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Rasulov Voxob Rustamovich,
associate professor of Fergana State University
Rasulov Rustam Yavkachovich,
professor of Fergana State University
Mamatova Makhliyo Adkhamovna,
doctoral student of Fergana State University
Isomaddinova Umida Mamirjonovna,
teacher of the Kokand State Pedagogical Institute
Kodirov Nurillo Ubaydullo ogli,
doctoral student of Fergana State University

INTERBAND SINGLE-PHOTON ABSORPTION OF POLARIZED LIGHT IN CRYSTALS WITH ALLOWANCE FOR THE EFFECT OF COHERENT SATURATION. 2-PART

Abstract. The spectral-temperature dependence of the coefficient of single-photon absorption of light in crystals of tetrahedral symmetry, due to optical transitions occurring from the spin-orbit splitting zone to the conduction band, is calculated. In this case, the contribution of the coherent saturation effect to the single-photon light absorption coefficient is taken into account.

Keywords: nonlinear light absorption, semiconductor, valence band, conduction band, direct optical transitions, interband light absorption.

In the first part of this work, it is indicated that the nonlinear absorption of light in a semiconductor with a degenerate valence band, which is due to direct optical transitions between the subbands of heavy and light holes and depends on the state of radiation polarization, was studied in [1–9]. In these papers, it is assumed that the nonlinearity in the intensity dependence of the single-photon absorption coefficient arises due to resonant absorption saturation.

We note here that the question of the spectral-temperature dependence of the single-photon absorption coefficient of light in the frequency range $\hbar\omega \geq E_g + \Delta_{SO}$, when optical transitions from the spin-orbit splitting zone to the conduction band, where $\hbar\omega$ is the photon energy, E_g is the band gap, and is Δ_{SO} the spin-orbit splitting energy, has remained open. Therefore, we further consider one-photon absorption of light between the spin-orbital splitting zone and the conduction band (at $E_g + \Delta_{SO} \leq \hbar\omega$).

Then the spectral-temperature dependence of the single-photon light absorption coefficient due to optical transitions between the spin-orbital splitting zone and the conduction band is determined as

$$K_{c,SO}^{(1)} = \frac{4\pi e^2}{c\hbar n_\omega}\frac{1}{3}p_{cV}^2 \iiint \left(\left|e_z'\right|^2 + \left|e_+'\right|^2\right)\left(f_{SO,\vec{k}} - f_{c,\vec{k}}\right)\delta\left(\frac{\hbar^2 k^2}{2m_c} + E_g + \Delta_{SO} - \left(-\frac{\hbar^2 k^2}{2m_{SO}}\right) - \hbar\omega\right)$$

or

$$K_{c,SO}^{(1)} = \frac{1}{3}\frac{e^2}{c\hbar n_\omega}\frac{p_{cV}^2}{\hbar^2}\mu_+^{(c,SO)} k_{c,SO}^{(1\omega)} f_{SO,k_{c,SO}^{(1\omega)}}\left\{1 - \exp\left[\frac{E_g}{k_B T}\left(x - 1 - \frac{E_{SO}}{E_g}\right)\right]\right\}, \tag{1}$$

where $\mu_+^{(c,SO)} = \frac{m_c m_{SO}}{m_c + m_{SO}}$ is the reduced effective mass, $k_{c,SO}^{(1\omega)} = \sqrt{\frac{2\mu_+^{(c,SO)}}{\hbar^2}\left(\hbar\omega - E_g\right)}$ is the wave vector of current carriers,

$$f_{SO,k_{c,SO}^{(1\omega)}} = \exp\left[\frac{E_F}{k_B T}\right] \cdot \cdot \exp\left[-\frac{1}{k_B T}\frac{\mu_+^{(c,SO)}}{m_{SO}}\left(\hbar\omega - E_g - E_{SO}\right)\right] \quad (2)$$

is the distribution function of current carriers in the spin-orbit splitting zone involved in optical transitions between the spin-orbit splitting zone and the conduction band.

