Positive magnetoresistance and hole-hole scattering in $GaAs/Al_{0.5}Ga_{0.5}As$ heterostructures under uniaxial compression

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Resistance, magnetoresistance, and their temperature dependencies have been investigated in the two-dimensional hole gas at a [001] p-type $GaAs/Al_{0.5}Ga_{0.5}As$ heterointerface under [110] uniaxial compression in the range of low and intermediate magnetic fields. Analysis performed in the frame of hole-hole scattering between carriers in the two subbands of the spin split ground heavy hole state indicates that hole-hole scattering is strongly suppressed by uniaxial compression. The value of the parameter α, which determines the mutual hole-hole friction coefficient $\eta=\alpha T^2$ reveals three times decrease under uniaxial compression 1.3 kbar. [S0163-1829(98)04948-0]

I. INTRODUCTION

In the middle of the eighties, when a successful growth of perfect modulation-doped p-type $GaAs/Al_xGa_{1-x}As$ heterostructures initiated an intensive study of two-dimensional (2D) hole systems, a strong positive magnetoresistance of 2D holes confined in an asymmetric triangular quantum well (QW) was observed in the region of low-magnetic fields.[1,2] The lack of inversion symmetry in a QW of this kind causes lifting of the spin degeneracy of the hole states at $k\neq 0$, i.e., splitting into two non-spin-degenerate subbands with different effective masses, sticking each other at $k=0$.[3] In this connection in the 2D-hole systems, with the two subbands of the spin split ground heavy hole states being occupied, the effect of positive magnetoresistance seemed to be associated with two-band carrier conductivity,[1,2] although its strong temperature dependence remained to be a puzzle. Recently, it was found[4] that this puzzle can be successfully removed for p-type $GaAs/Al_xGa_{1-x}As$ heterostructures by using the model of temperature-dependent mutual scattering of the holes (hole-hole scattering) in the two non-spin-degenerate subbands, which we refer below as spin subbands.

In the present paper we report on the resistance, magnetoresistance, and their temperature dependencies in the 2D hole gas at a p-type $GaAs/Al_{0.5}Ga_{0.5}As$ heterointerface in the low and intermediate magnetic-field range under uniaxial compression. Shubnikov–de Haas (SdH) oscillations and Hall effect were also studied in magnetic fields up to 3.5 T in order to determine the carrier concentrations. We analyzed these data in the frame of the simple isotropic two-band model with hole-hole (h-h) scattering as it was done in Ref. 4 and found, that h-h scattering mechanism is strongly suppressed by uniaxial compression.

II. EXPERIMENTAL RESULTS

The samples have been processed in the same way and from the same wafer as the ones reported on in Refs. 5 and 6, where the emphasis was put on the range of high magnetic fields, and where uniaxial pressure dependence of the effective mass m_1 as well as the carrier concentrations n_0 and n_1 in the two spin subbands ''0'' and ''1'' were obtained from SdH and quantum Hall effects. The wafer is a modulation-doped $GaAs/Al_{0.5}Ga_{0.5}As$ heterostructure grown by molecular-beam epitaxy on a [001] semi-isolating GaAs substrate and doped with Be in part of the $Al_{0.5}Ga_{0.5}As$. In the samples under investigation the uniaxial compression is applied along the [110] direction of a Hall bar mesa, cf. Ref. 5 for the experimental details.

The total carrier concentration N is determined from classical Hall effect in magnetic field B up to 3.5 T, where the Hall resistivity can be expressed by $\rho_{xy}=B/Ne$. The hole concentration n_1 in the more light and less populated spin subband ''1'' is derived from SdH oscillations of the longitudinal resistivity ρ_{xx}. The concentration in subband ''0'' is obtained as $n_0=N-n_1$. The pressure-dependent values of N, n_0, and n_1 correspond well to the data from Refs. 5 and 6 and are used as input parameters in calculations of the 2D hole mobilities μ_i and mutual scattering characteristics. Galvanomagnetic characteristics, taken in low and intermediate magnetic fields $\mu B\leqslant 10$ (where μ is the average Hall mobility) and in the temperature interval 1.7–4.2 K, are represented on Figs. 1 and 2 and show the following features.

(1) At zero pressure $P=0$ we observe a well-pronounced positive magnetoresistance $\rho_{xx}(B)$, that tends to saturation $[\rho_{xx}(B)\rightarrow\rho_{xx}^{sat}]$ in the region $\mu B\simeq 5$. The positive magnetoresistance strongly decreases with uniaxial compression and almost disappears at $P=2.0$ kbar [Fig. 1(a)].

