THERMO-MAGNETIC EFFECTS OF HOT ELECTRONS IN NON-DEGENERATE SEMICONDUCTORS UNDER THE CONDITIONS OF STRONG MUTUAL ELECTRON-PHONON DRAG

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The thermoelectromotive force and Nernst-Ettingshausen effects of non-degenerate semiconductors under the conditions of strong electron-phonon mutual drag are investigated by taking into account the electron and phonon heating in high electric field. The dependences of thermoelectromotive force and Nernst-Ettingshausen voltage on the electric field strength and lattice temperature are obtained.

Recently the theoretical and experimental interest in thermoelectric and thermo-magnetic effects in bulk and low-dimensional systems has been intensified [1-6]. There are also some theoretical investigations of thermoelectric and thermo-magnetic effects in semiconductors under high external electric and non-quantizing magnetic fields [7-12]. In addition, there are some review articles devoted to these subjects [13-14]. In this paper the thermoelectromotive force and transverse Nernst-Ettingshausen effect of non-degenerate semiconductors under the conditions of strong electron-phonon mutual drag are investigated by taking into account the electron and phonon heating in high electric ($\vec{E}$) field. The spectrum of electrons is assumed to be parabolic:

$$\varepsilon = \frac{p^2}{m}. \qquad (1)$$

The basic equations of the problem are the coupled Boltzmann transport equations for electrons and phonons. It is assumed that the electrons and phonons are scattered mainly by each other (the conditions of strong mutual drag) via the deformation interaction. We consider the quasi-elastic scattering of electrons by acoustic phonons. In this case the distribution functions of electrons $f(\vec{p},\vec{r})$ and phonons $N(\vec{q},\vec{r})$ may be written as:

$$f(\vec{p},\vec{r}) = f_0(\varepsilon,\vec{r}) + \vec{f}_1(\varepsilon,\vec{r})\frac{\vec{p}}{p}, \qquad (2)$$

$$N(\vec{q},\vec{r}) = N_0(q,\vec{r}) + \vec{N}_1(q,\vec{r})\frac{\vec{q}}{q}, \qquad (3)$$

where f_0 (N_0) and $\vec{f}_1(\vec{N}_1)$ are the isotropic and anisotropic parts of the electron (phonon) distribution functions, respectively. We assume that the so called "diffusion approximation" for electrons and phonons applies. Therefore, $|\vec{f}_1| << f_0$ and $|\vec{N}_1| << N_0$.

If the inter-electronic collision frequency ν_{ee} is much more than the collision frequency of the electrons for the energy transfer to lattice ν_ε, then $f_0(\varepsilon,\vec{r})$ is the Fermi distribution function with an electron temperature T_e. Note that all temperatures are in energy units.

We assume that in the lattice there is a "thermal reservoir" of short-wavelength (SW) phonons for long-wavelength (LW) phonons interacting with electrons: $q_{max} \approx 2\bar{p} << \frac{T}{s_0}$, where s_0 is the sound velocity in the crystal, q_{max} is the maximum quasi-momentum of LW phonons. Under these conditions LW phonons are heated and $N_0(q,\vec{r})$ has the form [15]

$$N_0(q) = \left[\exp\left(\frac{\hbar\omega_q}{T_p}\right) - 1\right]^{-1} \approx \frac{T_p}{\hbar\omega_q}, \qquad (4)$$

where T_p is the effective temperature of the LW phonons. In accordance with Ref. [15], in the case, when the phonons are scattered mainly by electrons, the temperature of LW phonons T_p becomes equal to the temperature of electrons T_e. Therefore, under the conditions of strong mutual drag $T_p = T_e$.

