Nonlinear optical parameters of Raman scattered mode in weakly polar magnetized semiconductor-plasma

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This paper presents an analytical investigation of nonlinear absorption coefficient and refractive index of the Raman scattered stokes mode resulting from the nonlinear interaction of an intense pumping light beam with molecular vibrations of semiconductor-plasma. The origin of this nonlinear interaction lies in the third-order (Raman) susceptibility arising from the induced current density and density fluctuations generated within the medium. The total refractive index and absorption coefficient are determined through the effective susceptibility derived with the help of coupled-mode theory of plasmas. The effect of Szigeti effective charge \( q \) and magnetic field \( \beta_0 \) has been introduced through equation of motion of lattice vibration and Lorentz force, respectively. The numerical estimates are made for \( n \)-type InSb crystal duly irradiated by a 10-nanosec pulsed 10.6 µm CO\(_2\) laser. The Szigeti effective charge contributes the Raman susceptibility at moderate excitation intensity. At high excitation intensity, the contribution of Szigeti effective charge is wiped off and nonlinearity in the medium is only due to differential polarizability. In the absence of Szigeti effective charge, the magnitude of Raman susceptibility is found to agree with other theoretical quoted values. The analysis establishes that a small absorption coefficient and large refractive index can easily be obtained by proper selection of magnetic field and doping concentration under moderate excitation intensity in weakly polar semiconducting crystals which proves its potential as candidate material for the fabrication of cubic nonlinear devices.

Keywords: Nonlinear absorption, Refraction, Stimulated Raman scattering, Magnetic field, Weakly polar III-V semiconductors

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1 Introduction

Nonlinear interaction of waves and particles in plasmas is the subject of extensive studies in nonlinear optics since last three decades. These nonlinear effects are crucial while studying plasma instability and turbulence. A great many research papers have been devoted to the nonlinear interaction of waves in infinite homogeneous plasma\(^1,2\). When an intense laser beam propagates in a plasma, it may excite the natural modes of vibrations of the plasma, i.e. the electron plasma and ion waves. When one of the excited modes is of high frequency (optical phonon mode), it gives rise to stimulated Raman scattering\(^3,5\) (SRS). SRS provides a unique tool for studying the vibrational energy levels of molecules and lattice vibrations of the optical branch in the crystal. It has been used to extend the tunable range of coherent optical source over a broad spectrum of the infrared regime\(^6,7\). Anti Stokes radiation from SRS with dye lasers can be used to generate tunable ultraviolet sources\(^8\). Four wave interactions arising out of third-order polarizability have already gathered much momentum and utilized for fabrication of nonlinear devices under certain conditions. An important current application of such type of interactions in modern optics has been used in fabrication of Raman lasers and all optical devices for ultrafast communication and signal processing\(^9,10\). In addition, both coherent anti-Stokes Raman spectroscopy (CARS) and Raman-induced Kerr effect spectroscopy (RIKES) techniques have already been experimentally used in laser nonlinear spectroscopy\(^11,12\).

In the past, SRS and its consequent instabilities have been widely studied in gaseous plasmas\(^13-15\). But the practical utilization of semiconductors drew the attention of many researchers in nonlinear optics\(^16-18\) due to their compactness, provision of control of material relaxation time, highly advanced fabrication technology and observation of large optical nonlinearities in the vicinity of band gap resonant transition even at low power. The nonlinear absorption observed in \( n \)-type semiconductors has been utilized to amplify reflected CO\(_2\) laser light via
degenerate four wave mixing in an optically induced free carrier plasma\textsuperscript{19}. The increase in the absorption coefficient associated with the free carrier is believed to have a resonant effect in limiting the efficiency of a spin flip InSb laser at high excitation intensities\textsuperscript{20}.

However, in a non-resonant nonlinear optical mixing process, at large amplitude of the incident electromagnetic waves, a number of nonlinear mode-coupling interactions may take place which modify the electrical and optical properties of the medium. The optical properties of a medium can also be modified by an externally applied electric\textsuperscript{21} or magnetic fields\textsuperscript{22,23}. The absorption coefficient and refractive index as functions of the applied electric and magnetic fields are responsible for many electro-optical and magneto-optical effects and their devices\textsuperscript{20,21}. In the recent past, Dubey and Ghosh\textsuperscript{24} have reported the nonlinear absorption and refractive index of a Raman scattered mode in centrosymmetric semiconductor plasmas and pointed out that significant Raman growth rate is possible if the excitation intensity ~5.3\times10^{12} \text{Wm}^{-2} but silent for the regard about the pulse duration of the pump wave. Practically, however, such pump field may damage the medium. For example, Krueer \textit{et al}\textsuperscript{25} pointed out that a typical excitation intensity ~4.2\times10^{12} \text{Wm}^{-2} of Q-switched 170 ns pulse 10.6 micron CO\textsubscript{2} laser damages InSb crystal at 300 K.

