Amplification of spin-filtering effect by magnetic field in GaAsN alloys

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Abstract: We have found that intensity \( I \) and circular polarization degree \( \rho \) of the edge photoluminescence, excited in GaAsN alloys by circularly polarized light at room temperature, grow substantially in the longitudinal magnetic field \( B \) of the order of 1 kG. This increase depends on the intensity of pumping and, in the region of weak or moderate intensities, may reach a twofold value. In two-charge-state model, which considers spin-dependent recombination of spin-oriented free electrons on deep paramagnetic centers, we included the magnetic-field suppression of spin relaxation of the electrons bound on centers. The model describes qualitatively the rise of \( \rho \) and \( I \) in a magnetic field under different pump intensities. Experimental dependences \( \rho(B) \) and \( I(B) \) are shifted with respect to zero of the magnetic field by a value of \( \sim 170 \) Gauss, while the direction of the shift reverses with change of the sign of circular polarization of pumping. As a possible cause of the discovered shift we consider the Overhauser field, arising due to the hyperfine interaction of an electron bound on a center with nuclei of the crystal lattice in the vicinity of the center.

PACS numbers: 72.20.Jv, 72.25.Fe, 72.25.Rb, 78.20.Bh, 78.55.-m

I. INTRODUCTION

In the last few years the spin properties of GaAsN alloys have aroused great interest\(^{1-17}\), since, under optical spin pumping, these alloys reveal an extremely high spin polarization of free electrons (up to 90\%) and its time preservation (\( \sim 1 \) ns) at room temperature\(^{14}\). The findings look promising for those compounds to be used in proposals for quantum computation and spintronics. The anomalous enhancement of free-electron polarization and its time conservation in GaAsN are due to the dynamic polarization of electrons bound on deep paramagnetic centers\(^{13,16}\). The paramagnetic centers arise with incorporation of nitrogen in GaAs\(^{10,12}\) and are polarized as a result of spin-dependent capture of the polarized conduction electrons on them. The polarized centers act as a spin filter, blocking the capture of the spin-majority free electrons and promoting the spin-minority photoelectrons to disappear from the conduction band. The spin-filter efficiency rises with excitation light intensity and can increase free electron polarization up to \( \approx 100\% \) under strong pumping. Besides of the increase of free-electron spin polarization, the accumulation of the spin-majority free electrons in the conduction band leads to a strong enhancement of the edge photoluminescence (PL) intensity (up to 8 times\(^{3,5,15}\), as well as the photoconductivity\(^{13,16}\). At present, the behavior of the nonlinear system of coupled spin-polarized free and bound electrons under different conditions is adequately investigated experimentally and analyzed theoretically, which makes it possible to determine all the nine parameters of the system\(^{15}\). However, these studies were all carried out either in a zero- or in a perpendicular magnetic field (Voigt geometry).

The present work investigates experimentally and theoretically the influence of a longitudinal magnetic field (Faraday geometry) on the coupled spin system of free and bound electrons under different intensities of continuous-wave (cw) optical pumping. We have found that the application of a longitudinal magnetic field of the order of 1 kG brings about a substantial (up to twice as much) increase in the circular polarization and, at the same time, in the edge PL intensity. The basis of this effect is the suppression of spin relaxation of localized bound electrons by the longitudinal field. In other words, the longitudinal magnetic field increases the efficiency of the spin filter set up by spin-polarized localized electrons. This amplification becomes the greatest at low or moderate pumping intensities, when the efficiency of spin-filter effect is rather small in the absence of the magnetic field. Under great intensities of pumping when even in a zero magnetic field the spin-dependent recombination leads to a practically full spin polarization of free and bound electrons, the influence of the longitudinal magnetic field weakens dramatically. In order to describe the increase of \( \rho \) and \( I \) theoretically, we have introduced phenomenologically the suppression of spin relaxation of bound electrons into the two-charge-state model\(^{3,5,15}\), earlier used with success to simulate basic experiments on spin-dependent recombination (SDR) in GaAsN in the zero- and the perpendicular magnetic field. The calculation results describe qualitatively the experimentally observed growth of \( \rho \) and \( I \) in a longitudinal magnetic field under different pump intensities.

We have also found that the experimental dependences of \( \rho \) and \( I \) on the longitudinal magnetic field are shifted by a value of \( \sim 170 \) Gauss with respect to zero of the field, the direction of the shift changing to the opposite when the sign of circular polarization of the exciting light changes. As a possible cause of such shifts, we consider the hyperfine interaction of paramagnetic centers with neighbouring nuclei of crystal lattice.
We studied the undoped 0.1 \( \mu \text{m} \)-thick GaAsN layer with nitrogen content of 2.1% grown by rf-plasma-assisted molecular-beam epitaxy at 350–450°C on semi-insulating (001) GaAs substrate. The as-grown structure was annealed for 5 min at 700°C in a flow of arsenic in the growth chamber. Free-electron spin polarization \( P \) was created upon the interband absorption of circularly polarized light. We measured the steady-state degree of circular polarization of the edge PL, which is proportional to free-electron polarization \( \rho \). The numerical factor \( \rho \) is defined as \( \rho = (I^+ - I^-)/I^\text{total} \). \( I^\text{total} \) is the total PL intensity. Continuous-wave tunable Ti:sapphire laser was used for photoluminescence excitation. The PL was dispersed by a monochromator and detected by a photomultiplier with an InGaAsP photodiode. The \( \rho \) and \( I \) values were measured using a high-sensitive polarization analyzer comprising a quartz polarization modulator operating at 34 kHz and a lock-in two-channel photon counter. The measurements were carried out at 300 K under normal incidence of the circular polarized laser beam onto the sample and the detection of luminescence in the opposite direction (backscattering configuration).

III. EXPERIMENTAL RESULTS

Figure 1 shows the spectra of PL intensity measured at room temperature in GaAs\(_{0.979}\)N\(_{0.021}\) layer in zero magnetic field under linear (dashed curve) and circular (solid curve) polarized excitation and also in a longitudinal magnetic field of 3.5 kG under circularly polarized pumping (dotted curve). The PL intensity in zero field grows significantly (by 35%) with polarization of pumping changed from the linear (dashed curve) to the circular one (solid curve), pointing clearly to a spin-dependent capture of conduction electrons onto deep paramagnetic centers, which brings about the dynamic spin polarization of centers and generation of spin-filtering effect under circularly polarized excitation.

The application of a relatively small longitudinal magnetic field of 3.5 kG under circularly polarized pumping leads to an additional strong (about two times) enhancement of PL intensity (dotted curve). This gives evidence of the strengthening of spin-filtering effect by magnetic field. It should be noted that the application of a longitudinal magnetic field of the same value under linearly polarized pumping, when the exciting light does not introduce the angular momentum in the system of electrons, and the paramagnetic centers are left non-polarized, does not change the PL intensity, so the measured PL spectrum (not shown here) does not differ from curve 2 in Fig. 1. The latter observation supports the conclusion that the growth of \( I \) in the magnetic field under circular pumping is actually comes from the increase in the efficiency of the spin filter caused by the longitudinal magnetic field.

Figure 2 shows the dependences of the PL intensity on the longitudinal magnetic field measured near the PL band maximum under excitation by right-circularly (solid circles), left-circularly (open circles) and linearly (solid squares) polarized light with intensity 75 mW. These dependences differ drastically for cases of the linearly- and the circularly-polarized pumping. Under linearly polarized pumping the PL intensity is independent of the magnetic field. On the contrary, under circularly polarized pumping the magnetic field brings about a substantial growth of \( I \), which becomes saturated in the field \( |B| \gtrsim 2 \text{kG} \), reaching a double value. Dependences \( I(B) \) are shifted with respect to zero of the field by a value \( B_{\text{eff}} \approx 170 \text{Gauss} \), and the sign of this shift changes to the opposite with polarization of excitation changing from \( \sigma^+ \) to \( \sigma^- \). These dependences can be approximated by Lorentz curves (solid curves in Fig. 2) of the form \( y(B) = y_{\text{max}} + (y_{\text{min}} - y_{\text{max}})/[1 + (B - B_{\text{eff}})^2/B_{1/2}^2] \), where \( y_{\text{min}} = y(B = B_{\text{eff}}) \), \( y_{\text{max}} = y(B \rightarrow \infty) \).
and $B_{1/2}$ is the half-width on the half-minimum of the curve. Later on we shall return to discussion of physical origin of the effective field $B_{\text{eff}}$, but now let us consider in detail the cause of accretion of the PL intensity in a magnetic field. It is known\cite{ef,ka} that a longitudinal magnetic field suppresses spin relaxation of electrons, leading to an increase of their polarization. Indeed, the measured degree of circular polarization of the edge luminescence $\rho$ (closed and open circles in Fig. 2a), which is directly proportional to the polarization degree of free electrons $P$ under circular ($\sigma^+$ or $\sigma^-$) polarization of pumping, increases in its absolute value (simultaneously with $I$ increasing) with increase of the magnetic field. For comparison, note that under linearly polarized excitation the value of $\rho$ remains equal to zero within the measurement error (closed squares in Fig. 2a). In the presence of spin-dependent recombination the polarization of free electrons is strengthened due to dynamic polarization of electrons bound on paramagnetic centers. Therefore the observed growth of $|\rho|$ in the magnetic field can arise as a result of suppression of the spin relaxation of both free and bound electrons. However, the lifetime of free electrons in the conduction band $\tau_s$, which is determined by rapid capture on deep centers and is in the order of magnitude of 1 ps\cite{sa,ad,du}, is by two orders shorter than the time of their spin relaxation $\tau_s \sim 150 \text{ps}$\cite{ad,du}, and so an increase of $\tau_s$ in the longitudinal magnetic field cannot involve the growth of $P$. On the contrary, the spin relaxation time of bound electrons $\tau_{sc} \sim 1 \text{ ns}$ at the used pumping intensities is comparable with their lifetime $\tau_c$, and even shorter than that under weak pumping. Hence the increase of $\tau_{sc}$ in a magnetic field must bring about an increase of polarization of bound electrons $P_c$. Since the polarization degree of bound electrons determines the efficiency of the spin filter, the $P_c$ growth is accompanied by the increase, on one hand, of free-electron polarization $P$ and, consequently, of $\rho$, and on the other hand, of free-electron concentration in the conduction band and, consequently, of $I$.

This explanation finds an additional confirmation in consideration of experimental dependences $|\rho(B)|$ and $I(B)$, measured at different intensities $J$ of the $\sigma^+$ (solid symbols) and $\sigma^-$ (open symbols) exciting light and plotted in Fig. 3. All these dependences grow with magnetic field growing and reach saturation in the field $|B| \sim 2 \text{ kG}$, while having minima shifted with respect to zero magnetic field by a value $|B_{\text{eff}}| \sim 170 \text{ Gauss}$. Note that the dependences for $\sigma^-$ pumping, being reflected in the plane relative to the axis of ordinates, coincide within a few metering errors with the curves recorded under $\sigma^+$ excitation. Attention is attracted to the fact that the saturation level and the extent of the increase of $\rho$, as well as $I$, depend on pumping intensity nonlinearly. The dependence of the saturation level of polarization $\rho(B_{\text{max}})$ (where $B_{\text{max}} = 6.5 \text{ kG}$ is the maximal applied magnetic field) on $\sigma^+$ excitation power is shown by closed circles in Fig. 3, together with polarization dependence in zero field $\rho(B = 0)$ (open circles). It is seen that $\rho(B_{\text{max}})$ is significantly larger than $\rho(B = 0)$ for the intensities in the region of 10 to 100 mW, while it approximates $\rho(B = 0)$ under the strong and weak pumpings. The dependences of maximal increases of $\rho$ and $I$ induced by magnetic field on pumping intensity can be easily followed, considering normalized curves $\rho(B_{\text{max}})/\rho(B = 0)$ (open squares) and $I(B_{\text{max}})/I(B = 0)$ (solid squares) in Fig. 4. We see that each of these curves has a maximum (at $J \approx 15 \text{ mW}$ and 70 mW respectively) and falls

![Figure 2](image-url)
drastically on both sides from it, tending to unity within the limit of strong and weak pumpings. Such non-monotonous influence of the magnetic field on intensity and polarization of PL fits in naturally with the picture of spin-dependent recombination. Indeed, the decrease of $J$ down to vanishingly small values leads to disappearance of the spin-filter effect, which must decrease the relationships $I(B_{\text{max}})/I(B = 0)$ and $\rho(B_{\text{max}})/\rho(B = 0)$ to unity. At large $J$ (in our case at $J \gg 70 \text{ mW}$) the values of $I(B_{\text{max}})/I(B = 0)$ and $\rho(B_{\text{max}})/\rho(B = 0)$ must also tend to unity, but for the opposite reason: under strong pumping the spin-filter effect provides a practically complete polarization of centers (and, simultaneously, free electrons) even in zero magnetic field, therefore the application of a longitudinal magnetic field cannot increase $P_\parallel$ (and $P$) and, as a consequence, the polarization and intensity of PL.

### IV. Model and Comparison with Experiment

For theoretical description of changes in $I$ and $\rho$ in a longitudinal magnetic field we have supposed that this field suppresses the spin relaxation of the electrons localized on centers. According to Ref. [18] (see also Chapter 2 in Ref. [18] and Chapter 1 in Ref. [19]), spin relaxation of localized electrons can be presented as a result of the action of chaotic local magnetic fields on their spins. The application of an external magnetic field $B$ parallel to the exciting beam (the mean spin of photoexcited electrons) suppresses the action of those local fields. This suppression becomes significant when the magnitude of magnetic field equals the characteristic value $B_f$ of the chaotic field or exceeds it.

The increase of the spin relaxation time of localized electrons $\tau_{sc}$ in an external magnetic field $B$ is described by the expression:

$$
\frac{1}{\tau_{sc}(B)} = \frac{2}{1 + \omega_f^2 \tau_{cor}^2} \left( \frac{1}{\tau_{sc}(0)} + \frac{1}{(B/B_{1/2})^2} \right),
$$

where $1/\tau_{sc}(0) = \frac{2}{\tau_{cor}} \omega_f$ is the spin relaxation rate at $B = 0$, $\omega_f = g_e \mu_B B_f/h$ and $\omega = g_e \mu_B B/h$ are the Larmor frequencies of the bound-electron spin in the random local magnetic field $B_f$ and external magnetic field $B$, respectively, the correlation time $\tau_{cor}$ is the characteristic time of changing the field $B_f$, $g_e$ is the bound-electron $g$-factor, $\mu_B$ is the Bohr magneton, and $B_{1/2} = h/(g_e \mu_B \tau_{cor})$ is the magnitude of the external field in which the spin relaxation time doubles. Equation (1) is obtained on the assumption of short correlation time when $\omega_f \tau_{cor} << 1$. According to Eq. (1), in a strong field $B >> B_{1/2}$ the spin relaxation is suppressed totally, independent of pumping intensity. Consequently, polarization of electrons must attain its maximum value, the same for any intensity of excitation.
the same time, as is seen from Fig. 3, the saturation level of PL polarization in a large magnetic field rises with increasing pumping. This is possible if there is an additional channel of spin relaxation, which is not suppressed by the used magnetic field $|B| \leq 6.5$ kG. The additional relaxation can be taken into account by introducing the term $1/\tau_{sc}$ into Eq. (4), where $\tau_{sc}$ is the spin relaxation time independent of the magnetic field:

$$\frac{1}{\tau_{sc}(B)} = \frac{1}{\tau_{sc}^*} + \frac{1}{\tau_{sc}^{(1)}} \frac{1}{1 + (B/B_1/2)^2},$$  

where $\tau_{sc}^{(1)} = [1/\tau_{sc}(0)] - 1/\tau_{sc}^*$.

As it has been demonstrated in Ref. [15], the two-charge-state model of SDR, based on assumption that the deep center may be occupied by one (paramagnetic state) or two (singlet state with zero spin) electrons, describes well the basic experimental results on spin dynamics in GaAsN in zero or a perpendicular magnetic field. In order to take into account the effect of the longitudinal magnetic field we have used the same model, introducing into the rate equations (4) of Ref. [15] the increase of spin relaxation time of localized electrons, given by Eq. (2). Besides $\tau_{sc}^*$ and $B_1/2$, the model contains 9 parameters, and for eight of them we have retained the values found in Ref. [15] for the same sample, viz., $\tau_{sc}(0) = 700$ ps, the spin relaxation time of free electrons $\tau_e = 140$ ps, the minimum lifetime of free electrons $\tau^* = 2$ ps, the minimum lifetime of free holes $\tau^*_h = 30$ ps. Lander $g$-factors of free and bound electrons $g = +1$ and $g_c = +2$, respectively, the density of deep centers $N_c = 3 \times 10^{15}$ cm$^{-3}$, and $P' = 0.28$, where $P'$ is the factor relating $\rho$ with $P$ ($P = P' P$). The ninth parameter, the initial polarization of electrons $P_i$, depends on the energy of exciting light quanta $\hbar\omega_{exc}$. We cannot use the value $P_i = 0.24$ from Ref. [15], since it was found at $\hbar\omega_{exc} = 1.312$ eV, while in the present work we have used much greater energy $\hbar\omega_{exc} = 1.393$ eV. In GaAs$_{0.979}$N$_{0.021}$ the excitation energy $\hbar\omega_{exc} = 1.393$ eV is close to the energy of optical transition from the spin-orbit split-off valence band to the conduction band. For this transition the spin polarization of the electrons in statu nascendi has the opposite sign, which can lead to a significant decrease of $P_i$. A strong decrease of $P_i$ is observed in GaAsN layers with [N]=1.3% and 2.6% as $\hbar\omega_{exc}$ increases up to values close to the band gap of the GaAs barrier.

Our calculations have shown that the ratio between the height of the maximum of the $I(B_{max}, J)/I(0, J)$ curve and the height of the maximum of the $\rho(B_{max}, J)/\rho(0, J)$ curve depends heavily on the magnitude of $P_i$. For instance, it decreases from $\approx 3$ to $\approx 1$ with $P_i$ decreasing from 0.24 to 0.08. The heights of maxima for the experimental curves $I(B_{max}, J)/I(0, J)$ and $\rho(B_{max}, J)/\rho(0, J)$ in Fig. 3 are about equal, which allows us to suppose that $P_i$ is close to 0.08. It is evident that an increase in time $\tau_{sc}^*$ increases the steepness of the build-up of the $\rho(B_{max})$ (and also $I(B_{max})$) dependence and, respectively, the height of the maximum of the $\rho(B_{max})/\rho(0)$ (and also $I(B_{max})/I(0)$) dependence on $J$. Analysis has shown that the influence of $\tau_{sc}^*$ on the height of maxima is rather weak. The heights of maxima for the calculated curves turn out equal to the heights of maxima of the respective experimental dependences in Fig. 3, at $P_i = 0.08$ and $\tau_{sc}(B_{max}) = \tau_{sc}^* = 2200$ ps (see dotted curves 1 and 1' in Fig. 3).

As shown in Ref. [15], the $P_i$ value can be determined independently from a model fitting of an experimental dependence of the SDR ratio $K_{SDR} = I(\sigma, B = 0)/I(\pi, B = 0)$ on the pump power, where $I(\sigma, B = 0)$ and $I(\pi, B = 0)$
FIG. 5: Calculated dependences $\rho(B = 0)$, $\rho(B = B_{\text{max}})$ (a) and $\rho(B_{\text{max}})/\rho(B = 0)$ (curves 1, 2 and 3), $I(B_{\text{max}})/I(B = 0)$ (curves $'1'$, $'2'$ and $'3'$) (b) versus the right-circular polarized pump power for $P_t = 0.08$ (dotted curves), $P_t = 0.1$ (solid curves), $P_t = 0.12$ (dashed curves) and $\tau_{\text{sc}}(B_{\text{max}}) = 2200\text{ps}$ (see text for details).

0) is the PL intensity in zero magnetic field under circularly and linearly polarized excitation, respectively. The experimental curve $K_{\text{SDR}}(J)$ recorded at $h\omega_{\text{exc}} = 1.393\text{eV}$ is shown in Fig.4 by open circles. Also presented here are the dependences $K_{\text{SDR}}(J)$, calculated for $P_t = 0.08$, 0.1, and 0.12 (dotted, solid, and dashed curves, respectively). It is seen that the curve calculated for $P_t = 0.08$ (dotted) runs appreciably below the experimental curve. The coincidence with experimental curve occurs for $P_t = 0.12$ (dashed). In this case, however, the ratio of maxima for the calculated curves $I(B_{\text{max}}, J)/I(0, J)$ and $\rho(B_{\text{max}}, J)/\rho(0, J)$ (dashed curves 2 and $'2'$ in Fig.4) is markedly more than 1. The optimal agreement between the calculation results and the experimental data in Fig.4 is obtained for $P_t = 0.1$ (see dashed-dotted curve in Fig.4) and solid curves 3 and $'3'$ in Fig.4.

The above determined values of the parameters $P_t = 0.1$ and $\tau_{\text{sc}} = 2200\text{ps}$ were used for computer simulation of the dependence of $\rho$ and $I$ on magnetic field. We evaluated the value of the last, eleventh model parameter, necessary for that computation, $B_{1/2} = 600\text{Gauss}$, from fitting of the experimental curves in Fig.3 by Lorentzians. Curves $\rho(B)$ and $I(B)$, calculated at different pump intensities, are shown in Fig.3 As is seen, they describe qualitatively basic peculiarities of the experimental curves in Fig.3. 1) both $\rho$ and $I$ increase in a magnetic field and reach saturation in a strong field $|B| \gtrsim 2\text{K}\text{G}$; 2) the saturation level of $\rho$ in a strong field depends on excitation intensity, growing with growth in $J$; 3) the maximum increase of $\rho$ and $I(B)$ in magnetic field depends nonmonotonically on pump intensity, decreasing under weak or strong pumping. The latter is seen distinctly in Fig.5, where calculated dependences $\rho(B_{\text{max}}, J)/\rho(0, J)$ (curve $'3'$) and $I(B_{\text{max}}, J)/I(0, J)$ (curve $'3'$) have maxima and tend to 1 at $J \rightarrow 0$ and $J \rightarrow \infty$, so confirming our qualitative argumentation.

Experimental dependences $\rho(B)$ and $I(B)$ in Fig.2 and Fig.3 are shifted respective to zero of the field by a value $|B_{\text{eff}}| \sim 170\text{Gauss}$. The investigated GaAsN alloy is a non-magnetic semiconductor, so the presence of such shifts indicates that the circularly polarized pumping generates an effective magnetic field, acting upon electron spins. This is confirmed by the fact that the field $B_{\text{eff}}$ reverses its direction when the sign of circular polarization of excitation changes. The effective magnetic field, dependent on the sign of polarization of pumping, is typical for low-temperature experiments on optical orientation in semiconductors and semiconductor nanostructures. This field is identified with the field of dynamically polarized nuclei of crystal lattice (Overhauser field), which arouses due to hyperfine interaction with localized electrons (localized on shallow donors in a bulk semiconductor, on fluctuations of the hetero-boundary potential in a quantum well or in a quantum dot). Usually the rise of crystal temperature delocalizes electrons, which destroys the hyperfine interaction and, consequently, the Overhauser field. The paramagnetic centers in GaAsN are deep and can maintain a strong hyperfine interaction with lattice nuclei up to the room temperature. Therefore we think that in our experiments the field $B_{\text{eff}}$ is an Overhauser field of the crystal lattice nuclei in the neighborhood of a paramagnetic center. Corroboration of this conclusion and elucidation of the peculiarities of the dynamic polarization of nuclei in the case of spin-dependent recombination calls for additional experiments, which are in progress.

It should be noted that the calculated curves $\rho(B)$ and $I(B)$ in Fig.3 are symmetric with respect to the ordinate axis, since our model takes no account of the effective field $B_{\text{eff}}$. Formally, the field $B_{\text{eff}}$ may be taken into account in calculation through substitution of the field $B$ by the total field $(B + B_{\text{eff}})$ where the sign of $B_{\text{eff}}$ depends on the sign of circular polarization of the exciting light.
FIG. 6: Calculated dependences of $\rho(B)$ (a) and $I(B)$ (b) for different $\sigma$ pump powers at $P_i = 0.1$, $\tau_{sc}^* = 2200$ ps and $B_{1/2} = 600$ Gauss (see text for details). $J$ (in mW): $1 - 8; 2 - 25; 3 - 75; 4 - 150; 5 - 250$.

V. CONCLUSION

In summary, under optical pump conditions the longitudinal magnetic field of the order of 1 kG increases the spin polarization of electrons and the luminescence intensity in GaAsN alloys at room temperatures. The increase in polarization, as well as in PL intensity depends on the pump intensity an can reach twice as much value. This effect can be used in problems of spintronics to obtain optimal conditions for the maximum polarization of free electrons, in particular, for intensification of spin-dependent photoconductivity\textsuperscript{13,16}. The modified two-charge-state-model, which includes suppression of spin relaxation of localized electrons by a longitudinal magnetic field describes adequately the behavior of the coupled spin system of free and bound electrons in GaAsN alloys in a longitudinal magnetic field under different pump intensities.

We suppose that the chaotic magnetic fields, bringing about the spin relaxation of GaAsN deep centers in zero magnetic field, are the field fluctuations of nuclei\textsuperscript{25}, coupled with paramagnetic centers by hyperfine interaction. Investigations aimed at elucidation of the nature of chaotic fields are in progress.

One of the most informative methods of studying centers and defects in semiconductors is the optically detected electron paramagnetic resonance (ODEPR). Its application, however, is limited to low temperatures, where the spin lifetime for localized electrons is long enough. For this reason, up to now the ODEPR spectra of paramagnetic centers, responsible for SDR in GaAsN alloys, have been measured only at liquid He temperature\textsuperscript{10,12}. The suppression of spin relaxation of the centers in a longitudinal magnetic field with simultaneous increase of their polarization up to a complete value makes it possible to approach the conditions indispensable for detection of the ODEPR of paramagnetic centers in GaAsN at higher temperatures, room temperature including.

The effective magnetic field $B_{\text{eff}}$, that acts upon localized electrons and changes the direction with the sign of circular polarization of the exciting light changed, has been detected at room temperature. We interpret this field as the Overhauser field of the lattice nuclei optically oriented in the vicinity of a paramagnetic center. Polarization of nuclei offers new possibilities of controlling the spin state of free and bond electrons at room temperature, for example, through its change under conditions of nuclear magnetic resonance.

Acknowledgments

This research was supported by the programmes of the Russian Academy of Sciences and the Russian Foundation
for Basic Research. We are grateful to E.L. Ivchenko, K.V. Kavokin and L.S. Vlasenko for fruitful discussions.

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