The anisotropic parts of the distribution functions of electrons and phonons are obtained by solving the coupled system of Boltzmann equations:

$$\frac{p}{m}\nabla f_0 - e\overrightarrow{E_c}\frac{p}{m}\frac{\partial f_0}{\partial \varepsilon} - \Omega\left[\vec{h}\vec{f}_1\right] + \nu(\varepsilon)\vec{f}_1 + \frac{2\pi m}{(2\pi\hbar)^3 p^2}\frac{\partial f_0}{\partial \varepsilon}\int_0^{2p}\vec{N}_1(q)W(q)\hbar\omega_q q^2 dq = 0, \qquad (5)$$

$$s_0\nabla N_0(q) + \beta(q)\vec{N}_1(q) - \frac{4\pi m}{(2\pi\hbar)^3}W(q)N_0(q)\int_{q/2}^{\infty}\vec{f}_1 dp = 0. \qquad (6)$$

Here e is the absolute value of the electron's charge, $\vec{E}_C = \vec{E} + \vec{E}_T$, $\vec{E}_T$ is the thermoelectric field, m is the electron's effective mass, $\Omega = eH/mc$ is the cyclotron frequency, $\vec{h} = \vec{H}/H$, $\hbar\omega_q = s_0 q$ is the phonon energy, $W(q) = \frac{\pi E_0^2}{\hbar\rho\ s_0} q$ is the square matrix element of the electron-phonon interaction, E_0 is the deformation potential constant, $\beta(q)$ and $\nu(\varepsilon)$ are the total phonon and electron momentum scattering frequencies, respectively:

$$\nu(\varepsilon) = \nu_p(\varepsilon) + \nu_i(\varepsilon), \beta(q) = \beta_e(q) + \beta_p(q) + \beta_b(q), \tag{7}$$

where the indices i, p, e and b denote the scattering by impurity ions, by phonons, by electrons and by crystal boundaries, respectively.

$$\nu_p(\varepsilon) = \frac{\sqrt{2} m^{\frac{3}{2}} T^{\frac{3}{2}} E_0^2}{\pi\hbar^4 s_0^2 \rho} \left(\frac{T_p}{T}\right)\left(\frac{\varepsilon}{T}\right)^{\frac{1}{2}}, \nu_i(\varepsilon) \cong \frac{e^4 N_i}{m^{\frac{1}{2}} T^{\frac{3}{2}} \chi_0^2} \left(\frac{\varepsilon}{T}\right)^{-\frac{3}{2}}, \tag{8}$$

$$\beta_e(q) = \left(\frac{\pi m s_0^2}{8T_e}\right)^{\frac{1}{2}} \frac{NE_0^2}{\hbar\rho\, s_0 T_e} q, \beta_p(q) = \frac{T^4}{4\pi\rho\ \hbar^4 s_0^4} q, \beta_b(q) = \frac{s_0}{L}, \tag{9}$$

where ρ and L are the density and the minimum size of specimen, respectively, χ_0 is the dielectric constant of the crystal, N and N_i are the concentrations of electrons and ionic impurity, respectively.

Solving the coupled equations (5) - (6) it is easy to calculate the electric current density of electrons

$$\vec{j} = -\frac{e}{3\pi^2\hbar^3} \int_0^\infty \vec{f}_1(\varepsilon) p^2(\varepsilon) d\varepsilon. \tag{10}$$

Let us direct external electric and magnetic fields along the y axis, and the gradient of lattice temperature (or the gradient of external electric field) along the z axis ($\vec{E}\|\vec{H}\|oy, \nabla T_e\|oz$). Using the equations $j_x = j_z = 0$ with (10) we obtain the following expressions for the thermoelectric field E_{Tz} and the transverse NE field E_{Tx}:

$$E_{Tz} + \frac{1}{e}\nabla_z \zeta(T_e) = \alpha_e \nabla_z T_e + \alpha_p \nabla_z T_p; \alpha_{e,p} = -\frac{\sigma_{11}\beta_{11}^{(e,p)} + \sigma_{12}\beta_{12}^{(e,p)}}{\sigma_{11}^{2} + \sigma_{12}^{2}}, \tag{11}$$

$$E_{Tx} = -H(Q_e \nabla_z T_e + Q_p \nabla_z T_p); Q_{e,p} = \frac{1}{H} \frac{\sigma_{11}\beta_{12}^{(e,p)} - \sigma_{12}\beta_{11}^{(e,p)}}{\sigma_{11}^{2} + \sigma_{12}^{2}}, \tag{12}$$

where $\alpha_{e,p}$ are the electron (e) and phonon (p) parts of the thermoelectromotive force and $Q_{e,p}$ are the respective parts of NE coefficient.