Literature survey reveals that in most of the previous reported work, the origin of SRS in polar semiconductors has been taken into finiteness of differential polarizability only. However, even in partial ionic crystals such as III-V semiconductors, the coupling between pump wave and optical phonon also depends on Szigeti effective charge, which cannot be neglected in the infrared regime\textsuperscript{20,27}. While studying the interaction of magneto-plasmons with optical phonons in polar semiconductors, it has been found that the coupling depends on the Szigeti effective charge of the semiconductor compounds and it is stronger for weakly polar semiconductors\textsuperscript{28}.

In the present paper, we have investigated analytically the nonlinear absorption coefficient and refractive index arising due to the SRS of an electromagnetic pump wave in a transversely magnetized weakly polar semiconductor-plasma. Using the coupled-mode theory of plasmas, the effective complex Raman susceptibility and consequently the nonlinear absorption coefficient and refractive index of the Raman-scattered Stokes mode are determined. Finally, we have applied the analysis to the cubic semiconductor (n-InSb) data to appropriate the numerical values of absorption coefficient and refractive index.

2 Theoretical Formulations

This section deals with theoretical formulation of complex effective Raman susceptibility and consequent the nonlinear absorption coefficient and refractive index for the Stokes component of scattered electromagnetic wave in weakly polar III-V semiconductors subjected to transverse magnetostatic field $\beta_k$ applied along z-axis, normal to propagation vectors $k_{\text{op}}$, $k_x$ and $k'_{\text{op}}$ (all parallel to x-axis) of three interacting waves, viz. pump $(\omega_0, k_0)$, signal $(\omega, k_s)$ and optical phonons $(\omega_{\text{op}}, k'_{\text{op}})$. The phase matching conditions in the present scheme are: $\omega_0 = \omega + \omega_{\text{op}}$ and $k_0 = k'_s + k'_{\text{op}}$. The Stokes mode originates from the coupling of the pump wave with density perturbations at an optical phonon frequency in the crystal. The optical phonon mode possesses transverse as well as longitudinal components. The polarization associated with the longitudinal vibration is much larger than the transverse component in weakly polar III-V crystals with zinc blend structures\textsuperscript{27}. Consequently, we neglect the transverse electric field and treat $\omega_{\text{op}}$ as the longitudinal optical phonon frequency.

We consider that the Raman medium consists of $N$ harmonic oscillators per unit volume: each oscillator being characterized by its position $x$ and normal vibrational coordinate $u(x, t)$. The equation of motion for a single oscillator (optical phonon) is then represented as\textsuperscript{29}:

$$
(\partial^2 u / \partial t^2) + \Gamma_{\text{op}} (\partial u / \partial t) + \omega_{\text{op}}^2 u = (N / M)^{1/2} qE_{\text{op}} + \\
(1/2)(N / M)^{1/2} \epsilon_0 \epsilon_r (\partial^2 u / \partial t^2) + \Gamma_{\text{op}} (\partial u / \partial t) + \omega_{\text{op}}^2 u = (N / M)^{1/2} qE_{\text{op}} + (1/2)(N / M)^{1/2} \epsilon_0 \epsilon_r (\partial^2 u / \partial t^2) + \Gamma_{\text{op}} (\partial u / \partial t) + \omega_{\text{op}}^2 u = (N / M)^{1/2} qE_{\text{op}} + (1/2)(N / M)^{1/2} \\
\epsilon_0 \epsilon_r (\partial^2 u / \partial t^2)$$

(1)

where $\Gamma_{\text{op}}$, $\omega_{\text{op}}$, $\epsilon_0$, $\epsilon_r$, $M$ and $q$ are phenomenological damping parameter, optical phonon frequency at $k'_{\text{op}} = 0$, differential polarizability, effective mass of
diatomic molecule and Szigeti effective charge $^{30}$

\[ \nu = \omega_{op} ((M / N) \varepsilon_0 (\varepsilon_s - \varepsilon_w)^{1/2} ; \varepsilon_0, \varepsilon_s \text{ and } \varepsilon_w \text{ being the permittivity of free space, static and high frequency dielectric constants of the crystal, respectively}) \]

respectively.