The Fermi energy for current carriers located in the zone of spin-orbital splitting is determined by the formula for the concentration of current carriers, i.e.

$$p_{SO} = \iiint f_{SO,\vec{k}} k^2 dk = = \exp\left[\frac{E_F - \Delta_{SO}}{k_B T}\right] \iiint \exp\left[-\frac{1}{k_B T}\left(\frac{\hbar^2 k^2}{2m_c}\right)\right] k^2 dk. \quad (3)$$

Where do we get

$$\exp\left(\frac{E_F}{k_B T}\right) = = \frac{1}{2}\left(\frac{k_B T}{2\pi\hbar^2}\right)^{-3/2} m_{SO}^{-3/2} p_{SO} \exp\left(\frac{\Delta_{SO}}{k_B T}\right). \quad (4)$$

On (fig. 1) shows the spectral-temperature dependence of the coefficient of single-photon absorption of polarized light, due to optical transitions between the spin-orbital splitting subband and the conduction band in *InSb* without taking into account (*a*) and taking into account (*b*) the temperature dependence of the band gap and their ratio (c), where not the contribution of the coherent saturation effect to the single-photon light absorption coefficient is taken into account. The red line marks the intersection of the spectral and temperature dependences of the single-photon absorption coefficient of polarized light, shown in (Figs. 1 *a* and *b)*. From (fig. 10) shows that in the spectral – temperature dependence of the single-photon absorption coefficient of polarized light, a maximum is observed.

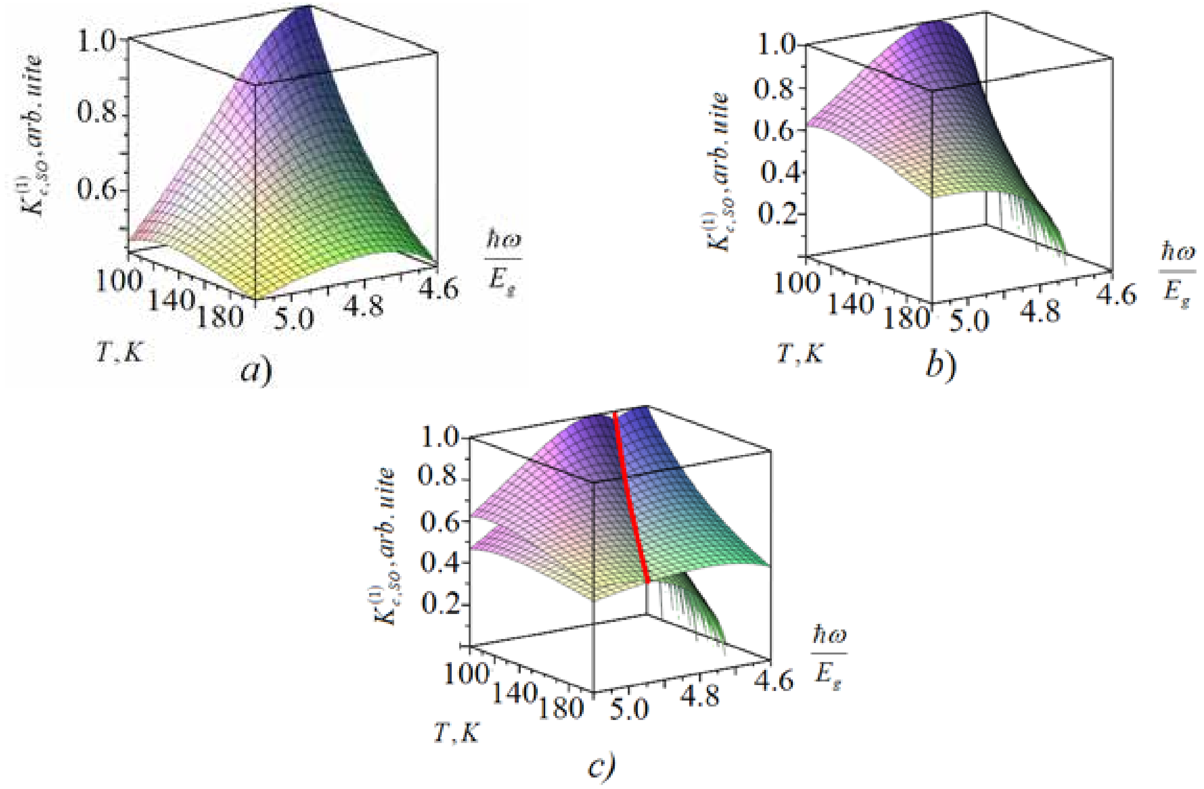

Figure 1.

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