$$\sigma_{1i} = \int_0^\infty a(x) \left(\frac{\Omega}{\nu(x)}\right)^{i-1} [1 + b_i(x)]\, dx, \ x = \frac{\varepsilon}{T_e}, \tag{13}$$

$$\beta_{1i}^{(e)} = \frac{1}{e} \int_0^\infty a(x) \left(\frac{\Omega}{\nu(x)}\right)^{i-1} \left\{ x - \frac{\zeta(\vartheta_e)}{T\vartheta_e} + \left[1 - \frac{\zeta(\vartheta_e)}{T\vartheta_e}\right] b_i(x) \right\} dx \tag{14}$$

$$\beta_{1i}^{(p)} = \frac{1}{e} \int_0^\infty a(x) \left(\frac{\Omega}{\nu(x)}\right)^{i-1} [\lambda(x) + \lambda(1) b_i(x)] dx \ , \vartheta_e = \frac{T_e}{T}. \tag{15}$$

Here $\zeta(\vartheta_e)$ is the chemical potential of hot electrons (16)

$$a(x) = \frac{e^2}{3\pi^2\hbar^3} \frac{p^3(x)\nu(x)}{m[\Omega^2 + \nu^2(x)]} \times exp\left[\frac{\zeta(\ \ _e)}{T\ \ _e} - x\right]$$

$$b_1(x)=\frac{\gamma(x)\nu(x)}{\Omega^2+\nu^2(1)(1-\gamma_0)^2}\left[\nu(1)(1-\gamma_0)-\frac{\Omega^2}{\nu(x)}\right], \tag{17}$$

$$b_2(x)=\frac{\gamma(x)\nu(x)}{\Omega^2+\nu^2(1)(1-\gamma_0)^2}\left[\nu(1)(1-\gamma_0)+\nu(x)\right], \tag{18}$$

The coefficient $\lambda(x)$ characterizes the efficiency of the thermal drag, whereas coefficient $\gamma(x)$ describes the same for the mutual drag:

$$\lambda(x)=\frac{1}{4p^4}\frac{ms_0^2}{T_e}\nu_p(x)\int_o^{2p}\frac{1}{\beta(q)}q^3dq\,, \tag{19}$$

$$\gamma(x)=\frac{1}{4p^4}\frac{\nu_p(x)}{\nu(x)}\int_o^{2p}\frac{\beta_e(q)}{\beta(q)}q^3dq\,,\gamma_0\equiv\gamma(x=1). \tag{20}$$

Under the conditions of strong electron-phonon mutual drag, i.e. when the electrons and phonons are scattered mainly by each other $\nu(\varepsilon)\approx\nu_p(\varepsilon),\beta(q)\approx\beta_e(q)$, and as it seen from (20) $\gamma\approx\gamma_0\to 1$. In this case from (17) and (18) follow, that $b_1(x)$ and $b_2(x)$ grow with raising γ_0 and tend to infinity at $\Omega\to 0,\gamma_0\to 1$. Thus to calculate γ from (20) one should take into account as well some other non-basic mechanisms of electron and phonon scatterings. In the conditions $\nu_i(\varepsilon)<<\nu_p(\varepsilon);\beta_p(q),\beta_b(q)<<\beta_e(q)$ the thermal drag coefficient $\lambda(x)$ and the mutual drag coefficient $\gamma(x)$ may be written in the form

