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Birefringence of $CuGa_2S_4$ crystals

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ABSTRACT

The interference of optical transmission spectra of thin $CuGaS_2$ single crystals is measured in E||c and E⊥c polarizations. The spectral dependencies of the refractive indexes n_o, n_e and $\Delta n = n_o - n_e$ near the absorption edge have been determined from interference spectra. The intersection of refractive indexes at two wavelengths has been revealed at 300 K and 10 K. The characteristics of Band-Pass-Mode Filter and Band-Elimination-Mode Filter have been measured, which possess 7 narrow absorption (transmission) bands and represent a comb filter. The characteristics of these filters have been studied.

1. Introduction

It is very important to be able to measure weak signals of the scattered light near the frequency of the excitation line when measuring Raman scattering, since the Raman frequencies of scattered light may be positioned very close near the excitation lines. The use of single monochromators in combination with narrow band filters with isotropic wavelength is discussed in the literature for this purpose [1–6]. Birefringent optically active crystals with isotropic wavelength can be successfully used as optical filters with narrow pass bands. These optical filters are narrowing (filtering) the radiation line of the excitation laser, that allows one measuring the Raman scattering at frequencies much closer to the excitation lines. The main peculiarity of these filters is the narrow band. The pass band of the filter can be changed by changing the crystal composition, temperature or the external pressure [5–8].

The intersection of the dispersion curves of the ordinary n_0 and extraordinary n_e refractive indexes on a fixed wavelength λ_0 is a feature of the single axis crystal. The single axis crystal is behaving itself like an optical isotropic medium at $\lambda = \lambda_0$, this is why the λ_0 wavelength is named "isotropic wavelength" (or isotropic point — IP).

A big amount of crystals that possess the isotropic wavelength have been revealed and studied up to date [1–16]. The platelets of $AgGaS_2$ with λ_o wavelength of the optical isotropy ("null wavelength" plates) were used for manufacturing Lyot filters and Solc filters [1,2]. The birefringence of $CuGaS_2$ crystals has been previously studied [11–13]. Materials with chalcopyrite structure possess a bigger birefringence as compared to crystals with wurtzite structure. The difference between the optical isotropy wavelength λ_o and the fundamental absorption edge in semiconductors with chalcopyrite structure is bigger as compared to wurtzite semiconductors [8–13].

2. Experimental method

$CuGaS_2$ crystals in the form of prisms or thin layers with natural faces have been grown from the gas phase. The faces parallel and perpendicular to the optical axis are of mirror quality without any polishing. The crystal thickness was varying from 1.2 μm to 200 μm. The spectra were measured with a double SDL-1 or an MDR-1 spectrometer. The thickness of the thin crystals was determined by an electron beam microscope. The thickness of thick crystals was measured using an ultraoptimeter. Polarization prisms Galan–Thomson were used in experiments.

3. Experimental data and discussions

Optical filters used for narrowing laser lines consisted of a birefringent optical active crystal and two polarizers. The filter possesses a narrow band at the wavelength λ_o of the optical isotropy of the crystal. Such filters can be manufactured on the basis of crystals that possess the isotropic point, i.e. the λ_o wavelength where the velocity of ordinary and extraordinary light rays is equal.

The dispersion on the short wavelength side of λ_o has a positive birefringence $(+\Delta n = n_e - n_o)$ and is determined by the selection rules of electron transitions in the minimum of the bandgap. This

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