The basic equations considered in the present analysis are:

\[ \frac{d\mathbf{v}_0}{dt} = -\frac{e}{m}(\mathbf{E}_e) - \nabla \mathbf{P}_0 \]

\[ \frac{d\mathbf{P}_1}{dt} = -\frac{e}{m}(\mathbf{E}_1 + \mathbf{P}_1 \times \mathbf{B}_0) - \mathbf{v}_0 \nabla \mathbf{P}_1 - (\nabla \mathbf{v}_1) \mathbf{v}_0 \]

\[ \frac{\partial n_1}{\partial t} + n_0(\partial \mathbf{v}_1 / \partial x) + n_1(\partial \mathbf{v}_0 / \partial x) + \mathbf{v}_0(\partial n_1 / \partial x) = 0 \]

\[ P_{mv} = \varepsilon N (\partial \mathbf{v}_1 / \partial u_0) u^* \mathbf{E}_e \]

\[ \frac{\partial \mathbf{E}_1}{\partial x} = -(n_1e / \varepsilon) - (1 / \varepsilon)(\partial \mathbf{P}_{mv} / \partial x) \]

\[ \mathbf{E}_e = \mathbf{E}_0 + \mathbf{P}_0 \times \mathbf{B}_0 \]

Eqs (2) and (3) represent the rate equations for the pump and the signal beam under the influence of magnetostatic field, respectively. \( v_0, \mathbf{v}_1 \) are the equilibrium and perturbed oscillatory fluid velocities of the electron of effective mass \( m \) and charge \( e \). \( v_0 \) is the electron collision frequency. In Eq. (2), \( \mathbf{E}_e \) represents the effective field, which includes the Lorentz force \( (\mathbf{P}_0 \times \mathbf{B}_0) \) due to external magnetostatic field and is given by Eq. (7). The electron continuity equation is given by Eq. (4) in which \( n_0 \) and \( n_1 \) are equilibrium and perturbed carrier densities, respectively. \( \mathbf{P}_{mv} \) given by Eq. (5) is the nonlinear polarization due to natural mode of vibrations driven by the electric field. Space charge field \( \mathbf{E}_1 \) is determined by Poisson’s equation [Eq. (6)].

The natural vibrations at frequency \( \omega_{op} \) give rise to carrier density perturbation within the Raman active medium. In a doped semiconductor, these density perturbations can be obtained by using standard approach$^{18}$:

\[ (\partial^2 n_1 / \partial t^2) + \nu(\partial n_1 / \partial t) + \Omega_p^2 \delta n_1 - i(\Omega_p^2 \varepsilon \delta_N k_s / 2 eM \Delta_{op}^2)[2q(\partial \alpha / \partial u_0)E_x - \varepsilon_w(\alpha / \partial u_0)E_y]E_v = (e\delta_{op} / m)\{(\partial n_1 / \partial x) + ik_{op} n_1\} \]

where \( \Omega_{op} = (n_0 e^2 \mu e)^{1/2} \) (electron plasma frequency), \( \omega = (e / m)B_0 \) (electron cyclotron frequency), \( \Delta_{op} = 1 - \omega_{op}^2 / \omega^2 \), \( \delta \) = \( 1 - 1 / \Delta_{op}^2 \), \( \Delta_{op} = \nu - i\omega \), \( \Delta_{op} = \nu - i\omega \) and \( \Delta_{op} = (\omega_{op}^2 - \omega^2 - i\Gamma_{op} \omega_{op}) \).

The density perturbation \( n_1 \) may oscillate at optical phonon \( (\omega_{op}) \) and electromagnetic wave frequencies \( (\omega_0 \pm \omega_{op}) \). The higher-order terms with frequencies \( \omega_q \pm q \omega_{op} \), \( q = 2, 3, 4 \ldots \) being off-resonant are neglected. In the forthcoming formulations, we will consider only the first-order Stokes component of the scattered electromagnetic wave. Under rotating wave approximation (RWA), the perturbed density of Raman active medium associated with optical phonon \( (n_{1op}) \) and first-order Stokes mode \( (n_{1st}) \) can be deduced from Eq. (8) as:

\[ (\partial^2 n_{1op} / \partial t^2) + \nu(\partial n_{1op} / \partial t) + \Omega_p^2 \delta n_{1op} + 2i[(\Omega_p^2 \varepsilon \delta_N k_s \nu(\partial \alpha / \partial u_0)] / 2 eM \Delta_{op}^2]E_v E_x \]

and

\[ (\partial^2 n_{1st} / \partial t^2) + \nu(\partial n_{1st} / \partial t) + \Omega_p^2 \delta n_{1st} + 2i[(\Omega_p^2 \varepsilon \delta_N k_s \nu(\partial \alpha / \partial u_0)] / 2 eM \Delta_{op}^2]E_v E_x \]

Eq. (9) represents the coupling between optical phonon and first-order Stokes mode of the density perturbations via pump electric field \( E_0 \) and magnetic field \( B_0 \) through \( \omega_e \), which acts as a distributed source that can feed energy to the scattered Stokes component \( (E_v) \) leading to the amplification of this field with a large gain coefficient.

Using Eqs (9 a and b), the expression for \( n_{1op} \) is obtained as:

\[ n_{1op}^* = (\eta e^2 \mu e \Omega_p^2 \delta_N k_s / 2 eM \Delta) \]
\[
[q(\partial \alpha / \partial u)_0 + \epsilon_0 \epsilon'_e (\partial \alpha / \partial u)^2_0 E^2_0] E E^* \quad \ldots(10)
\]

where \( \Delta = \eta_0^2 c \Delta p \Delta \Delta - 2(\delta_{\alpha} e k_i / m)^2 I_0 \),
\( \Delta \Delta = \Omega^2 I_{p} \delta - \omega_0^2 + i\nu \omega_0 \), and \( \Delta_{\alpha} \Delta = \Omega^2 I_{p} \delta - \omega_0^2 - i\nu \omega_0 \).

Here \( I_0 \) is the pump intensity.

We now address ourselves to the theoretical formulations for the effective polarization at Stokes frequency due to current density. The resonant Stokes component of the current density can be given as:
\[
J_{\text{eff}}(\omega_s) = n_0 e v_1 + n^*_0 e v_0^* \quad \ldots(11)
\]

Treating the effective polarization as the time integral of the effective current density, one may express
\[
P_{\text{cd,eff}}(\omega_s) = \int J_{\text{eff}}(\omega_s) dt \quad \ldots(12)
\]

Using equations (1) - (12), effective first- and third-order (Raman) susceptibilities of the medium can be given as:
\[
\chi_{\text{cd}}^{(1)} = i(\epsilon_0 \Omega^2 / \omega_s (\Delta \Delta^2 + \omega_0^2)) \quad \ldots(13)
\]

and
\[
\chi_{\text{R,cd}}^{(3)} = (\eta \epsilon'_c (e / m) \Omega^2 /\omega_s (\Delta \Delta^2 + \omega_0^2)) \times \left[ q(\partial \alpha / \partial u)_0 / (\Delta_{\alpha}^2 \Delta_{\Delta}^2 - 2(\delta_{\alpha} e k_i / m)^2 I_0) - i(2\epsilon_0 \epsilon'_e (\partial \alpha / \partial u)^2_0 E_0) / (\Delta_{\alpha}^2 \Delta_{\Delta}^2 - 2(\delta_{\alpha} e k_i / m)^2 I_0) \right] \quad \ldots(14)
\]

It is evident from Eqs (13) and (14) that both \( \chi_{\text{cd}}^{(1)} \) and \( \chi_{\text{R,cd}}^{(3)} \) are complex. The real part of \( \chi_{\text{cd}}^{(1)} \) is responsible for the linear refraction of laser beam while the imaginary part takes account of the linear absorption process within the crystal. It may be inferred from the Eq. (14) that \( \chi_{\text{R,cd}}^{(3)} \) strongly depends on effective charge and differential polarizability.

Besides \( \chi_{\text{R,cd}}^{(3)}(\omega_s) \), the system should also possess a Raman susceptibility \( \chi_{\text{R,rmv}}^{(3)} \) due to interaction of pump wave with the natural mode of vibrations generated within the medium such that
\[
\chi_{\text{R,rmv}}^{(3)} = (\epsilon_0 \epsilon'_c \omega_0^2 N(N / M)^{1/2} (\partial \alpha / \partial u)^2_0 / 2 \Delta_{\alpha}^2) \quad \ldots(15)
\]

The effective Raman susceptibility \( \chi_{\text{R,eff}}^{(3)} \) of the system will be the sum of \( \chi_{\text{R,cd}}^{(3)} \) and \( \chi_{\text{R,rmv}}^{(3)} \).

The total refractive index of the system is given by
\[
\eta = \eta_l + \eta_{nl} I_0 \quad \ldots(16)
\]
in which \( \eta_l \) and \( \eta_{nl} \) are, respectively, the linear and nonlinear parts of the refractive index of the material. From the real parts of susceptibility i.e. \( \chi_{\text{cd}}^{(1)} \) \text{real} and \( \chi_{\text{R,cd}}^{(3)} \) \text{real}, one can study the phenomena of the total refractive index because \( \eta_l \) and \( \eta_{nl} \) are given by:
\[
\eta_l = \sqrt{1 + (\chi_{\text{cd}}^{(1)}) \text{real}} \quad \ldots(17)
\]
and
\[
\eta_{nl} = (\chi_{\text{R,eff}}^{(3)}) \text{real} \quad \ldots(18)
\]

Now to study the total absorption coefficient \( a \) one may use the following standard relation:
\[
a = a_l + a_{nl} I_0 \quad \ldots(19)
\]
in which \( a_l \) and \( a_{nl} \) are real and nonlinear absorption coefficients, respectively.

From the imaginary parts of susceptibility i.e. \( \chi_{\text{cd}}^{(1)} \) \text{imag} and \( \chi_{\text{R,eff}}^{(3)} \) \text{imag}, in the following relations, one can study the phenomena of the total absorption coefficient. These relations are:
\[
a_l = \sqrt{(\chi_{\text{cd}}^{(1)}) \text{imag}} \quad \ldots(20)
\]
and
\[
a_{nl} = -(k_s / 2\epsilon_0) (\chi_{\text{R,eff}}^{(3)}) \text{imag} \quad \ldots(21)
\]

Now, Eqs (18) and (21) can be employed to study the nonlinear refractive index and absorption coefficient of a Raman active magnetized semiconductor plasma.
3 Results and Discussion

This section is devoted to the detailed numerical study of the refractive and absorptive characteristics due to Raman susceptibility in a specific doped III-V semiconductor, viz., n-type InSb crystal at 77 K duly shined by a pulsed off-resonant ($\eta \omega_0 \gg \eta \omega_t$; $\eta \omega_t$ being the band gap energy) 10.6 $\mu$m CO$_2$ lasers. The other physical parameters chosen are:

\begin{align*}
\omega_0 & = 1.78 \times 10^{14} \text{ sec}^{-1}, \quad m = 0.015 m_0; \quad m_0 \text{ being the rest mass of an electron, } \\
\epsilon_i & = 17.8, \quad \epsilon_\infty = 15.68, \quad N = 1.48 \times 10^{28} \text{ m}^{-3}, \quad (\partial \alpha / \partial u)_o = 1.68 \times 10^{-16} \text{ MKS units, } \\
M & = 236.47, \quad q = 1.2 \times 10^{-20} C, \quad \text{and } \omega_p = 3.64 \times 10^{13} \text{ sec}^{-1}.
\end{align*}

The threshold value of pump intensity required for the onset of SRS process for a weakly polar doped semiconductor subjected to an external magnetostatic field can be obtained by setting $(\chi^{(3)}_{R, eff})_{\text{imag}}$ equal to zero. With the above mentioned physical parameters, the threshold pump intensity $I_{0, \text{th}}$ required for onset of SRS are found to be $5 \times 10^{13}$ W m$^{-2}$ and $2.2 \times 10^9$ W m$^{-2}$ at $B_0 = 0$ and 3 tesla, respectively.

In order to study the effect of Szigeti effective charge on optical parameters of coherent Raman scattered mode, in Figure 1 (a and b), we have plotted $a$ and $\eta$ as a function of excitation intensity in the absence (curve a) and presence (curve b) of Szigeti effective charge $q$, respectively. One may notice that with increase in excitation intensity $a$ decreases and saturates at high excitation intensity, while $\eta$ increases and saturates at the same excitation intensity. This is quite obvious because increase in the transmitted power should decrease absorption. It is interesting to note that for $I_o < I_i (= 8 \times 10^9 \text{ W m}^{-2})$, the contribution of $q$ is more as compared to $(\partial \alpha / \partial u)_o$. However, for $I_o > I_i$, the optical parameters are due to differential polarizability. This is due to the fact that at excitation intensity $> I_o$, the second term inside square bracket of Eq. (14) dominates over the first and contribution of effective charge is nearly wiped off. At particular value of excitation intensity $I_o = I_i$, $q$ and $(\partial \alpha / \partial u)_o$ contributes equally to optical parameters. In the absence of Szigeti effective charge, the results are well in agreement with Dubey and Ghosh.

The nature of variation of nonlinear absorption coefficient $\alpha_{nl}$ and refractive index $\eta_{nl}$ with doping concentration $n_0$ in the presence of externally applied magnetostatic field ($B_0 = 3$ tesla) is shown in Fig. 2. It is found that the doping concentration plays a crucial role in modifying the nonlinear absorption coefficient nonlinear medium for the fabrication of cubic nonlinear optical devices as compared to highly polar semiconductor plasmas.

Fig. 1(a) — Behaviour of absorption coefficient $\alpha$ with excitation intensity $I_0$. Curves a and b are for $q = 0$ and $q \neq 0$, respectively.

Fig. 1(b) — Behaviour of refractive index with excitation intensity $I_0$. Curves a and b are for $q = 0$ and $q \neq 0$, respectively.
The nonlinear absorption coefficient $\alpha_{nl}$ decreases sharply and attains a minimum value of about $1.6 \times 10^{-8}$ m when plasma frequency $\Omega$ is resonant with modified Stokes frequency, say $\Omega_m$. With further increase in $n_0$, the absorption coefficient is very slowly decreasing function of doping concentration. However, the variation of nonlinear refractive index $\eta_{nl}$ as a function of doping concentration is plotted (with solid curve) in the same figure. For $\Omega_p < \omega_m$, $\eta_{nl}$ is a negative quantity and decreases with doping concentration. A slight increase in tuning between $\Omega_p$ and $\omega_m$ beyond this point causes a sharp rise in $\eta_{nl}$ making it vanish when $\Omega_p$ is closely tuned with $\omega_m$. This situation suggests almost 100% reflection of backward Stokes wave. This typical resonance condition between plasma frequency and modified Stokes frequency may be used to achieve high efficient SRS based optical phase conjugation in magnetized semiconductor-plasma. After the resonance condition, $\eta_{nl}$ rises very sharply and achieves a maximum value ~15. With a small change in value of $n_0$, $\eta_{nl}$ decreases rapidly and saturates at large value of free carrier concentration.

An optically induced refraction change with respect to the magnetostatic field $B_0$ is shown in Fig. 3. Curves a and b represent the features of $\eta_{nl}$ for two different doping concentrations $n_0 = 2 \times 10^{21}$ and $3.5 \times 10^{21}$ m$^{-3}$ at excitation intensity $I_0 = 6 \times 10^{11}$ Wm$^{-2}$. In general, the cyclotron absorption occurs in low temperature, high mobility semiconductors, expressed by the condition $\omega_c \tau >> 1$, at frequencies satisfying $\omega_0 = \omega_c$. It is presented at 30 K in n-InSb but characteristically disappears at liquid nitrogen temperature (i.e. at 77 K). An anomalous dispersion nature of refractive index of the magnetized semiconductor-plasma at $B_0 = 3$ tesla can be observed due to the resonance condition $\omega_p^2 - \omega_m^2$. It is clear from Fig. 3 that the anomalous dispersion regime widens and increases with doping concentration. At $B_0 = 3$ tesla, $(\eta_{nl})_{cd}$ dominates over $(\eta_{nl})_{ms}$.

The nature of variation of absorption coefficient $\alpha_{nl}$ with magnetic field $B_0$ at two different doping concentrations is plotted in Figure 4 and found that $\alpha_{nl}$ of semiconductor-plasma may be reduced substantially at moderate excitation intensity. Hence, the large nonlinear refractive and small absorption coefficient can be easily achieved in transversely magnetized weakly polar semiconductor plasmas with moderate excitation intensity. This establishes its
potential as a candidate material for the fabrication of cubic nonlinear optical devices.

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