$$\lambda(x)\equiv\lambda_0=\frac{2(2mT)^{\frac{3}{2}}}{3\pi^{\frac{3}{2}}\hbar^3N}\vartheta_e^{\frac{3}{2}}, \tag{21}$$

$$\gamma(x)=1-\frac{\nu_i(x)}{\nu_p(x)}-\frac{1}{4p^4}\int_o^{2p}\frac{\beta_p(q)}{\beta_e(q)}q^3dq-\frac{1}{4p^4}\int_o^{2p}\frac{\beta_b(q)}{\beta_e(q)}q^3dq\,. \tag{22}$$

Using (8) and (9), from (22) we obtain:

$$\gamma(x)=1-\frac{e^4\hbar^4\rho s_0^2N_i}{m^2T^3\chi_0^2E_0^2}\vartheta_e^{-3}x^{-2}-\frac{T^{\frac{11}{2}}}{\sqrt{2m}\pi^{\frac{3}{2}}\hbar^3s_0^4NE_0^2}\vartheta_e^{\frac{3}{2}}-\frac{4\hbar\rho s_0T}{3\sqrt{\pi}mLNE_0^2}\vartheta_e x^{-\frac{1}{2}}. \tag{23}$$

In the parabolic case the chemical potential of hot non-degenerate electrons with concentration N takes the form:

$$\zeta(\vartheta_e)=T\vartheta_e\ln\frac{4\pi^{\frac{3}{2}}\hbar^3N}{(2mT)^{3/2}}\vartheta_e^{-\frac{3}{2}}. \tag{24}$$

Under the conditions of the strong mutual drag ($\vartheta_e=\vartheta_p,\gamma_0\to 1$) the electron temperature is determined from the energy balance equation

$$\sigma(\vartheta_e)E^2=W_{pp}(\vartheta_e), \tag{25}$$

where $\sigma(\vartheta_e)$ is the conductivity of semiconductor in heating electric field, and $W_{pp}(\vartheta_e)$ is the power transferred by the LW phonons to the thermal reservoir of the SW phonons:

$$W_{pp}(\vartheta_e)=\frac{4\pi}{(2\pi\hbar)^3}\int_0^{\sqrt{8mT_e}}\beta_p(q)\hbar\omega_q\left[N_{T_e}(q)-N_T(q)\right]q^2dq\,. \tag{26}$$

We consider the case, when external electric and magnetic fields are directed along the y axis, and the gradient of lattice temperature (or the gradient of external electric field) along the z axis ($\vec{E}\|\vec{H}\|oy,\nabla T_e\|oz$). In these conditions

$$\sigma(\vartheta_e)=\frac{e^2}{3\pi^2\hbar^3m}\exp\left[\frac{\zeta(\vartheta_e)}{T\vartheta_e}\right]\int_0^\infty\frac{p^3(x)e^{-x}}{\nu(x)}\left[1+\frac{\gamma(x)}{1-\gamma_0}\frac{\nu(x)}{\nu(1)}\right]dx\,. \tag{27}$$

When $\nu_i(\varepsilon)<<\nu_p(\varepsilon);\beta_p(q),\beta_b(q)<<\beta_e(q)$, using (23) we obtain:

$$\sigma(\vartheta_e)=\frac{e^2N}{m}\frac{\pi\hbar^4\rho s_0^2\vartheta_e^{-\frac{3}{2}}}{\sqrt{2}m^{\frac{3}{2}}E_0^2T^{\frac{3}{2}}}\left[\frac{\nu_{i0}(T)}{\nu_{p0}(T)}\vartheta_e^{-3}+\frac{T^{\frac{11}{2}}}{\sqrt{2m}\pi^{\frac{3}{2}}\hbar^3 s_0^4 NE_0^2}\vartheta_e^{\frac{3}{2}}+\frac{4\hbar\rho s_0 T}{3\sqrt{\pi}mLNE_0^2}\vartheta_e\right]^{-1}. \qquad (28)$$

