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c(\eta)c(\phi)e_{nV}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 s_n(v)\times$$
$$\times 2\pi\int_0^1 c_n(w)\,g_V(u,v,w,T)\frac{\partial\tilde{V}_{i-100}(u,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c(\eta)c(\phi)e_{nV}(\vartheta)\times$$
$$\times\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(w)g_V(u,v,w,T)\frac{\partial\tilde{V}_{i-100}(u,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau,\ i\geq 1,$$

where $s_n(\chi) = sin\,(\pi\,n\,\chi)$;

$$\tilde{\rho}_{010}(\chi,\eta,\phi,\vartheta)=-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)e_{n\rho}(\vartheta)\int_0^{\vartheta}e_{n\rho}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\times$$
$$\times\left[1+\varepsilon_{I,V}g_{I,V}(u,v,w,T)\right]\tilde{I}_{000}(u,v,w,\tau)\,\tilde{V}_{000}(u,v,w,\tau)\,d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{\rho}_{020}(\chi,\eta,\phi,\vartheta)=-2\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)\,c_n(\phi)e_{n\rho}(\vartheta)\int_0^{\vartheta}e_{n\rho}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\left[1+\varepsilon_{I,V}\times\right.$$
$$\left.\times\,g_{I,V}(u,v,w,T)\right]\left[\tilde{I}_{010}(u,v,w,\tau)\tilde{V}_{000}(u,v,w,\tau)+\tilde{I}_{000}(u,v,w,\tau)\tilde{V}_{010}(u,v,w,\tau)\right]d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{\rho}_{001}(\chi,\eta,\phi,\vartheta)=-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)e_{n\rho}(\vartheta)\int_0^{\vartheta}e_{n\rho}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\times$$
$$\times\left[1+\varepsilon_{\rho,\rho}g_{\rho,\rho}(u,v,w,T)\right]\tilde{\rho}_{000}^2(u,v,w,\tau)d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{\rho}_{002}(\chi,\eta,\phi,\vartheta)=-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)e_{n\rho}(\vartheta)\int_0^{\vartheta}e_{n\rho}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\times$$
$$\times\left[1+\varepsilon_{\rho,\rho}g_{\rho,\rho}(u,v,w,T)\right]\tilde{\rho}_{001}(u,v,w,\tau)\tilde{\rho}_{000}(u,v,w,\tau)d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{I}_{110}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1 c_n(u)\times$$
$$\times\,g_I(u,v,w,T)\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nI}(\vartheta)\times$$
$$\times\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 s_n(v)\int_0^1 c_n(u)g_I(u,v,w,T)\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\times$$
$$\times\sum_{n=1}^{\infty}n\,e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(u)g_I(u,v,w,T)\frac{\partial\tilde{I}_{i-100}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau\times$$
$$\times\,c_n(\chi)c_n(\eta)c_n(\phi)-2\sum_{n=1}^{\infty}c_n(\chi)e_{nI}(\vartheta)c_n(\eta)c_n(\phi)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(v)\left[1+\varepsilon_{I,V}\times\right.$$
$$\left.\times\,g_{I,V}(u,v,w,T)\right]\left[\tilde{I}_{100}(u,v,w,\tau)\tilde{V}_{000}(u,v,w,\tau)+\tilde{I}_{000}(u,v,w,\tau)\tilde{V}_{100}(u,v,w,\tau)\right]d\,w\,d\,v\,d\,u\,d\,\tau$$

$$\tilde{V}_{110}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nV}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1 c_n(u)\times$$

$$\times g_V(u,v,w,T)\frac{\partial \tilde{V}_{i-100}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nV}(\vartheta)\times$$
$$\times\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 s_n(v)\int_0^1 c_n(u)g_V(u,v,w,T)\frac{\partial \tilde{V}_{i-100}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\times$$
$$\times\sum_{n=1}^{\infty}n\,e_{nV}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(u)g_V(u,v,w,T)\frac{\partial \tilde{V}_{i-100}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau\times$$
$$\times c_n(\chi)c_n(\eta)c_n(\phi)-2\sum_{n=1}^{\infty}c_n(\chi)e_{nI}(\vartheta)c_n(\eta)c_n(\phi)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1\left[1+\varepsilon_{I,V}\;g_{I,V}(u,v,w,T)\right]\times$$
$$\times c_n(w)\left[\tilde{I}_{100}(u,v,w,\tau)\tilde{V}_{000}(u,v,w,\tau)+\tilde{I}_{000}(u,v,w,\tau)\,\tilde{V}_{100}(u,v,w,\tau)\right]d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{I}_{101}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1 g_I(u,v,w,T)\times$$