(2) In the pressure interval where the positive magnetoresistance is still well pronounced, it reveals a strong temperature dependence that practically disappears in the saturation region (Fig. 2). Temperature dependence of the magnetoresistance is almost completely suppressed by uniaxial stress (Table I, the last column).

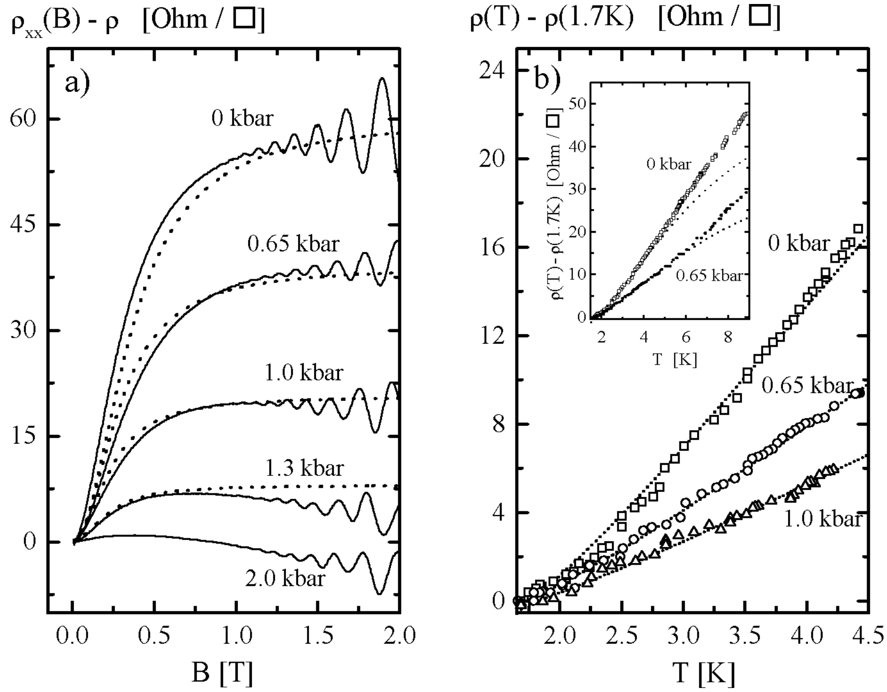

FIG. 1. Uniaxial compression influence on (a) the magnetoresistance at $T = 1.7$ K and (b) the temperature dependence of the zero-magnetic-field resistivity. Dotted lines are the results of calculations with h-h scattering mechanism taken into account.

(3) The zero-magnetic-field resistivity ρ noticeably depends on temperature, even at $T < 4.2$ K. This dependence decreases under uniaxial compression [Fig. 1(b)].

(4) In a qualitative agreement with the previous results,[6] the electrical resistivity ρ of the 2D hole gas in zero magnetic field reveals approximately two times decrease at $P = 2.0$ kbar (Table I), while the total carrier concentration exhibits about 10% decrease on the background of the carriers redistribution between the two spin subbands [Fig. 3(a)].

(5) At $P > 1.3$ kbar, where positive magnetoresistance drastically drops, a negative magnetoresistance becomes well noticeable in intermediate magnetic fields at $B > 0.5$ T [Figs. 1(a) and 4(a)].

The main experimental result consists in the strong suppression of the temperature dependence of the positive magnetoresistance and the zero-magnetic-field resistance under uniaxial [110] compression. The decrease of the positive magnetoresistance at fixed temperature [Fig. 1(a)] could be explained in the frame of the two-band model by the fact that the compression reduces the difference between the bands.[5,6] But this result should be regarded only together with the strong decrease of the temperature dependence of magnetoresistance and zero-magnetic-field resistivity under compression. The presence of the temperature dependence of magnetoresistance at $P = 0$ is the basic point for assumption of the temperature dependent h-h scattering mechanism in Ref. 4. The analysis, carried out in that paper, shows that the strong temperature dependence of magnetoresistance cannot be satisfactory explained by other effects: for example by the weak localization and the temperature smearing of the energy separation Δ_s between the spin subbands. The last one may be important in the uniaxial stress experiments since it was shown[6] that Δ_s decreases under [110] compression. Nevertheless, if we take the value of splitting $\Delta_s \simeq 2$ meV at $P = 0$ (Ref. 3) and assume that it decreases down to $\Delta_s \simeq 1$ meV at $P = 1.3$ kbar,[6] the condition $\Delta_s = k_B T_c$ (k_B is the Boltzmann constant) gives the corresponding values $T_c \simeq 24$ K and $T_c \simeq 12$ K, which are essentially higher than the temperatures of our experiment.