We consider the following limiting cases:

1) The relaxation channel of the electron momentum by impurities becomes wider than that of the phonon momentum scattering by the crystal boundaries or by the phonons ($\frac{\beta_p+\beta_b}{\beta_e}<<\frac{\nu_i}{\nu_p}$). In this case the calculation of the expression $\vartheta_e(E)$ from (25), (26) and (28) at $\vartheta_p=\vartheta_e>>1$ gives

$$\vartheta_e=\left(\frac{E}{E_1}\right)^{\frac{4}{3}};E_1=\frac{em^{\frac{5}{4}}T^{\frac{11}{4}}}{\hbar^{\frac{7}{2}}\chi_0\rho^{\frac{1}{2}}s_0^2}. \qquad (29)$$

2) The phonons are scattered by phonons or by crystal boundaries more intensively than electrons are scattered by impurities ($\frac{\beta_p+\beta_b}{\beta_e}>>\frac{\nu_i}{\nu_p}$). In this case there are two sub cases:

2a) $\beta_p>>\beta_b$. At $\vartheta_p=\vartheta_e>>1$ using (25), (26) and (28) we obtain:

$$_e=\left(\frac{E}{E_2}\right)^{\frac{1}{3}};E_2=\frac{\sqrt{2}m^2T^7}{\pi^{\frac{11}{4}}\hbar^7 eN\rho s_0^5}. \qquad (30)$$

2b) $\beta_p<<\beta_b$. In this sub case at $\vartheta_p=\vartheta_e>>1$ we obtain:

$$\vartheta_e=\left(\frac{E}{E_3}\right)^{\frac{4}{11}};E_3=\frac{2^{\frac{7}{4}}m^{\frac{7}{4}}T^{\frac{19}{4}}}{\pi^{\frac{9}{4}}\sqrt{3}\hbar^5 eN\rho^{\frac{1}{2}}s_0^{\frac{5}{2}}L^{\frac{1}{2}}}. \qquad (31)$$

In the region of weak-heated electric field $(\vartheta_e-1<<1)$ the electron temperature ϑ_e may be represented as:

$$\vartheta_e=1+\left(\frac{E}{E_i}\right)^2, \qquad (32)$$

where E_i ($i=1,2,3$) are the characteristic fields in the cases 1), 2a) and 2b).

Let us study the thermoelectric power $\alpha(0)$ and Nernst-Ettingshausen effects ($\Delta\alpha(H)$ and Q) of non-degenerate semiconductors under the conditions of strong electron-phonon mutual drag in weak ($\overline{\Omega}<<\overline{\nu}$) and strong ($\overline{\Omega}>>\overline{\nu}$) magnetic fields. On the basis of (11) to (15) it may be shown that under these conditions the phonon part of NE coefficient (Q_p) and the variation of the phonon part of the thermoelectric power ($\Delta\alpha_p(H)$) are equal to zero, both in weak and strong magnetic fields. Under the conditions of strong mutual drag, in the arbitrary magnetic fields we obtain from (11), (13) and (15):

$$\alpha_p=-\frac{1}{e}\frac{2(2mT)^{\frac{3}{2}}}{3\pi^{\frac{3}{2}}\hbar^3N}\vartheta_e^{\frac{3}{2}}. \qquad (33)$$