$$\times c_n(w)\frac{\partial \tilde{I}_{001}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,c_n(\chi)\,c_n(\eta)\,c_n(\phi)\,e_{nI}(\vartheta)\times$$

$$\times\int_0^1 s_n(v)\int_0^1 c_n(w)g_I(u,v,w,T)\frac{\partial \tilde{I}_{001}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,e_{nI}(\vartheta)c_n(\chi)c_n(\eta)c_n(\phi)\times$$
$$\times\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(w)g_I(u,v,w,T)\frac{\partial \tilde{I}_{001}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)\times$$
$$\times e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\left[1+\varepsilon_{I,V}g_{I,V}(u,v,w,T)\right]\tilde{I}_{100}(u,v,w,\tau)\,\tilde{V}_{000}(u,v,w,\tau)\,d\,w\,d\,v\,d\,u\,d\,\tau$$
$$\tilde{V}_{101}(\chi,\eta,\phi,\vartheta)=-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)c_n(\eta)c_n(\phi)e_{nV}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 s_n(u)\int_0^1 c_n(v)\int_0^1 g_V(u,v,w,T)\times$$
$$\times c_n(w)\frac{\partial \tilde{V}_{001}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0V}}{D_{0I}}}\sum_{n=1}^{\infty}n\,c_n(\chi)\,c_n(\eta)\,c_n(\phi)\,e_{nI}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\times$$
$$\times\int_0^1 s_n(v)\int_0^1 c_n(w)g_I(u,v,w,T)\frac{\partial \tilde{I}_{001}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-2\pi\sqrt{\frac{D_{0I}}{D_{0V}}}\sum_{n=1}^{\infty}n\,e_{nI}(\vartheta)c_n(\chi)c_n(\eta)c_n(\phi)\times$$
$$\times\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 s_n(w)g_V(u,v,w,T)\frac{\partial \tilde{V}_{001}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)\times$$
$$\times e_{nV}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\left[1+\varepsilon_{I,V}g_{I,V}(u,v,w,T)\right]\tilde{I}_{100}(u,v,w,\tau)\,\tilde{V}_{000}(u,v,w,\tau)\,d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$\tilde{I}_{011}(\chi,\eta,\phi,\vartheta)=-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)e_{nI}(\vartheta)\int_0^{\vartheta}e_{nI}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\left\{\tilde{I}_{000}(u,v,w,\tau)\times\right.$$
$$\left.\times\left[1+\varepsilon_{I,I}g_{I,I}(u,v,w,T)\right]\tilde{I}_{010}(u,v,w,\tau)+\left[1+\varepsilon_{I,V}g_{I,V}(u,v,w,T)\right]\tilde{I}_{001}(u,v,w,\tau)\tilde{V}_{000}(u,v,w,\tau)\right\}d\,w\,d\,v\,d\,u\,d\,\tau$$
$$\tilde{V}_{011}(\chi,\eta,\phi,\vartheta)=-2\sum_{n=1}^{\infty}c_n(\chi)c_n(\eta)c_n(\phi)e_{nV}(\vartheta)\int_0^{\vartheta}e_{nV}(-\tau)\int_0^1 c_n(u)\int_0^1 c_n(v)\int_0^1 c_n(w)\left\{\tilde{I}_{000}(u,v,w,\tau)\times\right.$$
$$\left.\times\left[1+\varepsilon_{I,I}g_{I,I}(u,v,w,T)\right]\tilde{I}_{010}(u,v,w,\tau)+\left[1+\varepsilon_{I,V}g_{I,V}(u,v,w,T)\right]\tilde{I}_{001}(u,v,w,\tau)\tilde{V}_{000}(u,v,w,\tau)\right\}d\,w\,d\,v\,d\,u\,d\,\tau$$

Equations for functions $\Phi_{\rho i}(x,y,z,t)$, $i \geq 0$ to describe concentrations of simplest complexes of radiation defects.

