Phonon-Drag Thermopower at High Temperatures

V.A.Vdovenkov

Moscow State Institute of Radioengineering, Electronics and Automation
(technical university)
Vernadsky ave. 78, 117454 Moscow, Russia

Abstract

The adiabatic cristal model is offered. It is shown that springy nuclei oscillations relatively electronic envelops and waves of such oscillations (inherent oscillations and waves) may exist in crystals. The analysis of experimental temperature dependencies of resistivity in semiconductors with electron-vibrational centres has shown that inherent oscillations effectively interact with crystalline phonons as well as with electrons and holes, creating powerful interaction of electrons and holes with phonons. The experimental narrow peaks of phonon-drag thermoelectric power at Debye temperatures from 77K to 700K confirm existence of inherent oscillations waves in crystals. Inherent oscillations and waves gives rise to strong electron-phonon interaction and probably can bring about superconductivity at temperatures as below so and well above room temperature.

Oscillations of crystals traditionally have always researched by analysing motion equations of their models. Atoms in such models are replaced by spots with masses of atoms. These models do not correspond to an adiabatic theory of solids because the nucleus and electron envelop of each atom in these models is considered to be hard are bound. Because in such conditions exchange of the energy between nuclei and electronic envelops is possible, the adiabatic principle is broken. That is why traditional crystal models are nonadiabatic. It’s possible to find out new phisical properties of crystals by researching their adiabatic models. So substantiated adiabatic crystal model is important to build.

1. Description of adiabatic model

It’s possible to build an adiabatic model of cristal in accordance with adiabatic solution of stationary Shredinger equation: \((T_e + T_z + V)\psi = W\psi\), where \(T_e\) and \(T_z\) - kinetic energy operators of electrons and nuclei, \(V\) - a cristalline potential, \(\psi\) - wave function and \(W\) - energy of cristal. This equation may be re-arranged to two equations supposing \(\psi = \phi\Phi\) and separating variables:

\[
(T_e + V)\phi = E\phi, \\
(T_z + E + A)\Phi = W\Phi,
\]

where \(E\) - energy of electrons and \(A\) - an adiabatic potential. Wave function \(\phi\) describes electrons motion in the cristalline potential field \(V\). Wave function \(\Phi\) describes nuclei motion. Because of presence adiabatic potential \(A\) in the equation \(\Phi\) the functions \(\phi\) and \(\Phi\) are mutually dependent, therefore electrons and nuclei in the cristal have a possibility to exchange the energy one with another. So the problem of cristal oscillations study on bases of equations \(\Phi\).
and (2) in general is nonadiabatic. However, if potential A is small and its contribution to the energy of the crystal can be neglected, it follows the adiabatic approach of Born-Oppenheimer [1]. In this approach an exchange of the energy between electrons and nuclei in the crystal is absent and equation (2) has a solution regardless of equation (1). Hartree-Fock method [2, 3] may be applied to the equation (2) to define an efficient potential \(V(R_j)\), which is dependent on coordinates only of the \(j\)-th nucleus, and reduce a problem about nuclei motion to one-particle problem: 

\[
[T_j + V(R_j)]\Phi_j = W_j \Phi_j,
\]

where \(\Phi_j\) - wave function of nuclei, \(T_j\) - a kinetic energy operator, \(W_j\) - a spectrum of the \(j\)-th nucleus stationary energy levels in the potential field \(V(R_j)\). Potential \(V(R_j)\) is defined by all electrons and nuclei except the \(j\)-th nucleus. Analysis shows that the main contribution to \(V(R_j)\) is introduced by s-electrons of K, L and M electronic orbits of the \(j\)-th atoms. Minimum \(V(R_j)\) defines a position comparatively which nucleus is capable to realize oscillatory motion. It is shown in [4] that adiabatic method equitable if the energy of nucleus oscillations does not exceed energy of electronic transitions. Under such condition the energy of nucleus oscillations cannot be sent to electrons. So electronic envelopes stay nondeformed and motionless but oscillatory motions of nuclei are principally possible. These oscillations can be called inherent (I) oscillations [5], since their properties are defined by inherent atom parameters - by mass, charge of nucleus and potential \(V(R_j)\) near centre of electronic envelope. Consequently, every atom of crystal in adiabatic model must be presented in a manner of inherent (I) oscillator which consist of nucleus and electronic envelope bounded with each other by springy force.

