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KOGERENT TO'YINGANLIK EFFEKTINI HISOBGA OLGAN HOLDA KRISTALLARDA QUTBLANGAN YORUG'LIKNING BIR FOTONLI YUTILISHI. 2 - QISM

Annonatsiya. *Tetraedr simmetriyali kristallaridagi chiziqli va sirkular qutblanish yorug'ligi bir fotonli yutilish koeffitsientining chastota va temperaturaga bog'liqligi uchun ifodalar olindi. Bu holda valent zonasining spin-orbital ajralgan tarmog’idan o'tkazuvchanlik zonasiga bir fotonli o'tishlarni hisobga olingan. Shuningdek kogerent to'yinganish effektining tarmoqlararo optik o'tishlarga qo'shgan hissasi ham hisobga olindi.*

Kalit so'zlar: *chastotaga va haroratga bog'liqlik, qutblangan yorug'likning nochiziqli zonalararo yutilishi, tetraedr simmetriyali yarim o'tkazgich, valent zonasi, o'tkazuvchanlik zonasi, vertikal optik o'tishlar, Rabi effekti*.

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МЕЖЗОННОЕ ОДНОФОТОННОЕ ПОГЛОЩЕНИЕ ПОЛЯРИЗОВАННОГО СВЕТА В КРИСТАЛЛАХ С УЧЕТОМ ЭФФЕКТА КОГЕРЕНТНОГО НАСЫЩЕНИЯ. 2 ЧАСТЬ

Аннотация. *Получены выражения для частотно -температурной зависимости однофотонного коэффициента поглощения света линейной и циркулярной поляризации в кристаллах тетраэдрической симметрии, где учтены однофотонные переходы, происходящие из подзон спин-орбитального расщепления валентной зоны в зону проводимости. Также учтен вклад эффекта когерентного насыщения в междузонные оптические переходы.*

Ключевые слова: *частотно -температурная зависимость, нелинейное межзонное поглощение поляризованного света, полупроводник тетраэдрической симметрии, валентная зона, зона проводимости, вертикальные оптические переходы, эффект Раби.*

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

Annotation. *Expressions are obtained for the frequency-temperature dependence of the single-photon absorption coefficient of light of linear and circular polarization in crystals of tetrahedral symmetry, which takes into account single-photon transitions originating from the spin-orbit splitting subbands of the valence band into the conduction band. The contribution of the coherent saturation effect to interband optical transitions is also taken into account.*

Key words: *frequency-temperature dependence, nonlinear interband absorption of polarized light, semiconductor of tetrahedral symmetry, valence band, conduction band, vertical optical transitions, Rabi effect.*

Introduction

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 [1–8]. 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 is the photon energy, is the band gap, and is 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 $E_g + \Delta_{SO} \leq \hbar\omega$).

Basic ratios

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

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

or

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

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

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

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.

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

Where do we get

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

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.

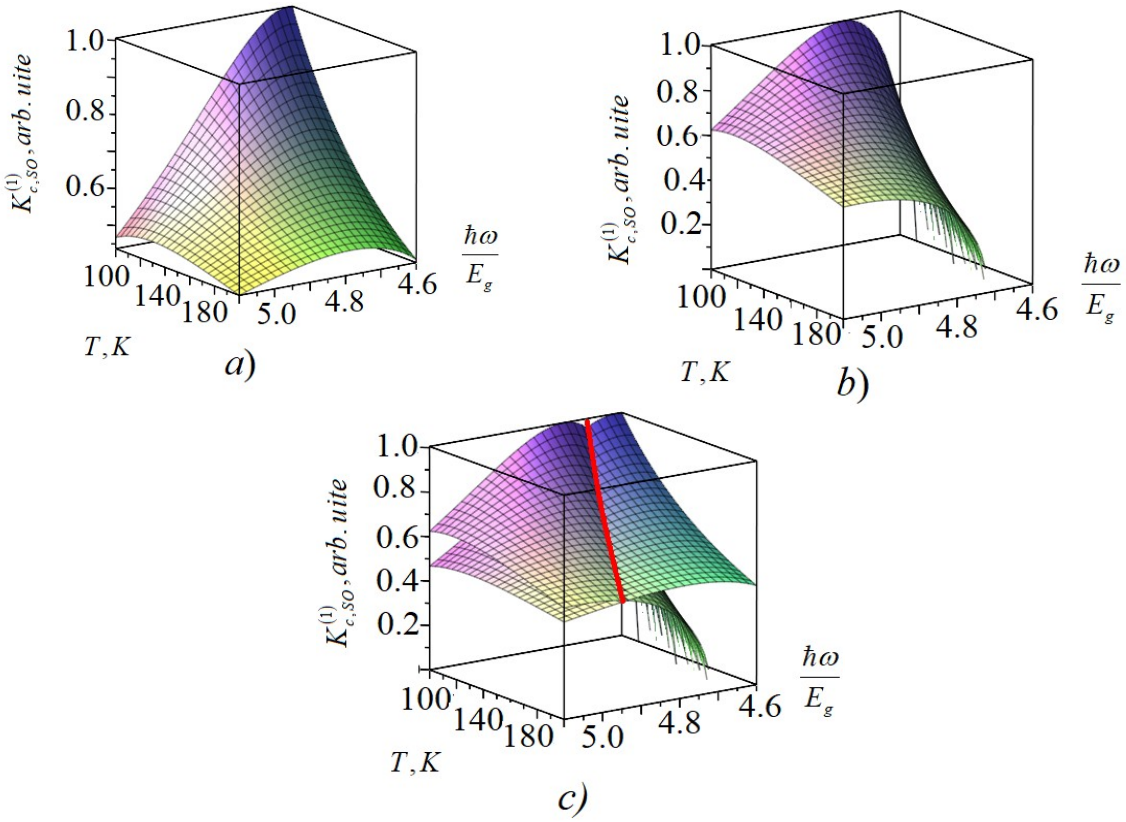

Fig.1. Spectral-temperature dependence of the single-photon absorption coefficient determined between subbands of the valence band

Conclusions

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

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