$$\frac{\partial\,\Phi_{I0}(x,y,z,t)}{\partial t}=D_{0\Phi I}\left[\frac{\partial^2\,\Phi_{I0}(x,y,z,t)}{\partial x^2}+\frac{\partial^2\,\Phi_{I0}(x,y,z,t)}{\partial y^2}+\frac{\partial^2\,\Phi_{I0}(x,y,z,t)}{\partial z^2}\right]+$$

$$+k_{I,I}(x,y,z,T)I^2(x,y,z,t)-k_I(x,y,z,T)I(x,y,z,t)$$

$$\frac{\partial \Phi_{V0}(x,y,z,t)}{\partial t}=D_{0\Phi V}\left[\frac{\partial^2 \Phi_{V0}(x,y,z,t)}{\partial x^2}+\frac{\partial^2 \Phi_{V0}(x,y,z,t)}{\partial y^2}+\frac{\partial^2 \Phi_{V0}(x,y,z,t)}{\partial z^2}\right]+$$

$$+k_{V,V}(x,y,z,T)V^2(x,y,z,t)-k_V(x,y,z,T)V(x,y,z,t);$$

$$\frac{\partial \Phi_{Ii}(x,y,z,t)}{\partial t}=D_{0\Phi I}\left[\frac{\partial^2 \Phi_{Ii}(x,y,z,t)}{\partial x^2}+\frac{\partial^2 \Phi_{Ii}(x,y,z,t)}{\partial y^2}+\frac{\partial^2 \Phi_{Ii}(x,y,z,t)}{\partial z^2}\right]+$$

$$+D_{0\Phi I}\left\{\frac{\partial}{\partial x}\left[g_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{Ii-1}(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[g_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{Ii-1}(x,y,z,t)}{\partial y}\right]+\right.$$

$$\left.+\frac{\partial}{\partial z}\left[g_{\Phi I}(x,y,z,T)\frac{\partial \Phi_{Ii-1}(x,y,z,t)}{\partial z}\right]\right\},\ i\ge 1,$$

$$\frac{\partial \Phi_{Vi}(x,y,z,t)}{\partial t}=D_{0\Phi V}\left[\frac{\partial^2 \Phi_{Vi}(x,y,z,t)}{\partial x^2}+\frac{\partial^2 \Phi_{Vi}(x,y,z,t)}{\partial y^2}+\frac{\partial^2 \Phi_{Vi}(x,y,z,t)}{\partial z^2}\right]+$$

$$+D_{0\Phi V}\left\{\frac{\partial}{\partial x}\left[g_{\Phi V}(x,y,z,T)\frac{\partial \Phi_{Vi-1}(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[g_{\Phi V}(x,y,z,T)\frac{\partial \Phi_{Vi-1}(x,y,z,t)}{\partial y}\right]+\right.$$
$$\left.+\frac{\partial}{\partial z}\left[g_{\Phi V}(x,y,z,T)\frac{\partial \Phi_{Vi-1}(x,y,z,t)}{\partial z}\right]\right\},\ i\ge 1;$$

Boundary and initial conditions for the functions takes the form

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

$$\left.\frac{\partial \Phi_{\rho i}(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial \Phi_{\rho i}(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,\ i\ge 0;\ \Phi_{\rho 0}(x,y,z,0)=f_{\Phi\rho}(x,y,z),$$

$$\Phi_{\rho i}(x,y,z,0)=0,\ i\ge 1.$$

Solutions of the above equations could be written as

$$\Phi_{\rho 0}(x,y,z,t)=\frac{1}{L_xL_yL_z}+\frac{2}{L_xL_yL_z}\sum_{n=1}^{\infty}F_{n\Phi_\rho}c_n(x)c_n(y)c_n(z)e_{n\Phi_\rho}(t)+\frac{2}{L}\sum_{n=1}^{\infty}n\,c_n(x)c_n(y)\,c_n(z)\times$$
$$\times e_{\Phi_\rho n}(t)\int_0^t e_{\Phi_\rho n}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\left[k_{I,I}(u,v,w,T)I^2(u,v,w,\tau)--k_I(u,v,w,T)I(u,v,w,\tau)\right]d\,w\,d\,v\,d\,u\,d\tau,$$

