CURRENT TRANSFER MECHANISM IN HETEROSTRUCTURES $nGe\text{-}p(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$

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Epitaxial layers $(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$ grown on germanium substrates attract researchers as a new semiconductor material, and the structures derived from them are theoretical and practical interest for the micro - and optoelectronics.

We have studied the solid solutions $(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$ grown by liquid phase epitaxy from a limited volume bismuth molten solution in an atmosphere of purified hydrogen palladium. The substrate was Ge washer with diameter 20 mm and thickness 350 microns, with the crystallographic orientation (111) n - type conductivity and with resistivity 1 ohm·cm. Epitaxial layers were p - type conductivity and thickness of the layers was 20 microns.

To study the structure of the semiconductor contacts were created by vacuum deposition of silver - solid on the back side and a rectangular with area of 8 mm^2 from the epitaxial layer.

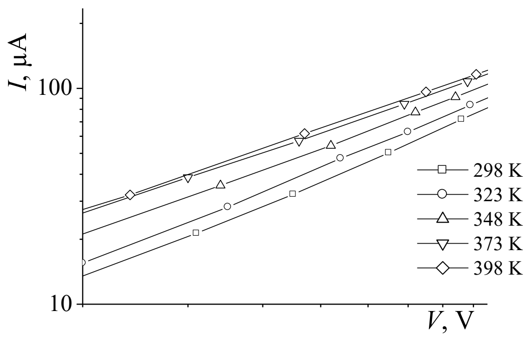

Fig.1. Current-voltage characteristics of $nGe\text{-}p(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$ structures in the

To determine the mechanism of current transport were measured current-voltage characteristics (CVC) of these structures at different temperatures (fig.1.). One can see from fig.1 CVC forward at temperatures of 298 - 398 *K* consists of two distinctive sections. Initial exponential section of the CVC up to *1 V* is well approximated by the well-known theory of V.I. Stafeev [1] and elaborated in [2] for p-i-n-structures:

$$I = I_o e^{\frac{qV}{ckT}} \tag{1}$$

where *q*- elementary charge, *k* - Boltzmann constant, *V* - the bias voltage, *T* is the absolute temperature. The value of *"c"* in the exponent can be directly calculated from the experimental points of the exponential section curves CVC using the relation

$$c = \frac{q}{kT} \cdot \frac{V_2 - V_1}{\ln \frac{I_2}{I_1}}, \tag{2}$$

where in I_1, I_2 - current values of two voltages V_1, V_2. Values *"c"* which calculated according to this formula, at different temperatures are shown in table 1. As it seen from table 1 the *"c"* decreases with increasing temperature from 298 *K* to 398 *K*.

Table 1. Characteristic parameters of the solid solution $(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$

T (K)	298	323	348	373	398
I0 (A)	11.96·10-6	12.26·10-6	14.5·10-6	19·10-6	16·10-6
C	17.75	15	12.53	12.8	10.23
B	12.7	15.4	19.25	18.74	24.9
ρ (Ohm·cm)	46.35·106	49.47·106	45.63·106	46.27·106	47·106
τ, s	1.1·10-8	1.08·10-8	1.05·10-8	9.9·10-9	8.5·10-9

On the other hand, as it shown in [3] *"c"* given by the following expression:

$$c = \frac{2b + ch\left(\frac{d}{L_p}\right) + 1}{b + 1}, \tag{3}$$

where *d* - thickness of the base, in our case *d* = 20 m, L_p-diffusion length of the major carriers - holes defined by the formula:

$$L_p = \sqrt{\frac{\varepsilon \varepsilon_0 kT}{q^2 p}} \tag{4}$$

where *ε* - dielectric constant determined from experimental data using the formula *C* = *εε0S / d,* where ε_0 - dielectric constant, *q* and *p* - charge and majority carrier concentration: *b* = μ_n/μ_p ratio of electron and hole mobilities. Using *d* = 20, and *b* = 12,7, from (4) one can find the value of the diffusion length L_p of major carriers, which is equal to $3{,}3\cdot 10^{-6}$ m. Mobility major carriers - holes, determined by the method of Hall, was μ_p = 378 $cm^2/V\cdot s$, the value of the mobility of the minority carriers (electrons) of the current defined from $\mu_n = b\cdot\mu_p$ = 4800 $cm^2/V\cdot s$. Then calculates the product of the mobility on the lifetime of the majority carriers $(\mu_p\cdot\tau_p)$ by the formula

$$\mu_p \tau_p = \frac{qL_p^2}{kT}. \quad (5)$$

At room temperature the product $\mu_p \tau_p$ is ~ 4,16·10^{-6} cm^2/V; in turn, it is possible to determine the lifetime of the majority carriers ~ τ_p = 1,1 · 10^{-8} s. Exponential factor I_0 in the formula (1) has the form [1]:

$$I_o = \frac{kT}{q} \cdot \frac{S \cdot b \cdot ch(d/L_p)}{2(b+1) \cdot L_p \cdot \rho \cdot tg(d/2L_p)} \quad (6)$$

where S - the sample area, ρ - resistivity layer between the Ge substrate and the solid solution $(Ge_2)_{1-x-y}(GaAs)_x(ZnSe)_y$ (i.e, the p-n junction). Value I_0, determined from the experimental points of the curves CVC data table 1 and using equation (6) at room temperature was equal to 12·10^{-6} A. Also calculated resistivity ρ of transition layer of the substrate and the film, which was 4,6 · 10^7 Ohm·cm at room temperature. It is shown in the table 1 that with increasing temperature resistivity layer between the substrate and the epitaxial film is almost unchanged.

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