The electron parts of longitudinal and transverse NE effects strongly depend on the magnetic field strength. In weak magnetic fields ($\overline{\Omega}<<\overline{\nu}$) for the thermoelectromotive force $\alpha_e(H)$ and for the change of thermoelectromotive force

$$\Delta\alpha_e(H)=|\alpha_e(H)|-|\alpha_e(0)| \qquad (34)$$

we obtain the following expressions:

$$\alpha_e(H)=-\frac{1}{e}\left[1+\frac{3}{2}\ln\frac{2mT}{\pi\hbar^2(4N)^{\frac{2}{3}}}\vartheta_e-\left(\frac{\mu(T)H}{c}\right)^2\vartheta_e^{-3}\right] \qquad (35)$$

$$\Delta\alpha_e(H)=-\frac{1}{e}\left(\frac{\mu(T)H}{c}\right)^2\vartheta_e^{-3}, \qquad (36)$$

where $\mu(T_e)$ is the mobility of hot electrons in the non-degenerate semiconductors:

$$\mu(T_e)=\frac{2\sqrt{2\pi}}{3}\frac{e\hbar^4\rho s_0^2}{m^{\frac{5}{2}}T^{\frac{3}{2}}E_0^2}\vartheta_e^{-\frac{3}{2}}=\mu(T)\vartheta_e^{-\frac{3}{2}}. \qquad (37)$$

From (35)-(36) it is seen that thermoelectromotive force in weak magnetic fields decreases with increasing of the magnetic field strength. The electron part of NE coefficient in weak magnetic fields:

$$Q_e=-\frac{\mu(T)}{ec}\vartheta_e^{-\frac{3}{2}}=-\frac{2\sqrt{2\pi}}{3}\frac{\hbar^4\rho s_0^2}{cm^{\frac{5}{2}}T^{\frac{3}{2}}E_0^2}\vartheta_e^{-\frac{3}{2}}. \qquad (38)$$

In strong magnetic field ($\overline{\Omega}>>\overline{\nu}$) for the thermoelectromotive force one obtains the following expressions:

$$\alpha_e(H)=-\frac{1}{e}\left[\frac{5}{2}+\frac{3}{2}\ln\frac{2mT}{\pi\hbar^2(4N)^{\frac{2}{3}}}\vartheta_e\right]. \qquad (39)$$

From (39) it is seen that the thermoelectromotive force increases in strong magnetic field:

$$\Delta\alpha_e(H)=\frac{3}{2e}. \qquad (40)$$

The electron part of NE coefficient in strong magnetic fields:

$$Q_e = -\frac{1}{e}\frac{64}{9\pi}\frac{c}{\mu(T)H^2}\vartheta_e^{\frac{3}{2}} = -\frac{16\sqrt{2\pi}}{3\pi^2}\frac{cm^{\frac{5}{2}}T^{\frac{3}{2}}E_0^2}{e^2\hbar^4\rho s_0^2 H^2}\vartheta_e^{\frac{3}{2}} \quad (41)$$

Experimentally interesting are the total thermoelectromotive force (V) and the NE voltage (U) given by

$$V = \int_0^{L_z}\left(\alpha_e\nabla_z T_e + \alpha_p\nabla_z T_p\right)dz = V_e + V_p, \quad (42)$$

$$U = -\int_0^{Lx}\left(HQ_e\nabla_z T_e + HQ_p\nabla_z T_p\right)dx = U_e + U_p, \quad (43)$$

where L_x and L_z is the linear dimensions of the specimen in the x- and z-directions, respectively. Let us consider dependences of V and U on the heating electric field and lattice temperature under the following conditions: at one end of the specimen the electrons are in a state characterized by the lattice temperature T, whereas at the other end they are heated $(\vartheta_e > 1)$ by the external electric field.

Taking into account the expressions of $\vartheta_e(E,T)$ in (33) to (43), we obtain explicit forms of V and U as functions of E and T. In the case of strongly heated ($\vartheta_e >> 1$) electron gas in the arbitrary magnetic fields for V_e and V_p we obtain the following expressions:

$$V_e \sim E^{\frac{4}{3}}T^{-\frac{11}{3}};\ V_p \sim E^{\frac{10}{3}}T^{-\frac{20}{3}}N^{-1} \quad \text{in the case 1)}, \quad (44)$$

$$V_e \sim E^{\frac{1}{3}}T^{-\frac{7}{3}}N^{\frac{1}{3}}; V_p \sim E^{\frac{5}{6}}T^{-\frac{10}{3}}N^{-\frac{1}{6}} \quad \text{in the case 2a)}, \quad (45)$$

$$V_e \sim E^{\frac{4}{11}}T^{-\frac{19}{11}}N^{\frac{4}{11}}; V_p \sim E^{\frac{10}{11}}T^{-\frac{20}{11}}N^{-\frac{1}{11}} \quad \text{in the case 2b)}. \quad (46)$$