where $F_{n\Phi_\rho}=\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\,f_{\Phi_\rho}(u,v,w)d\,w\,d\,v\,d\,u$, $e_{n\Phi_\rho}(t)=exp\left[-\pi^2n^2D_{0\Phi_\rho}t\left(L_x^{-2}+L_y^{-2}+L_z^{-2}\right)\right]$, $c_n(x) = cos\ (\pi n\ x/L_x)$;

$$\Phi_{\rho i}(x,y,z,t)=-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}n\,c_n(x)\,c_n(y)\,c_n(z)\,e_{\Phi_\rho n}(t)\int_0^t e_{\Phi_\rho n}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}g_{\Phi_\rho}(u,v,w,T)\times$$

$$\times c_n(w)\frac{\partial \Phi_{I_\rho i-1}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}n\,c_n(x)c_n(y)c_n(z)e_{\Phi_\rho n}(t)\int_0^t e_{\Phi_\rho n}(-\tau)\times$$
$$\times\int_0^t e_{\Phi_\rho n}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}s_n(v)\int_0^{L_z}c_n(w)g_{\Phi_\rho}(u,v,w,T)\frac{\partial \Phi_{I_\rho i-1}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}n\times$$

$$\times e_{\Phi_{\rho n}}(t)\int_0^t e_{\Phi_{\rho n}}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} c_n(v)\int_0^{L_z} s_n(w)\frac{\partial \Phi_{I_\rho i-1}(u,v,w,\tau)}{\partial w} g_{\Phi_\rho}(u,v,w,T)\, d\,w\, d\,v\, d\,u\, d\tau \times$$
$$\times\, c_n(x)\, c_n(y)\, c_n(z),\ i \geq 1,$$

where $s_n(x) = sin\,(\pi\, n\, x/L_x)$.

Equations for the functions $C_{ij}(x,y,z,t)$ ($i \geq 0$, $j \geq 0$), boundary and initial conditions could be written as

$$\frac{\partial C_{00}(x,y,z,t)}{\partial t} = D_{0L}\frac{\partial^2 C_{00}(x,y,z,t)}{\partial x^2} + D_{0L}\frac{\partial^2 C_{00}(x,y,z,t)}{\partial y^2} + D_{0L}\frac{\partial^2 C_{00}(x,y,z,t)}{\partial z^2};$$

$$\frac{\partial C_{i0}(x,y,z,t)}{\partial t} = D_{0L}\left[\frac{\partial^2 C_{i0}(x,y,z,t)}{\partial x^2} + \frac{\partial^2 C_{i0}(x,y,z,t)}{\partial y^2} + \frac{\partial^2 C_{i0}(x,y,z,t)}{\partial z^2}\right] +$$
$$+ D_{0L}\frac{\partial}{\partial x}\left[g_L(x,y,z,T)\frac{\partial C_{i-10}(x,y,z,t)}{\partial x}\right] + D_{0L}\frac{\partial}{\partial y}\left[g_L(x,y,z,T)\frac{\partial C_{i-10}(x,y,z,t)}{\partial y}\right] +$$
$$+ D_{0L}\frac{\partial}{\partial z}\left[g_L(x,y,z,T)\frac{\partial C_{i-10}(x,y,z,t)}{\partial z}\right],\ i \geq 1;$$

$$\frac{\partial C_{01}(x,y,z,t)}{\partial t} = D_{0L}\frac{\partial^2 C_{01}(x,y,z,t)}{\partial x^2} + D_{0L}\frac{\partial^2 C_{01}(x,y,z,t)}{\partial y^2} + D_{0L}\frac{\partial^2 C_{01}(x,y,z,t)}{\partial z^2} +$$
$$+ D_{0L}\frac{\partial}{\partial x}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial x}\right] + D_{0L}\frac{\partial}{\partial y}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial y}\right] +$$
$$+ D_{0L}\frac{\partial}{\partial z}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial z}\right];$$

$$\frac{\partial C_{02}(x,y,z,t)}{\partial t} = D_{0L}\frac{\partial^2 C_{02}(x,y,z,t)}{\partial x^2} + D_{0L}\frac{\partial^2 C_{02}(x,y,z,t)}{\partial y^2} + D_{0L}\frac{\partial^2 C_{02}(x,y,z,t)}{\partial z^2} +$$
$$+ D_{0L}\left\{\frac{\partial}{\partial x}\left[C_{01}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial x}\right] + \frac{\partial}{\partial y}\left[C_{01}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\times\right.\right.$$
$$\left.\left.\times\frac{\partial C_{00}(x,y,z,t)}{\partial y}\right] + \frac{\partial}{\partial z}\left[C_{01}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial z}\right]\right\} +$$
$$\times\frac{\partial C_{00}(x,y,z,t)}{\partial y}\left.\right] + \frac{\partial}{\partial z}\left[C_{01}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial z}\right]\left.\right\} + D_{0L}\left\{\frac{\partial}{\partial x}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\times\right.\right.$$
$$\left.\left.\times\frac{\partial C_{01}(x,y,z,t)}{\partial x}\right] + \frac{\partial}{\partial y}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{01}(x,y,z,t)}{\partial y}\right] + \frac{\partial}{\partial z}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{01}(x,y,z,t)}{\partial z}\right]\right\};$$

$$\frac{\partial C_{11}(x,y,z,t)}{\partial t} = D_{0L}\frac{\partial^2 C_{11}(x,y,z,t)}{\partial x^2} + D_{0L}\frac{\partial^2 C_{11}(x,y,z,t)}{\partial y^2} + D_{0L}\frac{\partial^2 C_{11}(x,y,z,t)}{\partial z^2} +$$
$$+\left\{\frac{\partial}{\partial x}\left[C_{10}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial x}\right] + \frac{\partial}{\partial y}\left[C_{10}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\times\right.\right.$$
$$\left.\left.\times\frac{\partial C_{00}(x,y,z,t)}{\partial y}\right] + \frac{\partial}{\partial z}\left[C_{10}(x,y,z,t)\frac{C_{00}^{\gamma-1}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{00}(x,y,z,t)}{\partial z}\right]\right\} D_{0L} +$$

$$+D_{0L}\left\{\frac{\partial}{\partial x}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{10}(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{10}(x,y,z,t)}{\partial y}\right]+\right.$$

$$\left.+\frac{\partial}{\partial z}\left[\frac{C_{00}^{\gamma}(x,y,z,t)}{P^{\gamma}(x,y,z,T)}\frac{\partial C_{10}(x,y,z,t)}{\partial z}\right]\right\}+D_{0L}\left\{\frac{\partial}{\partial x}\left[g_L(x,y,z,T)\frac{\partial C_{01}(x,y,z,t)}{\partial x}\right]+\right.$$

$$\left.+\frac{\partial}{\partial y}\left[g_L(x,y,z,T)\frac{\partial C_{01}(x,y,z,t)}{\partial y}\right]+\frac{\partial}{\partial z}\left[g_L(x,y,z,T)\frac{\partial C_{01}(x,y,z,t)}{\partial z}\right]\right\};$$

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

$$\left.\frac{\partial C_{ij}(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial C_{ij}(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,\ i\ge 0,\ j\ge 0;$$

$$C_{00}(x,y,z,0)=f_C\,(x,y,z),\ C_{ij}(x,y,z,0)=0,\ i\ge 1,\ j\ge 1.$$

Functions $C_{ij}(x,y,z,t)$ ($i\ge 0$, $j\ge 0$) could be approximated by the following series during solutions of the above equations

$$C_{00}(x,y,z,t)=\frac{F_{0C}}{L_xL_yL_z}+\frac{2}{L_xL_yL_z}\sum_{n=1}^{\infty}F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\cdot$$

Here $e_{nC}(t)=exp\left[-\pi^2n^2D_{0C}t\left(\frac{1}{L_x^2}+\frac{1}{L_y^2}+\frac{1}{L_z^2}\right)\right]$, $F_{nC}=\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}f_C(u,v,w)\,c_n(w)\,d\,w\,d\,v\,d\,u$;

$$C_{i0}(x,y,z,t)=-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}g_L(u,v,w,T)\times$$

$$\times c_n(w)\frac{\partial C_{i-10}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\times$$

$$\times\int_0^{L_x}c_n(u)\int_0^{L_y}s_n(v)\int_0^{L_z}c_n(v)g_L(u,v,w,T)\frac{\partial C_{i-10}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}n\,F_{nC}e_{nC}(t)\times$$

$$\times c_n(x)c_n(y)c_n(z)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}s_n(v)g_L(u,v,w,T)\frac{\partial C_{i-10}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau,\ i\ge 1;$$