So we consider, that the temperature dependence of the magnetoresistance is connected with the h-h scattering and the fact of its decrease under compression qualitatively demonstrates the suppression of this mechanism. At the same time, we confine our consideration of this effect by the pressure 1.3 kbar because the noticeable negative magnetoresistance starts to interfere with strongly decreased positive magnetoresistance [Figs. 1 and 4(a)].

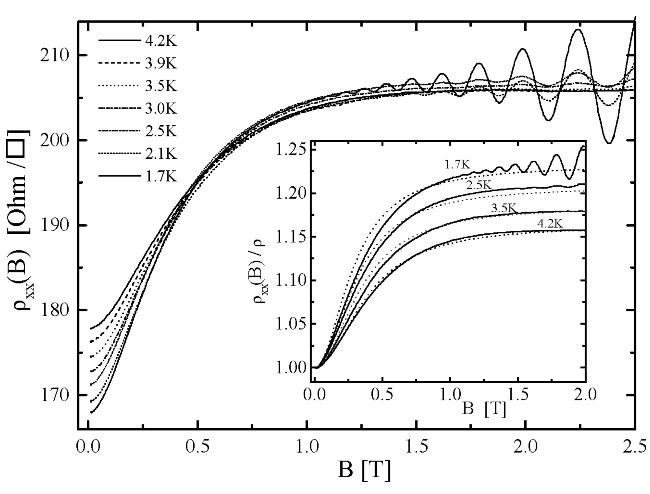

FIG. 2. Temperature dependence of the magnetoresistance at uniaxial compression of 0.65 kbar. The result of calculations is represented by the dotted lines on the insert.

TABLE I. The resistance in zero-magnetic field $\rho(1.7\ \mathrm{K})$, the positive magnetoresistance in the saturation range $\Delta\rho_{xx}(T)=\rho_{xx}^{sat}(T)-\rho(T)$ at 1.7 K and its temperature characteristic $\Delta\rho_{xx}(1.7\ \mathrm{K})-\Delta\rho_{xx}(4.2\ \mathrm{K})$ for two samples at different magnitudes of uniaxial stress.

	Stress (kbar)	$\rho(1.7\ \mathrm{K})$ (Ω)	$\Delta\rho_{xx}(1.7\ \mathrm{K})$ (Ω)	$\Delta\rho_{xx}(1.7\ \mathrm{K})-\Delta\rho_{xx}(4.2\ \mathrm{K})$ (Ω)
Sample 1	0	214.2	60	15.5
	0.65	168.8	39	8
	1.0	139.5	19.4	3.5
	1.3	116.8	7.7	1.3
	2.0	94.1	1.4	0.1
Sample 2	0	220.8	61.2	15.5
	0.65	179.1	41.9	9.7
	1.3	140.1	12.9	2.3
	2.0	106.9	2.5	

III. APPLICATION OF HOLE-HOLE SCATTERING MODEL

In the absence of a comprehensive theory of the transport phenomena in 2D hole systems with nonparabolicity and anisotropy taken into account, we use in our calculations the simple isotropic model with mutual friction of carriers in the two different spin subbands as it was done in Ref. 4.

The contribution of carrier-carrier scattering to electrical resistivity is possible when two types of carriers with different mobilities make up the electric current. In an electric field the carriers will acquire different velocities, and the velocity difference can be degraded by carrier-carrier scattering, which may be described in terms of mutual friction. By writing the electric current as a sum of two terms: one proportional to the total momentum and the other proportional to the relative momentum, Kukkonen and Maldague[7] demonstrated how the conservation of momentum (the total momentum) goes along with the mentioned contribution to the electrical resistivity. In the Drude model we then have two coupled vector equations of motion:

$$\frac{m_0\mathbf{V}_0}{\tau_0}=e\mathbf{E}+e\mathbf{V}_0\times\mathbf{B}-\eta n_1(\mathbf{V}_0-\mathbf{V}_1), \tag{1}$$