Nuclei oscillations relatively atom envelopes occur in small interval \((\approx 10^{-2}A^0)\) and in general it is necessary to research them by quantum methods. But, if study harmonic oscillations then it is suitable to use the known correspondence between results of quantum and classical theories. This correspondence consists in coinciding the frequency of transition between quantum adjacent oscillatory levels of harmonic oscillator with his classical oscillations frequency. So energy spectrum of the crystal harmonic oscillations is possible to research by classical method. We used this possibility for description of oscillations in adiabatic simple univariate crystal model. Such model is shown on insertion fig. 1 where circles are electronic envelopes of atoms and spots in circles centres are nuclei. Lattice spacing is equal to \(a\). System of motion equations for this model may be written as:

\[
M \frac{d^2 U'_n}{dt^2} = -\theta_1(U'_n - U''_n); \tag{3}
\]

\[
m \frac{d^2 U''_n}{dt^2} = -\theta_1(U''_n - U'_n) - \theta_2(2U''_n - U''_{n-1} - U''_{n+1}), \tag{4}
\]

where \(M\) - nucleus mass, \(m\) - an electronic envelope mass, \(U'_n\) and \(U''_n\) - displacements of nucleus and electronic envelopes, \(\theta_1\) and \(\theta_2\) - force factors, \(t\) - time and elementary cell number \(n = 0, \pm 1, \pm 2, \cdots\). If search solutions of this system of equations as harmonic waves, so the dependency of angular frequency \(\omega\) from wave vector \(q\) can be expressed as

\[
\omega_{1,2}(q) = (G/2)\{1 \pm \sqrt{1 - (4\theta_1\theta_2)/MmG^2}\}, \tag{5}
\]

\(G = \beta/m^* + \gamma C/m,\ C = 4\sin^2(aq/2),\ a\) - lattice spacings, \(m^* = (1/M + 1/m)^{-1}\). Qualitative curves \(\omega(q)\) are shown on the fig. 1 and contain known acoustic (A), as well as new (I) branches.
In complex real crystals except known acoustic and optical branches there are also branches of inherent oscillations. The number of I-branches is equal to $3r$ (r - a number of atoms in the unit cell of crystal). I-oscillations and waves can exist even though elementary cell keeps only one atom and optical oscillations are absent.

2. Distinctive properties of inherent oscillations and waves

Energy spectrum of inherent oscillations is possible to calculate taking into account an interaction between oscillations of different electronic envelops. Displacements of electronic envelops may be coherent within certain area with the distinctive size $\Lambda$ due to the interaction between them. Thermodynamic analysis of adiabatic crystal model gives the value: $\Lambda = \sqrt{Zm^*/ne^2\mu}$, where $Z$ - an atomic number, $m^*$ - effective mass of electronic envelop, $e$ - a charge of electron, $n$ - electronic density, $\mu$ - magnetic constant [5]. The value $\Lambda$ may exceed groups of ten lattice spasing. In such conditions a nucleus of each atom can realize oscillatory motion relatively big mass of crystal coherent area. Analysis shows that $\alpha$, $\beta$, $\gamma$ - types of inherent oscillations and waves are to exist in dependence of displacements K and L - orbits. $\alpha$-type of I-oscillations corresponds to nucleus oscillations relatively electronic envelop. Joint nucleus and K - orbit oscillations relatively remaining part of electronic envelop correspond to $\beta$ - oscillations. Joint nucleus, K and L - orbits oscillations relatively remaining part of electronic envelop correspond to $\gamma$ - oscillations. Elementary quantum $\hbar\omega_z$ of $\alpha$ - oscillations for neutral atom with number $Z > 2$ calculated with provision for shielding of nucleus by electrons can be expressed as:

$$\hbar\omega_z = \sqrt{\frac{\varepsilon^2}{3\pi\varepsilon_0(m_n + m_p)}} \left( \frac{\vartheta}{a_0} \frac{Z - \zeta - \xi}{Z - \zeta} \right)^3 \frac{\chi(Z - \xi)}{Z}. \quad (6)$$

Shielding is taken into account by $\zeta = 5/16$ and $\xi = sZ^{1/3}$, $s$ ranges from 1 to 1.15 when changing an atomic number $Z$ from 8 to 80, $\chi = 1.2$ takes into account a contribution in electronic density from s-states of L, M and N - orbitals, $\vartheta = 0.88534$, $a_0 = 0.529A^0$, $\varepsilon_0$ - electrical constant, $m_n$ and $m_p$ - masses of neutron and proton. Elementary quantum of $\beta$ - oscillations possible to define on the eq. (6), having place $\chi = 0.2$. Elementary quantum of $\gamma$ - oscillations possible to define on eq. (6), having place $\chi = 0.056$. Energy spectrum of harmonic inherent $\alpha$, $\beta$ or $\gamma$ - type oscillations and waves are possible to describe by harmonic oscillator formula

$$E(\nu) = E_o(\nu + 1/2), \quad (7)$$

where oscillatory quantum number $\nu = 0, 1, 2, \cdots$, and $E_0 = \hbar\omega_z$ for oscillations $\alpha$, $\beta$ or $\gamma$-type.

3. Interaction of inherent oscillations with phonons

Inherent oscillations and waves may exist in the ideal crystal but generate such oscillations and waves is possible (to the account of electrons or holes energy) by means of local centres with strong electron-phonon interaction. Inherent oscillations and waves distort a crystal. They are
capable effectively interact with other springy oscillations as well as with electrons and holes, ensuring efficient electron-phonon coupling. This can cause a phonon-drag component of thermoelectric power and other physical effects. So interaction of inherent oscillations with acoustic phonons is possible to track at simple univariate crystal model adding in to the equation (4) additional force $\delta U_n''$. This force describes effect from the coherent areas. Corresponding dependencies $\omega(q)$ is possible to get by replacing $G$ on $(G + \delta U_n'')$ in eq. (4). Acoustic branch suffers most alteration alongside centre of Brillouin area. At the condition $\delta > 0$ a forbidden frequency area $0 \cdot \omega^*$ appears. At condition $\delta < 0$ a forbidden area for wave vectors $0 \cdot q^*$ appears. Dependencies $\omega(q)$ for $\delta > 0$ and $\delta < 0$ are shown qualitatively on fig. 1 by dashed curves. Obviously at the conditions $\omega^* > 0$ and $|q^*| > 0$ experimental acoustic methods for crystal oscillations studies may turn out to be ineffective.

Acoustic phonons at the conditions $0 < \omega < \omega^*$ or $0 < |q| < |q^*|$ can not exist in crystals and consequently can not scatter charge carriers. For this reason superconductivity is possible if other mechanisms of scattering are absent.

4. Experiments, results, discussion

It is known that at temperatures $T < 70K$ thermoelectric power (TEP) may contain a phonon-drag component (PDC). Absence of PDC at $T > 70K$ earlier was explained by insufficiently strong coupling between electrons and phonons [3]. Such opinion in common was saved up to present time. However TEP in cristalline ropes of carbon nanotubes supposedly was explained by contribution of PDC at temperatures from 4.2K to 300K [4]. In carbon nanotube films on substrates at temperatures up to 600K narrow pias of TEP are discovered, connected with PDC [5, 6]. PDC in carbon nanotube films on substrates is stimulated by the interaction of electrons in film with phonons of substrate due to inherent $\alpha$-oscillations of Carbon ($E_0 = 0.25$ eV) and Oxygen ($E_0 = 0.22$ eV) atoms. In this work we measured PDC in monocristals GaP and Si, in porous silicon on silicon substrates.