$$C_{01}(x,y,z,t)=-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\times$$

$$\times\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\times$$

$$\times\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}s_n(v)\int_0^{L_z}c_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}n\,e_{nC}(t)\times$$

$$\times F_{nC}c_n(x)c_n(y)c_n(z)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}s_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$C_{02}(x,y,z,t)=-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\times$$

$$\times C_{01}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}F_{nC}c_n(x)c_n(y)\times$$

$$\times n c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}s_n(v)\int_0^{L_z}C_{01}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial v}\times$$

$$\times c_n(w)d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\times$$

$$\times\int_0^{L_z}s_n(w)C_{01}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}n\,c_n(x)\times$$

$$\times F_{nC}c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)C_{01}(u,v,w,\tau)\frac{\partial C_{00}(u,v,w,\tau)}{\partial u}\times$$

$$\times\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\times$$

$$\times\int_0^{L_y}s_n(v)\int_0^{L_z}c_n(w)\,C_{01}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}n\times$$

$$\times F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}s_n(w)C_{01}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\times$$

$$\times\frac{\partial C_{00}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\times$$

$$\times n\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{01}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}c_n(x)e_{nC}(t)\times$$

$$\times F_{nC}c_n(y)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}s_n(v)\int_0^{L_z}c_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{01}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau\times$$

$$\times n\,c_n(z)-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}c_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}s_n(w)\times$$

$$\times\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{01}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau;$$

$$C_{11}(x,y,z,t)=-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x}s_n(u)\int_0^{L_y}c_n(v)\int_0^{L_z}c_n(w)\times$$

$$\times g_L(u,v,w,T)\frac{\partial C_{01}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty}nF_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\times$$

$$\times\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} s_n(v)\int_0^{L_z} c_n(w)g_L(u,v,w,T)\frac{\partial C_{01}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\times$$

$$\times\sum_{n=1}^{\infty} n\, e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} c_n(v)\int_0^{L_z} s_n(w)g_L(u,v,w,T)\frac{\partial C_{01}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau\times$$

$$\times F_{nC}c_n(x)c_n(y)c_n(z)-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty} F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} s_n(u)\int_0^{L_y} c_n(v)\times$$

$$\times n\int_0^{L_z} c_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{10}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty} n\,F_{nC}c_n(x)c_n(y)\times$$

$$\times c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} s_n(v)\int_0^{L_z} c_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{10}(u,v,w,\tau)}{\partial v}d\,w\,d\,v\,d\,u\,d\,\tau-$$

$$-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty} n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} c_n(v)\int_0^{L_z} s_n(w)\frac{C_{00}^{\gamma}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\times$$

$$\times\frac{\partial C_{10}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_x^2L_yL_z}\sum_{n=1}^{\infty} n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} s_n(u)\times$$

$$\times\int_0^{L_y} c_n(v)\int_0^{L_z} c_n(w)C_{10}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial u}d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_y^2L_z}\sum_{n=1}^{\infty} n\times$$

$$\times F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\int_0^{L_y} s_n(v)\int_0^{L_z} c_n(w)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial v}\times$$

$$\times C_{10}(u,v,w,\tau)d\,w\,d\,v\,d\,u\,d\,\tau-\frac{2\pi}{L_xL_yL_z^2}\sum_{n=1}^{\infty} n\,F_{nC}c_n(x)c_n(y)c_n(z)e_{nC}(t)\int_0^t e_{nC}(-\tau)\int_0^{L_x} c_n(u)\times$$

$$\times\int_0^{L_y} c_n(v)\int_0^{L_z} s_n(w)C_{10}(u,v,w,\tau)\frac{C_{00}^{\gamma-1}(u,v,w,\tau)}{P^{\gamma}(u,v,w,T)}\frac{\partial C_{00}(u,v,w,\tau)}{\partial w}d\,w\,d\,v\,d\,u\,d\,\tau\,.$$

Citation: *E.L. Pankratov (2020). "On Approach to Optimize Manufacturing of a Current Source Circuit for Increasing of Integration Rate of Elements)", International Journal of Research Studies in Electrical and Electronics Engineering (IJRSEEE), 6(3), pp.7-24, DOI: http://dx.doi.org/10.20431/2454-9436.0603002.*