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On influence of mismatch-induced stress on charge carriers mobility in an implanted-junction rectifier

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Abstract
In this paper we analyze changing of charge carrier's mobility in an implanted-junction rectifier under influence of miss match-induced stress. A model for description the considered situation is introduced. An analytical approach for analysis of mass transfer is introduced. The model gives a possibility to take into account the simultaneous changing of parameters of mass transport in space and time. At the same time the approach gives a possibility to take into account nonlinearity charge carrier's transport.

Keywords: charge carrier's mobility, implanted-junction rectifier, miss match-induced stress, analytical approach for prognosis

Introduction
Currently one can find an intensive development of solid-state electronics devices. One of directions of the development is increasing of switching frequency of *p-n-* junctions [1-3]. To solve this problem, one can search new materials with a higher values of charge carriers mobility [4-7]. Another way to decrease the switching time is increasing of sharpness of *p-n-* junction [8, 9]. Earlier it was shown that manufacturing of *p-n-* junctions by diffusion or ion implantation in a heterostructure and optimization of annealing time of dopant and/or radiation defects make it possible to increase sharpness of the above *p-n-* junctions [10-12]. It is known that there are missmatch-induced stress in heterostructures due to difference between lattice constants in layers of considered heterostructure are presented [13, 14]. To analyze of influence of missmatch-induced stress on value of charge carriers mobility in a *p-n-* junctions we consider the following situation. Let us consider a two-layer heterostructure, which consist of a substrate and an epitaxial layer with a known types of conductivity (see Fig. 1). A dopant has been implanted into the substrate through the epitaxial layer to generate in it required type of conductivity, which is opposite to type of conductivity of the substrate. In this case, conditions of implantation are selected so that the main part of the dopant would be in the substrate. Next, the radiation defects were annealed. Main aim of this paper is analysis of changing of charge carriers mobility in the implanted-junction rectifier under the influence of missmatch-induced stress. An accompanying aim of this paper is introduction of an analytical approach for analysis of mass transport processes, which makes it possible to take into account the simultaneous change in the parameters of the process under consideration in space and time, as well as its nonlinearity.

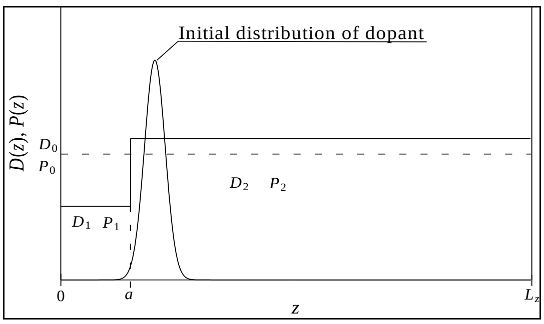

Fig 1: Heterostructure, which consist of substrate and epitaxial layer. Values D_1 and P_1 are the diffusion coefficient and limit of solubility of dopant in the epitaxial layer. Values D_2 and P_2 are the diffusion coefficient and limit of solubility of dopant in the substrate. Values D_0 and P_0 are the average values of diffusion coefficient and limit of solubility of dopant in the heterostructure

Method of solution

To solve our aims let us calculate spatiotemporal distribution of dopant. We calculate the distribution by solution the second low of Fourier [1-3] (the first three terms in the right side of the low describe free diffusion of dopant; other terms describe diffusion of dopant under influence of mismatch-induced stress).

$$\frac{\partial C(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_C\frac{\partial C(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_C\frac{\partial C(x,y,z,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial z}\left[D_C\frac{\partial C(x,y,z,t)}{\partial z}\right]+\Omega\frac{\partial}{\partial x}\left[\frac{D_S}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}C(x,y,W,t)dW\right]+ \quad (1)$$
$$+\Omega\frac{\partial}{\partial y}\left[\frac{D_S}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}C(x,y,W,t)dW\right]$$

with boundary and initial conditions (these conditions corresponds to absents of flow of dopants through external boundaries of the considered heterostructure)

$$\left.\frac{\partial C(x,y,z,t)}{\partial x}\right|_{x=0}=0,\ \left.\frac{\partial C(x,y,z,t)}{\partial x}\right|_{x=L_x}=0,\ \left.\frac{\partial C(x,y,z,t)}{\partial y}\right|_{y=0}=0,$$
$$\left.\frac{\partial C(x,y,z,t)}{\partial y}\right|_{y=L_y}=0,\ \left.\frac{\partial C(x,y,z,t)}{\partial z}\right|_{z=0}=0,\ \left.\frac{\partial C(x,y,z,t)}{\partial z}\right|_{z=L_z}=0,$$
$$C(x,y,z,0)=f_C(x,y,z). \quad (2)$$