In experiments were used flat semiconductor samples with the thickness 200 mkm containing local centres with the strong electron-phonon coupling. We investigated GaP samples with impurities of aluminum or sulphur ($\approx 10^{15}$cm$^{-3}$): GaP(Al) and GaP(S). Such impurities were chosen because atoms Al and S have masses vastly exceed mass of atom Ga. This advantages emergence electron-vibrational centres and generation of inherent oscillations. Investigated silicon samples had impurities of Phosphorus ($\approx 5 \cdot 10^{15}$cm$^{-3}$) and Oxygen($\approx 10^{18}$cm$^{-3}$): Si(P,O).

Before measurements the samples where subjected to heating in vacuum within 5 minutes at $T=600K$ then they were cooled up to room temperature within 0.2 minutes. Concentration of Oxygen in Si was determined on the basis of data about intensities of distinctive optical absorption near 9 mkm. Layers of porous silicon (Si$^*$) with the thickness about 0.3 mkm on n-silicon substrates with resistivity 3 Ohm$\cdot$cm were also investigated. In samples Si(P,O) and in Si$^*$ local centres seem to be formed by atoms of oxygen (A-centres) for which the constant of electron-phonon interaction is equal to 5.

Their were measured temperature dependencies of electrical resistivity $\rho(T)$ and temperature dependencies of thermoelectric power in samples within the range from 77K to 700K for
the reason of studying the influence of inherent oscillations and waves on migration of charge carriers. Temperature difference at measurements of TEP did not exceed $3K \pm 0.2K$. The spectrums of infra-red reflection modification (dR) were measured, caused by impurities in GaP samples, in the optical range from 15 mkm (83 meV) to 2 mkm (620 meV) at 300K. The angle between nonpolarized light beam and flat surface of sample was equal to $45^0$.

Typical temperature dependencies of electrical resistivity $\rho(T)/\rho_0$ of GaP samples are brought on fig. 2 in semilogarithmic coordinates. $\rho_0$ is a constant and does not influence magnitudes $E_a$. Magnitudes $\rho_0$ are selected for each curve that the curves were conveniently plased on the fig. 2. Curve 1 on fig 2 refers to temperature dependencies of electrical resistivity of GaP sample without impurities. Typical dependencies $\rho(T)/\rho_0$ of GaP(Al) and GaP(S) samples are presented on fig. 2 by curves 2 and 3. These curves are broken straight lines. Tangent to these curves select areas which correspond to concrete values $E_a$. Values $E_a$, measured at $T < 330K$, are contributed in Table 1 where stars choose the lines with energies fit known energies of phonons in GaP [10] which are brought here in the central column. Activation energies of GaP(Al) and GaP(S) measured at $T > 330K$ are contributed in Table 2 where values of oscillatory energy of impurity atoms also brought, calculated on the eq. (7) with provision for values ($E_0 = 0.283eV$) for Al and ($E_0 = 0.301eV$) for S. Modification of optical reflection (dR) caused by impurity atoms Al in GaP are presented on fig. 3. Experimental temperature dependencies of TEP for GaP samples are presented on fig. 4. Temperature dependencies of TEP for samples Si(P,O) and for polisilicon film on the silicon substrate ($Si^*$) are presented on fig 5.

Curve 1 on fig. 2 may be characterized with activation energy $E_a \approx 0.7$ meV at temperatures $T<330K$ but value $E_a$ is close to the width of GaP forbidden gape ($2.4$ eV) at temperatures $T > 330K$. Curve 2 and 3 on fig. 2 may be characterized by several activation energies. Corresponding values $E_a$ are contained in Table 1 and Table 2 and may be explained differently. Values $E_a$ in lines of Table 1, marked by the stars in the first column, close to crystalline phonons which intensively interact with local centers. These phonons are pointed out in central column in Table 1. It is impossible to explain the experimental dependencies $\rho(T)$ by dissipation of charge carriers by phonons since the dissipation is capable to create an opposite effect to the observed effect of reducing resistance when increasing the temperature. We connect these energies with generation of free charge carriers from electron-vibrational levels of local centers created by atoms Al or S. Other energies in Table 1 supposedly may be explained by generation of free charge carriers from electron-vibrational levels formed by inherent oscillations ($\beta$ and $\gamma$-types) of Al or S and possible by combinations of such oscillations with cristalline phonons.

It is seen from Table 2 that activation energies of samples with each type of impurities can be divided into two groups which corresponds to two columns dextral. One group consists of activation energies which are described by the equation for quantum harmonic oscillator (7). These activation energies are connected with inherent oscillations of impurity atoms and correspond to transitions from oscillatory energy levels with $\nu = 0, 1, 2, \cdots$ in the minimum of oscillatory potential where oscillatory energy is zero. Such transition for free quvantum harmonic oscillator are forbidden but they are possible for classical oscillator. Consequently, inherent oscillators of impurity atoms show duality of properties that can be explained by their interaction with the cristal. Other group of energies in Table 2 consists of energies multiple
Table 1: Activation energies for GaP(Al) and GaP(S) at $T < 330K$

| Activation energies $E_a$ (meV) for GaP(Al) samples with numbers: | Phonons in GaP (meV) | Activation energies $E_a$ (meV) for GaP(S) samples with numbers: |
|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 8.1 | — | — | 7.2 | 8.0 | — | — | — | — | — |
| *15.0 | — | — | 14.8 | 14.5 | 14.25 | 15.0 | 14.8 | — | — | 14.3 |
| *24.5 | — | — | — | 25.0 | 24.42 | 24.0 | — | 24.6 | — | — |
| — | 35.0 | — | — | — | — | — | — | 28.0 | 28.0 |
| *45.0 | — | — | — | 44.6 | 44.75 | — | 42.0 | — | — | — |
| *— | — | 49.0 | 48.0 | — | 47.00 | 47.0 | — | — | — | — |
| 75.0 | — | 83.0 | — | — | — | — | — | 70.0 | — | — |

$E_0$. Energies of this group are also connected with inherent oscillations of impurity atoms and correspond to transitions between different oscillatory energy levels (between levels with different $\nu$). It is seen that the value $E_0$ is the same for both groups of energies. Consequently, both groups of energies refer to the same type of centres that show a classical and quantum properties (duality of properties).

Studies of infra-red reflection (R) also confirm presence of inherent oscillations in GaP(Al) and GaP(S) samples and their intensive interaction with electrons and crystalline phonons. Modification of infra-red reflection spectrum (dR) caused by impurities atoms was separated on components in accodance with complex oscillator model [11, 12] taking into account the contributions from $j$ different charged oscillators. These components are marked on fig. 3 by numerals $j$: 2, 3, 4 and 5. Every component involved contribution into reflection (R) reach the highest value when optical frequency ($\omega$) satisfy to the conditions $\omega_p > \omega > \Omega$. $\Omega$ - an oscillator frequency and $\omega_p$ - a frequency of springy oscillations of lattice. Minimum dR locates near $\omega_p$.

Agreement of experimental - 1 and amount of calculated spectrums 2, 3, 4 and 5 is reached if energies $h\omega_p$ are equal to the energies of $\alpha$ - tipe inherent oscillations for Al: $0.5E_0$, $E_0$, $1.5E_0$, $2E_0$. Two from them comply with calculated on eq. (7) if $E_0 = 0.283$ eV and $\nu = 0$ or 1 but two other are multiple the same $E_0 = 0.283$ eV. Reflection spectrums of GaP(S) also are described within the complex oscillator model [11, 12] if $E_0 = 0.301$ eV. Energies $h\Omega$ for both types of impurities (Al,S) may be connected with $\gamma$ - type of inherent oscillations Al(61.1 meV) or S(65.0 meV). Energy loss of inherent oscillators is great ($G/\Omega \simeq 0.09$; $G$- damping factor) and corresponds to the tight binding of impurity atoms with the cristalline phonons. Thereby centres formed by impurities Al and S in GaP show duality of optical properties. These properties are defined by interaction of inherent oscillations of impurities atoms, cristalline phonons and electrons with each other.

The best consent of calculated and experimental reflection spectrums is reached if optical dielectric permeability ($\varepsilon \simeq 2$) is small in contrast with the highfrequency dielectric permeability GaP ($\varepsilon = 8.457$) [13]. Probably measured value of dielectric permeability follow refer to local centres in which electronic optical transitions occur. A cross section of photons capture can be
Table 2: Activation energies for GaP(Al) and GaP(S) at $T > 330K$

| $E_a$ (eV) for GaP(Al) samples with numbers: | Calculated on eq. (7) | Multiple $E_0$ (eV) |
|---|---|---|
| 1 | 2 | 3 | 4 | 5 | --- | --- |
| 0.14 | 0.14 | 0.14 | 0.138 | 0.137 | 0.1415 ($\nu = 0$) | --- |
| 0.28 | 0.29 | 0.29 | 0.28 | 0.28 | --- | $E_0 = 0.283$ |
| 0.42 | 0.42 | 0.43 | 0.42 | 0.43 | 0.4245 ($\nu = 1$) | --- |
| --- | 0.57 | --- | 0.56 | 0.58 | --- | $2E_0 = 0.566$ |
| 0.71 | --- | 0.72 | --- | --- | 0.7075 ($\nu = 2$) | --- |
| --- | --- | --- | 0.85 | --- | --- | $3E_0 = 0.849$ |
| --- | 0.97 | --- | --- | --- | 0.9905 ($\nu = 3$) | --- |
| 1.10 | --- | --- | --- | 1.11 | --- | $4E_0 = 1.132$ |

| $E_a$ (eV) for GaP(S) samples with numbers: | --- | --- |
|---|---|
| 6 | 7 | 8 | 9 | 10 | --- | --- |
| 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.1505 ($\nu = 0$) | --- |
| 0.3 | 0.29 | 0.3 | 0.3 | 0.31 | --- | $E_0 = 0.301$ |
| --- | --- | --- | --- | --- | 0.4515 ($\nu = 1$) | --- |
| 0.6 | --- | 0.6 | 0.61 | --- | --- | $2E_0 = 0.602$ |
| --- | --- | --- | 0.74 | 0.7525 ($\nu = 2$) | --- | --- |
| --- | 0.92 | --- | --- | --- | $3E_0 = 0.903$ | --- |
| 1.03 | --- | --- | --- | 1.0500 ($\nu = 3$) | --- | --- |

defined by wavelength of crystalline phonons which interact with the centres.

Inherent oscillations can spread in crystals as waves of inherent oscillations. Inherent oscillations, crystalline phonons and electrons (holes) powerfully interact with each other and give rise to electrical currents. This is confirmed by particularities of TEP. Curve 1 on fig. 4 is typical temperature dependency of TEP for samples GaP(S). Curve 2 on fig. 4 is typical for GaP samples without impurities and may be explained by close to inherent conductivity. Temperature dependency of TEP for GaP(Al) is like curve 1. Curve 1 on fig. 4 keeps pius which marked by arrows and by letters. Polarity of these pius agrees with the polarity of drift TEP. We connect these pius with the phonon drag of electrons. Pius A, B, C and F are situated at Debye temperatures of crystalline phonons in GaP [10]: 95K (TA, 8.2 meV); 168K (TA, 14.25 meV); 288K (LA, 24.42 meV); 542K (LO, 44.75 meV). Broad pius D ($\approx 345K$) and E ($\approx 475K$) can to be explained by combinations of crystalline phonons: (TA+TA, 28.6 meV) and (TA+LA, 38.67 meV). Investigations of $\rho(T)$, TEP temperature dependency and infra-red reflection show that inherent oscillations Al and S in GaP actively interact with crystalline phonons and electrons. This ensures electron-phonon interaction sufficient for the realization of phonon drag effect (and probably superconductivity) at very high temperatures.

Curve 1 on fig. 5 represents peculiar temperature dependencies of TEP for samples Si(P,O). It has pius specified by arrows and by letters a, b, c, d, e. Polarity of these pius coincides
with the polarity of drift TEP. Pius a, b, c are situated at Debye temperatures of acoustic phonons with wave vectors along certain directions: \( <111> \), 200.4K (16.7 meV); \(<110>\), 214.8K (17.9 meV); \(<100>\), 252K (21.0 meV). We explain these pius by phonon drag of electrons. Pius d and e we involve with TO phonons in Si. Curve 2 on fig. 5 represents the temperature dependency of TEP in Si* and has pius p, q, r, h with different polarities. Temperatures of these pius are equal to Debye temperatures of phonons in critical points in the Brillouin area of Si: L(W) - 551K (45.9 meV); L(L) - 606K (50.5 meV); TO(X) - 683K (56.9 meV) and TO(L) - 712K (60.9 meV) accordingly. We explain pius f, g, h, i by phonon drag of holes but peak j we explain by phonon drag of electrons.

The sufficient interaction between electrons (holes) and phonons in silicon samples can be explained by inherent oscillations of centres which are formed by impurities of Oxygen \( (E_0=0.22 \text{ eV}) \). These are to be A-centres. Such interpretation agrees with experimental temperature dependencies of electrical resistivity for the same samples. These dependencies are described by several activation energies among which there are multiple \( E_0 = 0.22 \text{ eV} \) or equal to calculated on the eq. if \( E_0 \) is equal to the same value.

5. conclusion

The analysis of experimental results has shown that phonon drag effect is caused by the phonons which actively interact with electron-vibrational centres formed by impurity atoms (Sulphur and Aluminium in GaP, Oxygen in silicon samples). Such centres can generate inherent oscillations and waves. Theoretical possibility of strong electron-phonon interaction, caused by inherent oscillations and waves, was confirmed by the phonon drag effect at temperatures up to about 700K. The phonon drag component of thermoelectric power also has confirmed the presence of inherent oscillations waves in crystals. The expected superconductivity from about room temperatures up to temperatures more 700K provided by inherent oscillations and waves probably will be realized.

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Figure captions

Fig. 1. Inherent (I) and acoustic (A) branches of oscillations in adiabatic simple univariate crystal model (1 - at $\delta=0$; 2 - at $\delta>0$; 3 - at $\delta<0$). Fragment of adiabatic simple univariate crystal model is shown on insertion.

Fig. 2. Temperature dependencies of electrical resistivity $\rho(T)$ for samples GaP: 1 - without impurities, 2 - with impurity of Aluminium; 3 - with impurity of Sulphur.

Fig. 3. Change of optical reflection (dR) caused by impurity of Aluminium in GaP – 1. Calculated components of dR connected with inherent oscillations of Aluminium: 2, 3, 4, 5.

Fig. 4. Temperature dependency of thermoelectric power: 1 - in GaP with impurity of Sulphur; 2 - in GaP without impurities.

Fig. 5. Temperature dependency of thermoelectric power: 1 - in Si with impurity of Phosphorus and Oxygen; 2 - in porous silicon ($Si^*$).