$$\frac{m_1\mathbf{V}_1}{\tau_1}=e\mathbf{E}+e\mathbf{V}_1\times\mathbf{B}-\eta n_0(\mathbf{V}_1-\mathbf{V}_0), \tag{2}$$

where $\mathbf{E}$ and $\mathbf{B}$ are the electric and magnetic fields, $\mathbf{V}_i$ are the carrier velocities, m_i are the effective masses, τ_i are the momentum relaxation times, and the subscripts ''0'' and ''1'' characterize each of the two types of carriers. Comparing these equations to the corresponding equations in Kukkonen and Maldague,[7] we find that the ''friction coefficient η'' is expressed as

$$\eta=\frac{m_0m_1}{(n_0m_0+n_1m_1)\tau_{01}}, \tag{3}$$

where τ_{01} is the decay time for the relative momentum.

Solving Eqs. (1) and (2) for the velocity components and using the expression for the current density

$$\mathbf{j}=n_0e\mathbf{V}_0+n_1e\mathbf{V}_1=\sigma\mathbf{E}$$

we obtain the components σ_{xx} and σ_{xy} of the conductivity tensor to be given by the same expressions that were found in Ref. 4:

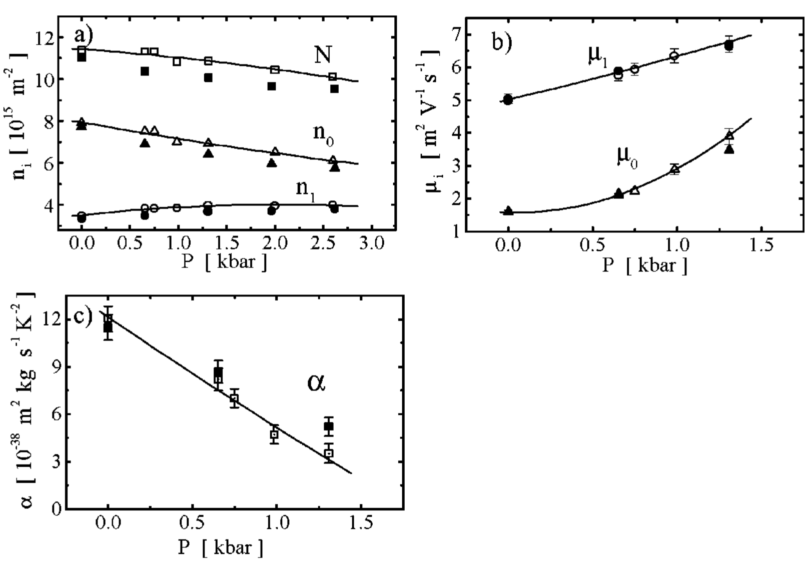

FIG. 3. Uniaxial stress influence on (a) total carrier concentration N and spin-subband carrier concentrations n_0 and n_1, (b) spin-subband mobilities, and (c) h-h friction parameter α. Open and solid symbols correspond to different samples.

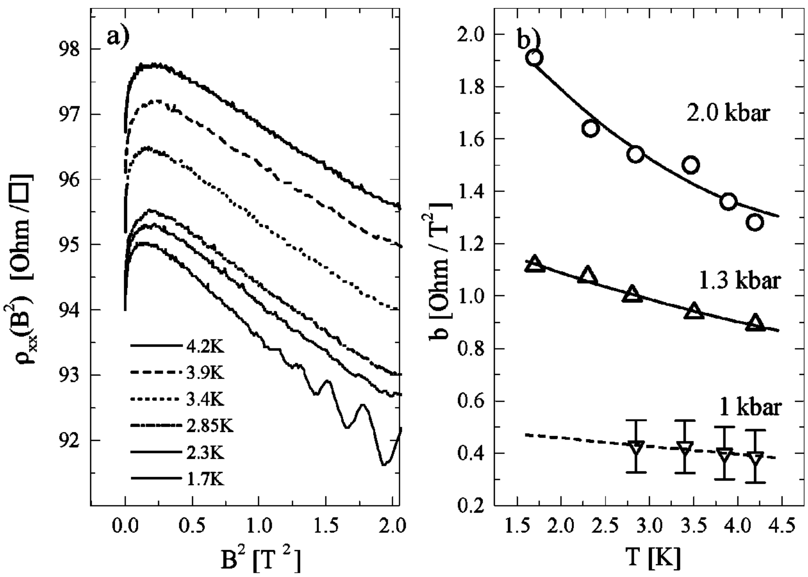

FIG. 4. (a) Negative magnetoresistance under uniaxial compression 2.0 kbar at different temperatures and (b) temperature dependence of the negative magnetoresistance parameter b for 1.3, 2.0, 2.6, and 3.3 kbar.

$$\sigma_{xx}=\frac{[N\omega(Be)^2+(\eta N\omega+\omega_0\omega_1)(\eta N^2+n_0\omega_1+n_1\omega_0)]e^2}{(Be)^4+[N^2\eta^2+2\eta(n_0\omega_1+n_1\omega_0)+\omega_0^2+\omega_1^2](Be)^2+(\eta N\omega+\omega_0\omega_1)^2}, \tag{4}$$

$$\sigma_{xy}=\frac{[N(Be)^2+N^3\eta^2+2\eta N(n_0\omega_1+n_1\omega_0)+n_0\omega_1^2+n_1\omega_0^2]Be^3}{(Be)^4+[N^2\eta^2+2\eta(n_0\omega_1+n_1\omega_0)+\omega_0^2+\omega_1^2](Be)^2+(\eta N\omega+\omega_0\omega_1)^2}, \tag{5}$$

where

$$\omega_i=\frac{e}{\mu_i}=\frac{m_i}{\tau_i} \quad \text{and} \quad \omega=\frac{n_0\omega_0+n_1\omega_1}{N}. \tag{6}$$

Finally, the diagonal resistivity element is calculated from

$$\rho_{xx}=\frac{\sigma_{xx}}{\sigma_{xx}^2+\sigma_{xy}^2}. \tag{7}$$

We have already pointed out that the total carrier concentration N and the concentrations n_0 and n_1 in the two subbands were determined from Hall effect and SdH measurements. The remaining parameters of the model were evaluated from the expressions for the high-field saturation value of ρ_{xx}:

$$\rho_{xx}=\frac{\omega}{Ne^2} \quad \text{for} \quad \mu B\gg 1 \tag{8}$$

and the zero-field value:

$$\rho=\frac{\eta(T)N\omega+\omega_0\omega_1}{[\eta(T)N^2+n_0\omega_1+n_1\omega_0]e^2} \quad \text{for} \quad B=0. \tag{9}$$

For the high-field saturation value the parameter ω can be obtained from Eq. (8). Afterwards we calculate η from Eq. (9) at each of the experimental temperatures for an array of ω_1 values [ω_0 was eliminated by using of Eq. (6)]. Thus, each value of ω_1 give the friction coefficient as a function of temperature. We finally determine the value of ω_1 as the one that gives the best fit of η to the relation

$$\eta(T)=\alpha T^2, \tag{10}$$

which is the expected temperature dependence when Fermi-Dirac statistics is prevailing; i.e., when $k_BT\ll E_F$.[8] This condition is valid at $T=1.7-4.2$ K: in the samples under investigation, the Fermi energy is $E_F\simeq 6$ meV. The resulting parameter values ω_0, ω_1, and α are displayed in Figs. 3(b) and 3(c), where ω_0 and ω_1 are replaced by the corresponding mobilities μ_0 and μ_1.

IV. NEGATIVE MAGNETORESISTANCE AND TEMPERATURE DEPENDENCE OF CARRIER MOBILITIES, $P\geqslant 1.3$ kbar

At $P\geqslant 1.3$ kbar the negative magnetoresistance starts to be noticeable [Fig. 1(a)] and should be taken into account.

For illustration we represent our data at $P=2$ kbar, where the negative magnetoresistance is well expressed [Fig. 4(a)]. We may regard the $\rho_{xx}(B^2)$ dependences on Fig. 4(a) to be a superposition of the positive and negative magnetoresistance. In the range of magnetic fields $B>0.5$ T, where at low stress the positive magnetoresistance tends to the saturation value ρ_{xx}^{sat}, the dependence $\rho_{xx}(B^2)$ reveals the linear behavior and can be expressed

$$\rho_{xx}(B^2)=\rho_{xx}^{*}-bB^2.$$

Here ρ_{xx}^{*} is considered to be ρ_{xx}^{sat} of the positive contribution to magnetoresistance within the accuracy of the saturation condition

$$\frac{\partial \rho_{xx}(B^2)}{\partial (B^2)} = \text{const},$$

and it is used in calculations at $P=1.3$ kbar, where the influence of the negative magnetoresistance is essential.

It should be noted, that the slope b of the linear in respect to B^2 negative magnetoresistance depends on temperature and pressure [Fig. 4(b)]. The magnitude of b has a tendency to strongly decrease when pressure decreases, and this is the reason why we neglect the negative magnetoresistance in our calculations at low pressure. At $P=1$ kbar [Fig. 4(b)], the magnitude of b can be estimated only with a high error. The origin of the negative magnetoresistance is not clear for us at present.

In the model described in Sec. III carrier mobilities are supposed to be temperature independent, that appears not to be strictly correct even at $T<4.2$ K. According to Eq. (8), at sufficiently high magnetic field the contribution of h-h scattering to the temperature dependence of magnetoresistance is suppressed. It allows us to estimate from the experimental curves the temperature dependence of resistivity, connected with other scattering mechanisms, and make the necessary corrections. At low stress these corrections can be neglected (Fig. 2), but above 1 kbar start to be essential in comparison with the value of depressed temperature dependence of the positive magnetoresistance.

In the frame of h-h scattering model the correction, connected with the contribution of other scattering mechanisms, can be taken into account by representing ω_i as a temperature-dependent parameter:

$$\omega_i = \omega_i(T) \equiv \omega_i^{*} f_i(T). \tag{11}$$

Here, we represent ω_i as the product of the temperature-independent constant ω_i^{*} and temperature-dependent function $f_i(T)$. For simplicity, we suppose that both mobilities have the same temperature dependence and thus, $f_0(T) = f_1(T) = f(T)$. We normalize $f(T)$ in such a way that at the lowest temperature of our experiment $f(1.7\ \text{K})=1$. It gives us the values $\omega_i^{*}=\omega_i(1.7\ \text{K})$ and according to Eq. (6), ω can be expressed as $\omega=\omega^{*} f(T)$, where $\omega^{*}=(n_0\omega_0^{*} + n_1\omega_1^{*})/N$.

As the temperature dependence of N is not detected in the temperature interval under investigation, Eq. (8) can be modified to the expression

$$\rho_{xx}^{sat}(T) = \frac{\omega^{*}}{Ne^2} f(T), \tag{12}$$

where only $f(T)$ depends on temperature. By this way $f(T)$ can be extracted from the experimental temperature dependence of $\rho_{xx}^{sat}(T)$:

$$f(T) = \frac{\rho_{xx}^{sat}(T)}{\rho_{xx}^{sat}(1.7\ \text{K})}. \tag{13}$$

The result of the analysis is represented on Fig. 5 for $P \geqslant 1.3$ kbar. The replacing ω_i in Eqs. (4)-(9) by expression (11) in the procedure, described in Sec. III, gives us the corrected values of ω_i and α. Just these data are represented for $P>1$ kbar on Figs. 3(b) and 3(c).

With the help of this empirical procedure we can take into account an additional temperature dependence, due to other scattering mechanisms, in determination of h-h scattering parameters even if the origin of these mechanisms is not known. But it should be noted that we determine $f(T)$ only in a restricted temperature interval 1.7–4.2 K and the parameters can be calculated only within this temperature interval. On Fig. 3(b) for $P>1$ kbar we refer $\mu_i = e/\omega_i$ to the temperature 1.7 K.

The temperature dependence of mobilities, which is expressed by the function $f(T)$ on Fig. 5 and supposed not to be connected with h-h scattering, is not linear. At the highest pressures $P=2.6$ kbar and $P=3.3$ kbar it follows well to the low $f \sim T^5$. Such temperature behavior was observed in 2D electron transport,[9] where the authors explained it by piezoelectric component of electron-phonon scattering (Bloch-Gruneisen regime). As far, the theory of transport phenomena in 2D hole system, especially at $T<4.2$ K, is not well developed at present there exist certain difficulties in interpretation of these data, all the more the effect of the extracted temperature dependence $f(T)$ is very small in the interval 1.7–4.2 K. Following Ref. 10, we can only suppose that the acoustic phonon scattering remains in a little part below 4.2 K and, in analogy with 2D electrons, there may exist a temperature dependence of the screening constant. We cannot also exclude the possibility that this temperature dependence may be partly connected with some mechanism responsible for the negative magnetoresistance.

V. RESULTS AND DISCUSSION

The behavior of the magnetoresistance at different pressures and temperatures has been calculated from expressions (4), (5), and (7) with the obtained parameter values ω_0, ω_1, and α. The corresponding dependencies are depicted on Figs. 1 and 2 by dotted curves. The maximal deviation of calculations from the experimental curves $\Delta\rho_{xx} = \rho_{xx}(B) - \rho$ does not exceed 10% in the whole interval of magnetic fields, pressures, and temperatures under investigation. Thus, we can conclude that the complete set of experimental data on zero-magnetic-field resistance, positive magnetoresistance and their temperature dependencies at different uniaxial pressures can be well described by mutual scattering of holes in the two spin subbands. At $T>5$ K the temperature dependence of the resistance in zero-magnetic field does not follow the h-h scattering model calculations [see inset on Fig. 1(b)]. The most possible reason is the growing $k_B T$ and increasing scattering on acoustic phonons. It should be noted once more that the calculations were performed only for the pressure interval up to 1.3 kbar, because the noticeable negative magnetoresistance at higher pressure (Fig. 1), introduces an apparent deviation from the model, described by expressions (4), (5), and (7).

The pressure dependencies of the mobilities μ_0 and μ_1 ($\mu_i = e/\omega_i$) in the two spin subbands reveal their increase under uniaxial compression [Fig. 3(b)], while the value of α, which describes the mutual friction coefficient $\eta = \alpha T^2$, strongly decreases [Fig. 3(c)]. The last result indicates that

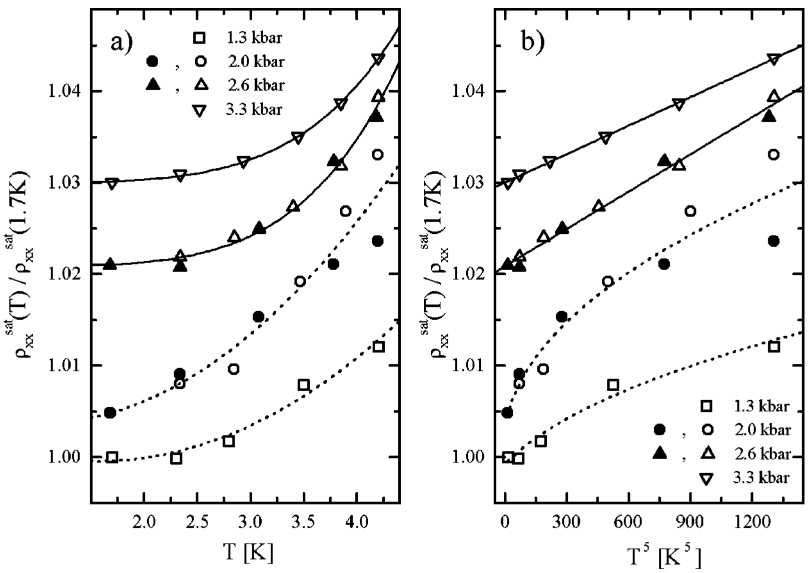

FIG. 5. Temperature dependence of $f(T)=\rho_{xx}^{sat}(T)/\rho_{xx}^{sat}(T=1.7\text{ K})$ at 1.3, 2.0, 2.6, and 3.3 kbar. Open and solid symbols correspond to different samples.

h-h scattering in spin subbands is noticeably depressed. The simplicity of the used model makes us suppose that its application rather demonstrates the effect of h-h scattering suppression than gives strict numerical results. Nevertheless, we believe that if the simple h-h scattering model works at $P=0$,[4] it should definitely show the proper tendency in h-h scattering change at low values of pressure.

The magnitude of $\alpha=1.2\times10^{-37}\text{ m}^2\text{ kg s}^{-1}\text{ K}^{-2}$ obtained at $P=0$ in the present work is 30 times less than $\alpha=3.7\times10^{-36}\text{ m}^2\text{ kg s}^{-1}\text{ K}^{-2}$ from Ref. 4, but this apparent discrepancy reflects mainly the difference in the hole density. For comparison we use the theoretical expression [Ref. 4, Eq. (7)]:

$$\eta=\frac{8}{3h^3}\left(\frac{m_1m_0}{m_1+m_0}\right)\frac{1}{n_1n_0}\ln\left(\frac{\sqrt{n_1}+\sqrt{n_0}}{\sqrt{n_1}-\sqrt{n_0}}\right)(k_BT)^2. \quad (14)$$

If we take $m_0=0.9m_e$;[11] $m_1=0.25m_e$,[6] and n_i from the present work, it gives at $P=0$ the value of $\alpha^{theor}\simeq8\times10^{-37}\text{ m}^2\text{ kg s}^{-1}\text{ K}^{-2}$ (in Ref. 4 $\alpha^{theor}\simeq7\times10^{-36}\text{ m}^2\text{ kg s}^{-1}\text{ K}^{-2}$). The agreement with our experimental value of α seems to be satisfactory. The ratio of α^{theor} to the corresponding value from Ref. 4 is about 0.1 and is mainly determined by three times less carrier concentration in the samples from Ref. 4 (effective masses differ not so strong). It should be noted however that the Eq. (14) was obtained on the basis of the simple model for Si inversion layers,[12] which neglects not only the anisotropy and nonparabolicity of the energy spectrum but also intervalley transitions. The last simplification may be acceptable for Si electron Fermi surfaces, which are far apart in momentum space, but not in the case of spin subbands in p-type materials. If at $P=0$ the expression (14) may give a reasonable order of magnitude for α, it obviously starts to be not applicable under uniaxial stress, as far Δ_S decreases and increasing probability of intersubband scattering may introduce an essential error in estimation of η. Moreover, the change of m_0 under uniaxial stress is not determined and speculations on this subject may lead to an additional error. In this connection the value of α, extracted directly from the experimental curves $\rho_{xx}(B,T)$ and $\rho(T)$, seems to be more reliable even in the frame of the simple model described in Sec. III, as far as we do not need any assumption about the pressure dependence of the effective masses.

The decay time τ_{01} of the relative momentum may be estimated with the help of Eq. (3). In our case, at zero pressure and $T=4.2$ K $\tau_{01}=12$ ps, if we use the experimental value of $m_1=0.25m_e$ from Refs. 5 and 6 and theoretical magnitude of $m_0=0.9m_e$ from Ref. 11. Under the same condition, the lattice relaxation times τ_0 and τ_1, evaluated from the obtained parameters μ_1 and μ_0 [Fig. 3(b)], are of the same order of magnitude. Calculations for the sample from Ref. 4 gives the value $\tau_{01}=2$ ps at 4.2 K. It obviously means that in our samples the h-h scattering probability occurs to be about six times less.

A further result of the analysis is connected with the increase under compression of the mobilities in the two spin subbands [Fig. 3(c)]. Such the behavior of mobility may be caused by a change of the effective masses under uniaxial compression, because we cannot claim that the dispersion low and energy spectrum anisotropy do not change. Moreover, in Ref. 6 it is supposed that the more heavy effective mass m_0 should decrease under compression. At the same time the effective mass m_1 measured in Ref. 6 from the temperature dependence of Shubnikov–de Haas oscillation amplitude, reveals the increase under uniaxial compression and therefore seems not to be responsible for the increase of the mobility in this subband. We are thus led to suppose two possibilities that may exist together. (i) The observed discrepancy indicates the noticeable change of the Fermi-surface anisotropy. In this case the mobilities are determined by transport masses, but not by the cyclotron ones. (ii) The growth of the mobilities also can be due to a decrease of the scattering on charged states. These states may be connected with misfit dislocations (dangling bonds) near the heterointerface. In this case they reveal much more high influence on

2D hole scattering process than remote shallow acceptors of Be in the active layer and can cause strong increase of mobilities without significant changes in carrier concentration.[13] In the heterostructure under investigation the density of dangling bonds may be $N_{DB} \simeq 1.7 \times 10^{16}\ \mathrm{m}^{-2}$ (Ref. 14). The presence of deep levels that are close to the p-type $GaAs/Al_{0.5}Ga_{0.5}As$ heterointerface was detected in Ref. 15 by deep-level transient spectroscopy.

VI. SUMMARY

In summary, we have observed a significant influence of uniaxial compression along [110] direction on zero-field resistivity and magnetoresistance of 2D holes in an asymmetric [001] triangular QW as well as on the temperature dependencies of these quantities. The experimental results can be well described in the frame of the classical two-band model, where the two subbands of the spin-split ground heavy hole state constitute the two bands of the model, and where temperature-dependent mutual scattering between the holes in these bands is taken into account. The results of our calculations indicate that the h-h scattering mechanism in the 2D hole system under investigation is strongly suppressed by uniaxial compression. Stress-induced increase of calculated mobilities in the both subbands is supposed to be connected with change of the Fermi-surface anisotropy and (or) decrease of the scattering on charged states in the nearest vicinity of the heterointerface.

ACKNOWLEDGMENTS

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