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Wavelength modulation optical spectra of Ag3AsS3 crystals in the energy gap

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Abstract

Absorption spectra of Ag3AsS3 single crystals in E||c and E⊥c polarizations were investigated at temperatures 10 and 300 K. The edge absorption temperature dependence was analyzed in temperature range 300 - 10 K in E⊥c and E||c polarizations. Transmission spectra in crossed polarizers for single crystal plates with different thicknesses were studied. Indirect energy intervals (Eg1ind. and Eg2ind.) for both polarizations were found out in wavelength modulation transmission spectra (ΔT/Δλ) measured at 10 K. In photoluminescence spectra at 11 K an emission maximum associated with indirect excitonic transitions was discovered. Temperature dependences of photoconductivity of Au–Ag3AsS3–Au structure were researched.

Keywords: *optical spectroscopy, photoconductivity, proustite, wavelength, modulation spectra*

Introduction

Proustite crystals (Ag3AsS3) are well known a long time as natural mineral. Due to physical properties and possible technical application of Ag3AsS3 crystals attract great attention. Ag3AsS3 crystals have a lot of unique properties [[1], [2], [3], [4], [5]]. They are piezoelectric, pyroelectric, thermo- and photo-sensitive semiconductors [[5], [6], [7], [8], [9]]. Also these crystals possess nonlinear optical and acoustooptical properties. These allow to use its as photosensitive semiconductor structures in acoustoelectric and nonlinear optics. They are ferroelectric at low temperatures and superionic conductors at high temperatures. Proustite uses as electooptical crystal with nonlinear parameters. It can be used as uniaxial crystal for optical modes mixing and second harmonic generation [[9], [10], [11], [12]].

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At room temperature proustite belongs to the asymmetric class C6v3-R3c. In the unit cell of Ag_3AsS_3 a chaotic distribution of weakly bound silver ions over equivalent positions is observed. One of the main reasons for the high ionic conductivity of proustite is that Ag ions can easily leave their equilibrium positions, forming cationic defects. This is facilitated by the presence of vacant positions in the lattice for silver ions [7]. Ag_3AsS_3 crystals are characterized by hole mechanism of dark conductivity and high resistivity. About disordering of silver sublattice in proustite is mentioned in Refs. [[4], [5], [6], [7]]. Ion-electron conduction mechanisms and polarization affects under the influence of a constant electric field are observed in Ag_3AsS_3 crystals [8].

In the present work the absorption spectra in E||c and E⊥c polarizations for Ag_3AsS_3 crystals at temperatures 10 and 300 K were investigated. The polarized edge absorption temperature dependence in temperature range 300 - 10 K was analyzed. The features observed in measured in E||c and E⊥c polarizations at 10 K wavelength modulation transmission spectra ($\Delta T/\Delta\lambda$) can be associated with indirect transitions Eg1ind. and Eg2ind. Photoluminescence spectra near the edge absorption onset were investigated at different temperatures 11–300 K. The observed emission maximum can be associated with indirect electron transitions from conduction band C1 to valence band V1. The photoluminescence maximum sifts with temperature increasing toward lower energies. The maximum observed in photoconductivity spectra of Ag_3AsS_3 structure wint gold contacts at 20.5 eV at room temperature was revealed.

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