In weak magnetic fields ($\overline{\Omega} << \overline{\nu}$) for U_e one obtains the following expressions:

$$U_e \sim E^{-\frac{2}{3}}T^{\frac{4}{3}}H \quad \text{in the case 1)}, \quad (47)$$

$$U_e \sim E^{-\frac{1}{6}}T^{\frac{2}{3}}HN^{-\frac{1}{6}}; \quad \text{in the case 2a)}, \quad (48)$$

$$U_e \sim E^{-\frac{2}{11}}T^{\frac{4}{11}}HN^{-\frac{2}{11}} \quad \text{in the case 2b)}. \quad (49)$$

In strong magnetic fields ($\overline{\Omega} >> \overline{\nu}$):

$$U_e \sim E^{\frac{10}{3}}T^{-\frac{20}{3}}H^{-1} \quad \text{in the case 1)}, \quad (50)$$

$$U_e \sim E^{\frac{5}{6}}T^{-\frac{10}{3}}H^{-1}N^{\frac{5}{6}} \quad \text{in the case 2a)}, \quad (51)$$

$$U_e \sim E^{\frac{10}{11}}T^{-\frac{20}{11}}H^{-1}N^{\frac{10}{11}} \quad \text{in the case 2b)} \quad (52)$$

Note that under the conditions of strong mutual drag $|\alpha_p| >> |\alpha_e|$, both in weak and strong magnetic fields, i.e., the total thermoelectromotive force mainly consists of the phonon part [16].

From (32), (41) and (42) it follows that in the region of weak-heated $(\vartheta_e - 1 << 1)$ electric field the total thermoelectromotive force V and the NE voltage U are proportional E^2.

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GÜCLÜ ELEKTRON-FONON QARŞILIQLI SÖVQÜ ŞƏRAITINDƏ CIRLAŞMAMIŞ YARIMKEÇIRICILƏRDƏ QIZMAR ELEKTRONLARIN TERMOMAQNIT EFFEKTLƏRI

Elektron və fononların elektrik sahəsində qızması nəzərə alınmaqla, güclü elektron-fonon qarşılıqlı sövqü şəraitində, cırlaşmamış yarımkeçiricilərdə qızmar elektronların termoelektrik hərəkət qüvvəsi və Nernst-Ettingshausen effektləri tədqiq edilmişdir. Termoelektrik hərəkət qüvvəsinin və Nernst-Ettingshausen gərginliyinin elektrik sahəsinin intensivliyindən və qəfəs temperaturundan asılılıqları tapılmışdır.

М.М.БАБАЕВ

ТЕРМОМАГНИТНЫЕ ЭФФЕКТЫ ГОРЯЧИХ ЭЛЕКТРОНОВ В НЕВЫРОЖДЕННЫХ ПОЛУПРОВОДНИКАХ В УСЛОВИЯХ СИЛЬНОГО ВЗАИМНОГО УВЛЕЧЕНИЯ ЭЛЕКТРОНОВ И ФОНОНОВ

Исследованы термо-эдс и эффекты Нернста - Эттингсгаузена в невырожденных полупроводниках, в условиях сильного взаимного увлечения и разогрева электронов и фононов в греющем электрическом поле.Получены зависимости термо-эдс и напряжения Нернста - Эттингсгаузена от напряженности электрического поля и температуры решетки.

Resevied: