5. CONCLUSION

Calculations of the output current-voltage characteristics of SOI MOS-transistors were performed. During the calculations it was assumed that when a MOS-transistor is created according to the standard technology in the thickness-limited silicon film and during the formation of the drain-source regions the depth where high-doped regions are situated automatically reaches the end of the silicon film, then simultaneously a bipolar transistor is formed the functioning of which influences the functioning of a MOS-transistor. The potential of the drifting substrate and the current of the bipolar transistor have been calculated. It has been found that when both transistors are functioning simultaneously in the output current-voltage characteristics there is observed a sharp gain of the drain current known as a kink-effect. The obtained theoretical characteristics are in good conformity with the experimental studies current-voltage characteristics of SOI MOS-transistors.

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Jaroslav Budjak[1], Oleksandra Hotra[2]

[1]Lviv Polytechnic National University, Department of Semiconductor Microelectronics, 12 Bandery Str., 79013 Lviv, Ukraine.
[2]Lviv State Medical University, Department of Biophysics, 69 Pekarska Str., 79010 Lviv, Ukraine.

ABOUT THE NATURE OF THE MAIN PARAMETERS OF TEMPERATURE SENSORS

Key words: kinetic properties, conductivity, dispersion law, scattering

The results of study of the nature of sensor materials properties are given in this paper. For study of the nature of conductivity and other kinetic properties of semiconductor materials modern kinetic theory was used. The theory is based on statistical sum of large nonequilibrium ensemble of charge carrier gas particles in semiconductors.

Electronic temperature sensors the work of which is based on current passage processes are characterized by several parameters. These parameters depend on kinetic properties of sensor materials. Conductivity is one of these important properties. Study of the nature of conductivity of sensor materials is substantial practical problem of solid-state electronics.

To study conductivity and other kinetic properties of semiconductor materials one can use statistical calculations, which are based on great statistical sum Z_{be} of large nonequilibrium ensemble of charge carrier gas particles in semiconductors [1-3].

The statistical sum of large canonical nonequilibrium ensemble of particles considering spin degeneration is equal

$$Z_{be} = \prod_{\vec{k}} [1 + \exp(\frac{\mu + \Delta\varepsilon_{\vec{k}} - \varepsilon_{\vec{k}}}{kT})]^2 , \tag{1}$$

where $\vec{k}$ is wave vector of charge carrier, μ is chemical potential, k is Boltzmann constant, T is temperature, $\varepsilon_{\vec{k}}$ is dispersion law, $\Delta\varepsilon_{\vec{k}}$ is some change of energy of one particle under excitation which make the crystal nonequilibrium, when excitation is absent $\Delta\varepsilon_{\vec{k}} = 0$. $\Delta\varepsilon_{\vec{k}}$ is calculated.

Such ensemble is characterized by large Gibbs potential:

$$\Omega_e = -kT \ln Z_{be} = -2kT \sum_{\vec{k}} \ln\left\{1 + \exp\left[\left(\mu + \Delta\varepsilon_{\vec{k}} - \varepsilon_{\vec{k}}\right) / kT\right]\right\} \tag{2}$$

One can calculate all heat and kinetic properties of this nonequilibrium ensemble of particles, which cause kinetic properties of conducting materials, using methods of thermodynamics. As it is shown, in ohmic region of material conductivity concentration of charge carriers gas n and conductivity of material σ are equal correspondingly:

$$n = \int_0^{\infty} G(\varepsilon)\left(-\frac{\partial f_0}{\partial \varepsilon}\right) d\varepsilon , \tag{3}$$

where $f_0 = \left[\exp\left(\frac{\varepsilon_{\vec{p}} - \mu}{kT} + 1\right)\right]^{-1}$ is Fermi-Dirac function,

$$\sigma = en\langle u \rangle_s \tag{4}$$

$$\langle u_i \rangle_s = \int_0^{\infty} G(\varepsilon) \langle u_i \rangle_s \left(-\frac{df_0}{d\varepsilon}\right) d\varepsilon \Big/ \int_0^{\infty} G(\varepsilon)\left(-\frac{df_0}{d\varepsilon}\right) d\varepsilon \tag{5}$$

$$\langle u_i \rangle_s = \oint u_i(p) \frac{dS}{|\nabla_p \varepsilon|} \Big/ \oint \frac{dS}{|\nabla_p \varepsilon|} \tag{6}$$

$$G(\varepsilon) = \int_0^{\varepsilon} g(\varepsilon) d\varepsilon , \tag{7}$$

where $g(\varepsilon) = \frac{2}{h^3} \oint \frac{dS}{|\nabla_p \varepsilon_p|}$ is density of states. Surface integrals are taken by unbounded surface which is given by dispersion law

$$\varepsilon_{\vec{p}} = \varepsilon(\vec{p}) , \tag{8}$$

where $\vec{p} = \hbar \vec{k}$ is quazi-momentum of charge carrier.

In expression (6) $u_i(p)$ is anisotropic function with dimensionality of mobility of charge carrier whereby scattering mechanisms influence on kinetic properties of crystals. As a result of this in the general case the conductivity of conducting materials is described by diagonal second-rank tensor which becomes scalar in isotropic crystals. Thus $u_i(p)$ is unaveraged component of diagonal tensor of microscopical mobility of charge carriers and is equal

$$u_i(p) = \frac{e\tau}{m_i} - \frac{e\tau}{p_i}\left(\frac{d\varepsilon_i}{dp_i}\right) \tag{9}$$

$$\tau_i(p) = \frac{1}{\left(\int \left(1 - p'_i / p_i\right) W\left(p, p'\right) dp'_i dp'_j dp'_k\right)} \tag{10}$$

where W(p, p’) is quantum-mechanical probability of scattering.
One can show that anisotropic magnitude $\tau_i(p)$ in expression (9) with dimentionality of time in the crystals with isotropic dispersion law $\varepsilon_{\vec{p}} = \varepsilon(\vec{p})$ and with elastic scattering of charge carriers on the crystal lattice defects is equal

$$\tau_i(p) = \frac{1}{\left(\int \left(1 - pp'_i / p_i{}^2\right) W\left(p, p'\right) dp'_i dp'_j dp'_k\right)} \tag{11}$$

I.e. anisotropic function $\tau_i(p)$ in anisotropic crystals becomes scalar which coincide with classic time of charge carrier quazi-momentum relaxation in the processes of scattering on the crystal lattice defects. One can conclude that $\tau_i(p)$ in the anisotropic crystals is diagonal component of relaxation time.

In multi-valley crystals in which equivalent energy valleys are located in Brillouine zone as in n-type germanium or silicon the components of diagonal tensor $\langle u_i \rangle_s$ are equal

$$\langle u_i \rangle_s = \left\langle \left\langle \left(u_1 + u_2 + u_3\right)/3 \right\rangle_s \right\rangle^{(b)} \tag{12}$$

It means that in multi-valley crystals the tensor of mobility becomes scalar that is why conductivity in such crystals is scalar:

Expressions (1)-(12) give the general methods of calculation of conductivity of crystals with any given charge carrier dispersion law, which corresponds to the lattice symmetry laws. Charge carriers scatter on any given lattice defects in any given quantized magnetic field.

As can be seen from these expressions the nature of conductivity depends on dispersion law, chemical potential, nature of lattice defects which cause charge carrier scattering.

Determination of dispersion law and its connection with crystal nature is complicated quantum-mechanical problem of solid-state physics. It is connected with the problem of solution of Shreddinger equation for crystal.

The scattering processes influence on kinetic properties by functions $u_i(p)$ which are in expressions (5)-(6). These functions depend on dispersion law and quantum-mechanical probability of scattering W(p, p’) which depends on the nature of lattice defects on which free charge carriers scatter.

Chemical potential μ is very important physical magnitude. The concentration of free charge carriers in crystals depend on chemical potential. Chemical potential is in Fermi-Dirac equilibrium distribution function f_0. In the solid-state physics chemical potential is determined by neutrality equation.

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I. Bolshakova[1], C. Leroy[2], M. Kumada[3]

[1] Magnetic Sensor Laboratory, Lviv Polytechnic National University, Lviv, Ukraine
[2] Laboratory R-J.A.-Levesque, Montreal University, Montreal, Canada
[3] National Institute of Radiological Sciences, Chiba, Japan

INVESTIGATION OF INDIUM ANTIMONIDE MICROCRYSTALS IRRADIATED WITH FAST NEUTRONS

Microcrystals of III-V semiconductor compound indium antimonide were obtained by means of complex doping in the growth process. Such compounds are stable after irradiation with fast neutron fluences up to 10^{16} n·cm^{-2}. Magnetic field microsensors developed on their base are applied in magnetic measuring systems for charged particle accelerators and in the space instrumentation building.

INTRODUCTION

Indium andimonide is known as a material for the electronics, in particular for sensors. The investigation of the behaviour of this semiconductor material under high radiation loads may contribute to the possibility of the development of radiation resistant sensors and sensor devices on its base.

This paper continues the systematic investigations we started in the last years, as to the possibility to obtain III-V microcrystals with the parameters, applicable for the manufacturing of time-stable magnetic field microsensors for operation under extreme conditions, in particular, under conditions of hard irradiation [1]. This paper presents the investigation results of the influence of the irradiation with high fast neutron fluences on the parameters of indium antimonide microcrystals, as well as technological processes for improvement of the radiation resistance of microcrystals and magnetic field sensors manufactured on their base.