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Research Article

Resonance Raman Scattering in $TlGaSe_2$ Crystals

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The resonance Raman scattering for geometries $Y(YX)Z$ and $Y(ZX)Z$ at temperature 10 K and infrared reflection spectra in $E \parallel a$ and $E \parallel b$ polarizations at 300 K were investigated. The number of A_a (B_a) and A_u (B_u) symmetry vibrational modes observed experimentally and calculated theoretically agree better in this case than when $TlGa_2Se_4$ crystals belong to D_{2h} symmetry group. The emission of resonance Raman scattering and excitonic levels luminescence spectra overlap. The lines in resonance Raman spectra were identified as a combination of optical phonons in Brillouin zone center.

1. Introduction

$TlGaSe_2$ crystals are triple thallium chalcogenides with a layered structure [1, 2]. One of these crystals features is the strong anisotropy of physical characteristics due to the specificity of the crystals lattice [1–3]. Optical spectra in the absorption edge region [4–11] and resonance Raman scattering for different geometries and temperatures (77–400 K) [12] were investigated in $TlGaSe_2$ crystals. Reflection spectra for the 50–4000 cm^{-1} region were studied and polar vibrational modes LO and TO and their parameters were determined. Such crystals had an effect of switching of current-voltage and acoustooptic characteristics [13–15]. There are a lot of materials dedicated to the investigations of these materials (see [4–16] and the references therein). But resonance Raman scattering in $TlGaSe_2$ crystals has not been investigated.

2. Experimental Methods

Raman scattering spectra of $TlGaSe_2$ crystals were measured on double high-aperture spectrometers DFS-32 with linear dispersion of 5 Å/mm and relative aperture of 1 : 5 and resonance Raman scattering spectra on spectrometer SDL-1 with dispersion of 7 Å/mm and relative aperture of 1 : 2. The photomultiplier working in the photon counting regime was used as a detector. Resonance Raman spectra had an accuracy of ±0.5 meV. Reflection spectra in $E \parallel a$ and $E \parallel b$ polarizations in the range 50–400 cm^{-1} were measured on a vacuum spectrometer KSDI-82 using an acoustooptical receiver with an accuracy of ±1 cm^{-1}. Cleft crystals of $TlGaSe_2$ with different thicknesses mounted on a cold finger of a closed-circuit helium cryostat LTS-22 C 330 optical cryogenic system were used in the measurements. The Raman scattering was excited by 6328 Å line of a He-Ne laser. The resonance Raman scattering was excited by lines 4579 Å and 5145 Å of an Ar^+ laser.

3. Experimental Results and Discussions

According to the crystallographic data, the $TlGaSe_2$ structure is described by the space group $C2/c$ (C_{2h}^6). The unit cell contains 8 formula units of $TlGaSe_2$. The main motive of the structure is formed by tetrahedral polyhedrons of Ga_4Se_{10}, consisting of 4 tetrahedrons of $GaSe_4$. These tetrahedrons have common atoms of selenium on the tops of the octahedron [1–3]. These tetrahedral polyhedrons have common vertices of 4 selenium atoms and take up layered positions perpendicular to the c axis. The layers are rotated to each other at 90°. The edges of polyhedrons lie in the xy plain and are situated along the diagonal of the base square. Thus, the $TlGaSe_2$ compound has a monoclinic pseudotetragonal