THERMOELECTROMOTIVE FORCE OF TWO-DIMENSIONAL ELECTRONIC GAS

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The analytic expression for thermoelectromotive force of two-dimensional electronic gas in quantum well with parabolic holding potential is obtained.

As it is known the expression for electronic thermoelectromotive force has the form [1, 2]:

$$\alpha = -\frac{k_0}{e}\frac{<(x-\eta)\tau>}{<\tau>} \tag{1}$$

where

$$<A(\varepsilon)> = \int_0^\infty A(\varepsilon)\left(-\frac{\partial f_0}{\partial \varepsilon}\right)d\varepsilon .$$

The expression for reverse relaxation time in the approximation of shape-elastic scattering has the form:

$$\frac{1}{\tau_I} = 2\sum_{\vec{k}'} W\left(0,\vec{k}',0,\vec{k}\right)\left(1-cos\theta\right) \tag{2}$$

We consider the situation of quantum limit when only one subband of dimensional quantization (*N=N′=0*).

$$W(0,\vec{k}',0,\vec{k}) = \frac{2\pi}{\hbar}|\tilde{M}_{0\vec{k}',0\vec{k}}|^2\ \delta(\varepsilon_{0k'}-\varepsilon_{0k}) \tag{3}$$

Ni is impurity concentration

$$\tilde{M}_{0\vec{k}',0\vec{k}} = M_{0\vec{k}',0\vec{k}}(1+M_{0\vec{k}',0\vec{k}}\Pi(0,0)^{-1} \tag{4}$$

$$M^{e-e}_{k_1'k_2',k_1k_2} = \int\int \psi^*_{0k_1'}(\vec{r}_1)\psi_{0k_1}(\vec{r}_1)V(\vec{r}_1-\vec{r}_2)\psi^*_{0k_2'}(\vec{r}_2)\psi_{0k_2}(\vec{r}_2)d\vec{r}_1 d\vec{r}_2 \tag{5}$$

$$M_{0\vec{k}',0\vec{k}} = \iiint \psi_{0\vec{k}'}(x,y,z)V(x,y,z)\psi_{0\vec{k}}(x,y,z)dxdydz \tag{6}$$

V(x,y,z) is scattering potential, for example, for scattering on ionized impurities.

$$V(x,y,z) = \frac{Ze^2}{\chi}\left(x^2+y^2+z^2\right)^{-1/2} \tag{7}$$

$$\psi_{0,\vec{k}}(x,y,z) = \frac{1}{\sqrt{L_xL_y}}\frac{1}{\sqrt[4]{\pi R^2}}Exp\left(-\frac{z^2}{2R^2}\right)e^{ik_x x+ik_y y} \tag{8}$$

$$\varepsilon_{0,k} = \frac{\hbar^2k^2}{2m}+\frac{1}{2}\hbar\omega \tag{9}$$

$$\Pi(0,0) = \int_{\varepsilon_0}^\infty \rho(\varepsilon)\left(-\frac{\partial f_0}{\partial \varepsilon}\right)d\varepsilon , \tag{10}$$

(10) is polarization operator, taking into consideration the scattering potential screening [3]. $\rho(\varepsilon)=\frac{m}{\pi\hbar^2}$ is density of states of two-dimensional electronic gas, f_0 is Fermi equilibrium distribution function.

Let's consider the case of strong screening when the second summand in (4) much more than 1.

Neglecting by small dependence τ on energy we obtain the following expression for thermoelectromotive force:

$$\alpha = -\frac{k_0}{e}\left(\frac{\hbar\omega}{2k_0T}-\eta+\left(1+exp\left(\frac{\hbar\omega}{2k_0T}-\eta\right)\right)\ln\left(1+exp\left(\eta-\frac{\hbar\omega}{2k_0T}\right)\right)\right) \tag{11}$$

From this it is seen the thermoelectromotive force of electronic gas doesn't depend on diffuser parameters in the case of strong screening of electron interaction potential with impurities and is defined by position of chemical potential level quantum well bottom. For electron nondegenerate gas ($\eta<0$):

$$\alpha = -\frac{k_0}{e}\left(\frac{\hbar\omega}{2k_0T}-\eta\right) \tag{12}$$

We have the following formula:

$$\alpha = -\frac{k_0}{e}\left(\eta - \frac{\hbar\omega}{2k_0T}\right)exp\left(\frac{\hbar\omega}{2k_0T} - \eta\right) \qquad (13)$$

in the case of strong degeneration when $\frac{\hbar\omega}{2k_0T} < \eta < \frac{\hbar\omega}{k_0T}$.

[1] *B.M. Askerov.* Elektronnie yavleniya perenosa v poluprovodnikakh. «Nauka», Moskva, 1985, 318.

[2] *Yu-Ming Lin, Xiangzhong Sun, M.S. Dresselhaus*. Phys. Rev. B 62, 4610-4623 (2000)

[3] *T.Ando, A.Fowler, F.Stern*, Electronic properties of two-dimensional systems, Rev.Mod.Phys., vol.34, No.2, 1982 (T. Ando, A. Fauler, F. Stern. Elektronnie svoystva dvumernikh system, «Mir», Moskva, 1985, 415 (in Russian)).

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İKİÖLÇÜLÜ ELEKTRON QAZININ TERMOELEKTRİK HƏRƏKƏT QÜVVƏSİ

Parabolik potensiallı kvant çuxurunda ikiölçülü elektron qazının termo e.h.q. üçün analitik ifadə olunmuşdur.

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ТЕРМОЭДС ДВУМЕРНОГО ЭЛЕКТРОННОГО ГАЗА

Получено аналитическое выражения для термоэдс двумерного электронного газа в квантовой яме с параболическим удерживающим потенциалом.

Received: 10.10.08