Here $C(x, y, z, t)$ is the spatiotemporal distribution of dopant; Ω is the atomic volume; symbol ∇_S denotes surface gradient; $\int_0^{L_z}C(x,y,z,t)dz$ is the surface concentration of dopant on interface between layers of heterostructure; $\mu(x, y, z, t)$ is the chemical potential; D_C and D_S are the coefficients of volumetric and surface diffusions, respectively. The surface diffusion in this situation is the effect of missmatch- induced stress. Values of the diffusion coefficients depend on properties of materials of layers of heterostructure, rates of heating and cooling of heterostructure spatiotemporal distributions of concentrations of dopant and radiation defects. The dependences can be approximated by the following relations [2].

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

In the relations we used the following values: $D_L(x, y, z, T)$ and $D_{SL}(x, y, z, T)$ are the spatial (due to inhomogeneity of heterostructure and radiation damage of materials) and temperature (due to Arrhenius law) dependences of dopant diffusion coefficients; T is the annealing temperature; $P(x, y, z, T)$ 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, 15]; $V(x, y, z, t)$ is the spatiotemporal distribution of vacancies; V^* is the equilibrium distribution of vacancies. Dependence of dopant diffusion coefficients on concentration of dopant are discussed in details in [15]. Dependences of dopant diffusion coefficients on concentrations of vacancies is generalization of analogous relation in [16]. The generalization accounting generation of vacancies. The generation accounting by quadratic terms of the approximation [18]. Spatiotemporal distributions of concentrations of radiation defects we determine by solution the following system of equations [17, 18] (the first three terms in the right side of the low describe free diffusion of point radiation defects; other terms describe diffusion of point radiation defects under influence of mismatch-induced stress)

$$\frac{\partial I(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial y}\right]-$$
$$-k_{I,I}(x,y,z,T)I^2(x,y,z,t)+\frac{\partial}{\partial z}\left[D_I(x,y,z,T)\frac{\partial I(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)\times$$
$$\times I(x,y,z,t)V(x,y,z,t)+\Omega\frac{\partial}{\partial x}\left[\frac{D_{IS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}I(x,y,W,t)dW\right]+$$
$$+\Omega\frac{\partial}{\partial y}\left[\frac{D_{IS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}I(x,y,W,t)dW\right] \quad (4)$$
$$\frac{\partial V(x,y,z,t)}{\partial t}=\frac{\partial}{\partial x}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial y}\right]-$$
$$-k_{V,V}(x,y,z,T)V^2(x,y,z,t)+\frac{\partial}{\partial z}\left[D_V(x,y,z,T)\frac{\partial V(x,y,z,t)}{\partial z}\right]-k_{I,V}(x,y,z,T)\times$$

$$\times I(x,y,z,t)V(x,y,z,t) + \Omega\frac{\partial}{\partial x}\left[\frac{D_{IS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}V(x,y,W,t)dW\right] +$$

$$+\Omega\frac{\partial}{\partial y}\left[\frac{D_{IS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}V(x,y,W,t)dW\right]$$

With boundary and initial conditions (these conditions corresponds to absents of flow of dopants through external boundaries of the considered heterostructure)

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

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

$$\left.\frac{\partial V(x,y,z,t)}{\partial x}\right|_{x=0} = 0, \left.\frac{\partial V(x,y,z,t)}{\partial x}\right|_{x=L_x} = 0, \left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=0} = 0, \quad (5)$$

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

$I(x, y, z, 0)=f_I(x, y, z)$, $V(x, y, z, 0)=f_V(x, y, z)$.

Here $I(x, y, z, t)$ is the spatiotemporal distribution of interstitials; I^* is the equilibrium distribution of interstitials; $D_I(x,y,z,T)$, $D_V(x, y, z, T)$, $D_{IS}(x, y, z, T)$, $D_{VS}(x, y, z, T)$ are the volumetric and surface diffusion coefficients of interstitials and vacancies; terms $V^2(x, y, z, t)$ and $I^2(x, y, z, t)$ correspond to generation of divacancies and diinterstitials (see, for example [18], and appropriate references in the work); $k_{I,V}(x, y, z, T)$, $k_{I,I}(x, y, z, T)$ are $k_{V,V}(x, y, z, T)$ are the parameters of recombination of point defects (first of them) and generation of their complexes, respectively.

We calculate the spatiotemporal distributions of concentrations of divacancies $\Phi_V(x, y, z, t)$ and diinterstitials $\Phi_I(x, y, z, t)$ as solution of the following system of equations [17-19] (the first three terms in the right side of the low describe free diffusion of complexes of point radiation defects; other terms describe diffusion of complexes of point radiation defects under influence of mismatch-induced stress).

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

$$+\frac{\partial}{\partial z}\left[D_{\Phi I}(x,y,z,T)\frac{\partial\Phi_I(x,y,z,t)}{\partial z}\right] + k_I(x,y,z,T)I(x,y,z,t) + k_{I,I}(x,y,z,T)\times$$

$$\times I^2(x,y,z,t) + \Omega\frac{\partial}{\partial x}\left[\frac{D_{\Phi IS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}\Phi_I(x,y,W,t)dW\right] + \Omega\frac{\partial}{\partial y}\left[\frac{D_{\Phi IS}}{kT}\times\right.$$

$$\left.\times\nabla_S\mu(x,y,z,t)\int_0^{L_z}\Phi_I(x,y,W,t)dW\right] \quad (6)$$

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

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

$$\times V^2(x,y,z,t) + \Omega\frac{\partial}{\partial x}\left[\frac{D_{\Phi VS}}{kT}\nabla_S\mu(x,y,z,t)\int_0^{L_z}\Phi_V(x,y,W,t)dW\right] + \Omega\frac{\partial}{\partial y}\left[\frac{D_{\Phi VS}}{kT}\times\right.$$

$$\left.\times\nabla_S\mu(x,y,z,t)\int_0^{L_z}\Phi_V(x,y,W,t)dW\right]$$

With boundary and initial conditions (these conditions corresponds to absents of flow of dopants through external boundaries of the considered heterostructure)

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

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

$$\left.\frac{\partial V(x,y,z,t)}{\partial y}\right|_{y=L_y} = 0, \left.\frac{\partial V(x,y,z,t)}{\partial z}\right|_{z=0} = 0, \left.\frac{\partial\Phi_V(x,y,z,t)}{\partial z}\right|_{z=L_z} = 0, \quad (7)$$

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

Here $D_{\Phi I}(x, y, z, T)$, $D_{\Phi V}(x, y, z, T)$, $D_{\Phi IS}(x, y, z, T)$ and $D_{\Phi VS}(x, y, z, T)$ are the diffusion coefficients of volumetric and surface diffusions of divacancies and diinterstitials, respectively; $k_I(x, y, z, T)$ and $k_V(x, y, z, T)$ are the parameters of decay of complexes of defects (divacancies and diinterstitials). Chemical potential in Eqs. (1), (4), (6) could be determined by the following relation [13, 14].

$$\mu = E(z)\,\Omega\,\sigma_{ij}\,[u_{ij}(x, y, z, t)+u_{ji}(x, y, z, t)]/2, \tag{8}$$

Where $E(z)$ is the Young modulus, which depends on properties of layers of heterostructures; σ_{ij} is the stress tensor; $u_{ij}=\frac{1}{2}\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)$ is the deformation tensor; u_i, u_j are the components $u_x(x, y, z, t)$, $u_y(x, y, z, t)$ and $u_z(x, y, z, t)$ of the displacement vector $\vec{u}(x,y,z,t)$; x_i, x_j are the coordinate x, y, z. The Eq. (8) could be transform to the following form

$$\mu(x,y,z,t)=E(z)\left[\frac{\partial u_i(x,y,z,t)}{\partial x_j}+\frac{\partial u_j(x,y,z,t)}{\partial x_i}\right]\left\{\frac{1}{2}\left[\frac{\partial u_i(x,y,z,t)}{\partial x_j}+\frac{\partial u_j(x,y,z,t)}{\partial x_i}\right]-\right.$$

$$\left.-\varepsilon_0\delta_{ij}+\frac{\sigma(z)\delta_{ij}}{1-2\sigma(z)}\left[\frac{\partial u_k(x,y,z,t)}{\partial x_k}-3\varepsilon_0\right]-K(z)\beta(z)[T(x,y,z,t)-T_0]\delta_{ij}\right\}\frac{\Omega}{2},$$

where σ is Poisson coefficient; $\varepsilon_0 = (a_s-a_{EL})/a_{EL}$ is the mismatch parameter; a_s, a_{EL} are lattice distances of substrate and epitaxial layers; K is the modulus of uniform compression; β is the coefficient of thermal expansion; T_r is the equilibrium temperature, which coincide (for our case) with room temperature. Components of displacement vector could be obtained by solution of the following equations [20].

$$\begin{cases}\rho(z)\frac{\partial^2 u_x(x,y,z,t)}{\partial t^2}=\frac{\partial\sigma_{xx}(x,y,z,t)}{\partial x}+\frac{\partial\sigma_{xy}(x,y,z,t)}{\partial y}+\frac{\partial\sigma_{xz}(x,y,z,t)}{\partial z}\\ \rho(z)\frac{\partial^2 u_y(x,y,z,t)}{\partial t^2}=\frac{\partial\sigma_{yx}(x,y,z,t)}{\partial x}+\frac{\partial\sigma_{yy}(x,y,z,t)}{\partial y}+\frac{\partial\sigma_{yz}(x,y,z,t)}{\partial z}\\ \rho(z)\frac{\partial^2 u_z(x,y,z,t)}{\partial t^2}=\frac{\partial\sigma_{zx}(x,y,z,t)}{\partial x}+\frac{\partial\sigma_{zy}(x,y,z,t)}{\partial y}+\frac{\partial\sigma_{zz}(x,y,z,t)}{\partial z}\end{cases}$$

where $\sigma_{ij}=\frac{E(z)}{2[1+\sigma(z)]}\left[\frac{\partial u_i(x,y,z,t)}{\partial x_j}+\frac{\partial u_j(x,y,z,t)}{\partial x_i}-\frac{\delta_{ij}}{3}\frac{\partial u_k(x,y,z,t)}{\partial x_k}\right]+K(z)\delta_{ij}\times\times\frac{\partial u_k(x,y,z,t)}{\partial x_k}-\beta(z)K(z)[T(x,y,z,t)-T_r]$, $\rho(z)$ is the density of materials of considered heterostructure, δ_{ij} Is the Kronecker symbol. With account the relation for σ_{ij} last system of equation could be written as

$$\rho(z)\frac{\partial^2 u_x(x,y,z,t)}{\partial t^2}=\left\{K(z)+\frac{5E(z)}{6[1+\sigma(z)]}\right\}\frac{\partial^2 u_x(x,y,z,t)}{\partial x^2}+\left\{K(z)-\frac{E(z)}{3[1+\sigma(z)]}\right\}\times$$

$$\times\frac{\partial^2 u_y(x,y,z,t)}{\partial x\partial y}+\frac{E(z)}{2[1+\sigma(z)]}\left[\frac{\partial^2 u_y(x,y,z,t)}{\partial y^2}+\frac{\partial^2 u_z(x,y,z,t)}{\partial z^2}\right]+\left[K(z)+\frac{E(z)}{3[1+\sigma(z)]}\right]\times$$

$$\times\frac{\partial^2 u_z(x,y,z,t)}{\partial x\partial z}-K(z)\beta(z)\frac{\partial T(x,y,z,t)}{\partial x}$$

$$\rho(z)\frac{\partial^2 u_y(x,y,z,t)}{\partial t^2}=\frac{E(z)}{2[1+\sigma(z)]}\left[\frac{\partial^2 u_y(x,y,z,t)}{\partial x^2}+\frac{\partial^2 u_x(x,y,z,t)}{\partial x\partial y}\right]-\frac{\partial T(x,y,z,t)}{\partial y}\times$$

$$\times K(z)\beta(z)+\frac{\partial}{\partial z}\left\{\frac{E(z)}{2[1+\sigma(z)]}\left[\frac{\partial u_y(x,y,z,t)}{\partial z}+\frac{\partial u_z(x,y,z,t)}{\partial y}\right]\right\}+\frac{\partial^2 u_y(x,y,z,t)}{\partial y^2}\times \tag{9}$$

$$\times\left\{\frac{5E(z)}{12[1+\sigma(z)]}+K(z)\right\}+\left\{K(z)-\frac{E(z)}{6[1+\sigma(z)]}\right\}\frac{\partial^2 u_y(x,y,z,t)}{\partial y\partial z}+K(z)\frac{\partial^2 u_y(x,y,z,t)}{\partial x\partial y}$$

$$\rho(z)\frac{\partial^2 u_z(x,y,z,t)}{\partial t^2}=\frac{E(z)}{2[1+\sigma(z)]}\left[\frac{\partial^2 u_z(x,y,z,t)}{\partial x^2}+\frac{\partial^2 u_z(x,y,z,t)}{\partial y^2}+\frac{\partial^2 u_x(x,y,z,t)}{\partial x\partial z}+\right.$$

$$\left.+\frac{\partial^2 u_y(x,y,z,t)}{\partial y\partial z}\right]+\frac{\partial}{\partial z}\left\{K(z)\left[\frac{\partial u_x(x,y,z,t)}{\partial x}+\frac{\partial u_y(x,y,z,t)}{\partial y}+\frac{\partial u_x(x,y,z,t)}{\partial z}\right]\right\}+$$

$$+\frac{1}{6}\frac{\partial}{\partial z}\left\{\frac{E(z)}{1+\sigma(z)}\left[6\frac{\partial u_z(x,y,z,t)}{\partial z}-\frac{\partial u_x(x,y,z,t)}{\partial x}-\frac{\partial u_y(x,y,z,t)}{\partial y}-\frac{\partial u_z(x,y,z,t)}{\partial z}\right]\right\}-$$

$$-K(z)\beta(z)\frac{\partial T(x,y,z,t)}{\partial z}.$$

Conditions for the system of Eq. (9) could be written in the form

$$\frac{\partial\vec{u}(0,y,z,t)}{\partial x}=0;\ \frac{\partial\vec{u}(L_x,y,z,t)}{\partial x}=0;\ \frac{\partial\vec{u}(x,0,z,t)}{\partial y}=0;\ \frac{\partial\vec{u}(x,L_y,z,t)}{\partial y}=0;$$

$\frac{\partial \vec{u}(x,y,0,t)}{\partial z} = 0; \frac{\partial \vec{u}(x,y,L_z,t)}{\partial z} = 0; \vec{u}(x,y,z,0) = \vec{u}_0; \vec{u}(x,y,z,\infty) = \vec{u}_0.$

Solutions of the considered equations have been obtained by method of averaging of function corrections [11, 12, 19, 21] and was presented in section Appendix.

Discussion

Let us consider the mobility of charge carriers with allowance for their scattering on neutral atoms of impurity. The corresponding relation was obtained in [22] and could be written as

$$\mu = \frac{e^2 m^*}{20\varepsilon_r \hbar^3 C(x,t)} + \frac{4el}{3\sqrt{2\pi m^* kT}}, \quad (14)$$

Where e is the electron charge; m^* is the effective mass of the electron; ε_r is the relative dielectric constant of the material; $\hbar \approx 1{,}054 \cdot 10^{-34}$ $J{\cdot}c$ is the Planck's constant; l is the free path length of charge carriers. Substitution of the obtained distributions of the impurity concentration into relation (14) allows one to obtain the dependences of the mobility of charge carriers on the coordinate and time. These dependences are shown in Fig. 2. Curve 1 in Fig. 2 corresponds to a material with compressive stress, curve 2 corresponds to an unstressed material. The opposite relationship between the curves occurs under tensile stresses. It should also be noted that the presence of radiation treatment of the heterostructure during ion doping makes it possible to reduce the value of mismatch-induced stress (see Fig. 3). The reduction has the following reason. Implantation of ions of dopant leads to generation of interstitials and vacancies. Interstitials have larger diffusion coefficient, than vacancies. In this situation interstitials leave damaged area faster in comparison with vacancies. After that one can find compression of materials of heterostructure under influence of mismatch-induced stress due to present larger quantity of vacancies in damaged area. At the same time one can find decreasing of difference between lattice constants of substrate and epitaxial layer.

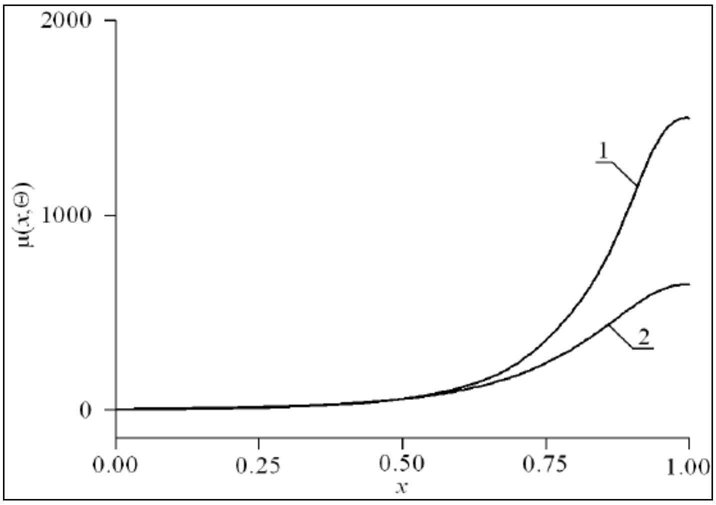

Fig 2: Normalized distributions of the mobility of charge carriers in the considered heterostructure along the interface. Curve 1 corresponds to the compressive stress epitaxial layer. Curve 2 corresponds to an unstressed epitaxial layer

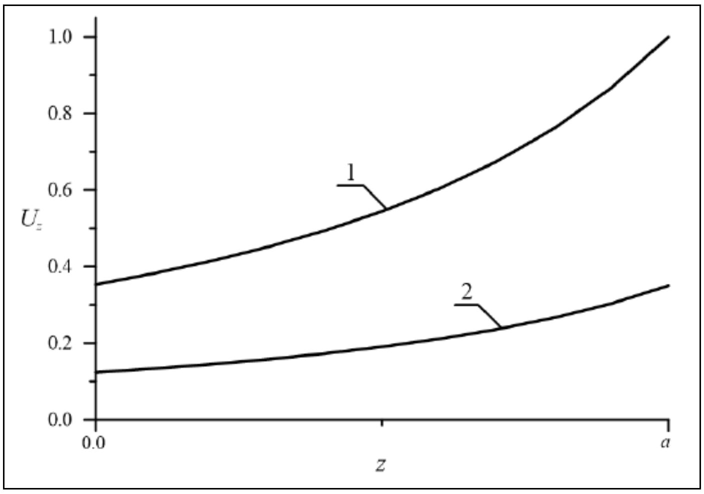

Fig 3: Normalized dependences of the component of the displacement vector u_z on the coordinate z for unstressed (curve 1) and stressed (Curve 2) epitaxial layers

Conclusion

In this paper we analyze changing of charge carriers mobility in an implanted-junction rectifier under influence of missmatch-induced stress. A model for description the considered situation is introduced. An analytical approach for analysis of mass transfer is introduced. The model gives a possibility to take into account the simultaneous changing of parameters of mass transport in space and time. At the same time the approach gives a possibility to take into account nonlinearity charge carriers transport.

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