Birefringence in Anisotropic Crystals $CuGa(Al)S_2$ and Based on Them Optical Filters

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***Abstract* — In uniaxial birefringence crystals are observed two refractive index of refraction (n_o and n_e) with its dispersion curves, that can intersect for a given wavelength. Phenomenon of intersect the dispersion curves n_o and n_e observed in the crystals due to the fact that as the light energy from the minimum band gap, change the nature of the electronic transition. The spatial dispersion, depending optical function on the orientation wave vector K in the crystal, is an important role in gyrotropic crystals. The amplitude of the contour of the reflection spectra were calculated using the dispersion relations. Using of the filters based on isotropic wavelength give a definite advantage when measuring Raman spectroscopy.**

***Index Terms* — birefringence crystals, refraction, dispersion curves, dispersion relation, optical filters.**

I. INTRODUCTION

In uniaxial birefringence crystal are observed two refractive index (n_o and n_e) with its dispersion curves, that can intersect at a certain wavelength. Phenomenon of intersect the dispersion curves n_o and n_e observed in the crystals due to the fact that as the light energy from the minimum band gap, change the nature of the electronic transition. At what is the wavelength of the ordinary and extraordinary waves are aligned in phase. If the crystal performed phase condition, the energy transfer can take place from one mode to another, orthogonally polarized. It is assumed that there is an element of communication between the modes. The phenomenon of energy transfer between modes, the conversion of energy between the modes is performed in all the known anisotropic crystals, including crystals $CuGaS_2$ [1-3].

II. EXPERIMENTAL RESULTS AND DISCUSSION

As we move away from the absorption edge to longer wavelengths the absorption for polarization EIIc decreases more sharply than that in polarization E⊥c. At certain wavelength λ_0 absorption curves intersect, and hence the curves *n*. Propagating through the crystal light with a wavelength $\lambda = \lambda_0$ occurs with transfer energy out mode, polarized as n_o (or n_e) in the mode, polarized as n_e (or n_o), i.e. in the isotropic crystals is observed interaction between two orthogonally polarized modes.

Figure 1 shows the transmission spectra of the crystal thickness 4.5 μm in the EIIc and E⊥c polarizations. The figure shows that the curves of the transmission spectra intersect in the region at wavelengths 641.9 nm (λ_{01}) and 526.6 nm (λ_0). Calculations of the refractive indices for ordinary n_0 (EIIc) and extraordinary n_e (E⊥c) rays, confirmed the presence of isotropic wavelengths at 637 and 526 nm.

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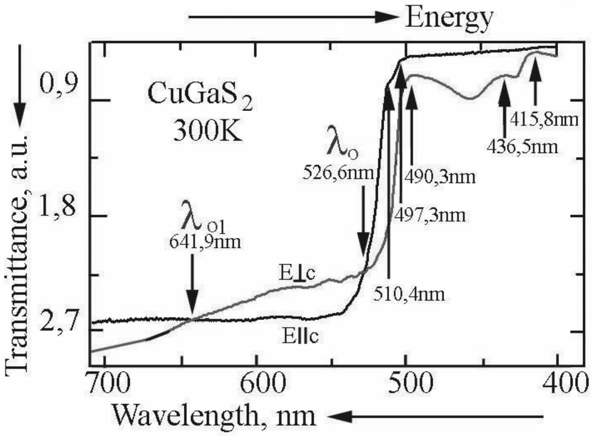


Fig.1. Transmission spectra of the crystals $CuGaS_2$ thickness 4.5 μm for the EIIc and E⊥c polarization at 300K and spectral dependence of the refractive indices for ordinary n_0 (EIIc) and extraordinary n_e (E⊥c) rays in the $CuGaS_2$ crystals (thickness crystals is 4.5 μm)

On the propagation of ordinary and extraordinary waves in birefringence crystals an important role is are refractive indices n_e, n_o, real ε_1 and imaginary ε_2 parts of the complex dielectric constant for these waves. Depending on these parameters varies the amplitude and phase of the reflected light. The spectral dependence of the reflection coefficient R, absorption coefficient K, phase of the reflected light ϕ and spectral dependence of the real ε_1 and imaginary ε_2 parts of the complex dielectric constant for EIIc polarization (Γ_4 exciton) in the crystals $CuGaS_2$ were investigated in the works [1, 2]. In the region "bottleneck" phase of the reflected light varies from -0.25 to -0.7, i.e. almost 70-80°. The absorption coefficient K to the calculation of the reflection spectra has a maximum value of 10^6 cm^{-1} for the values of transversal exciton frequency ω_T.

The phenomenon of spatial dispersion, i.e. depending optical functions on the orientation of the wave vector K in the space of the crystal are an important role in gyrotropic crystals. Figure 2 shows the change the amplitude of the reflection spectra at different angles of incidence and reflection on two different crystal surfaces $CuGaS_2$.

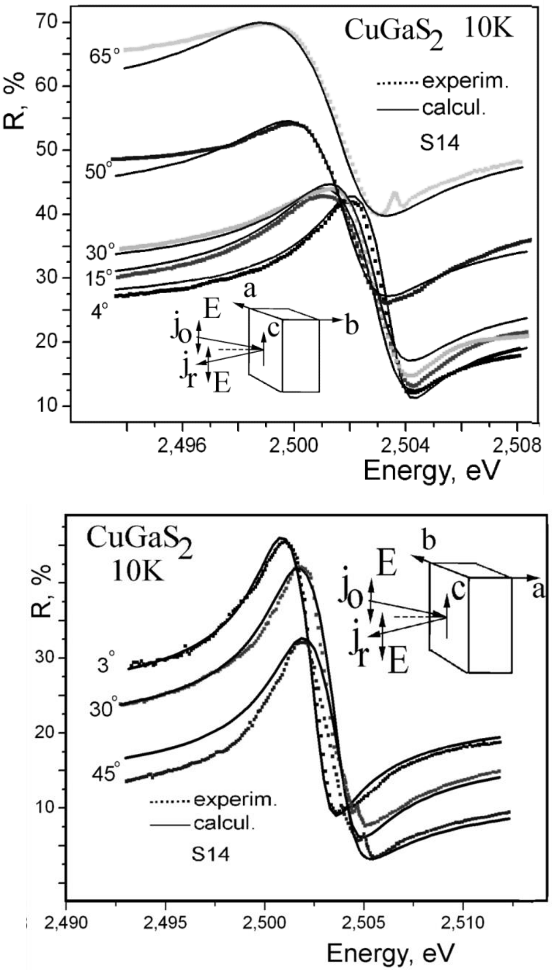


Fig.2. The spectral dependence of the reflection coefficient R for Γ_4 exciton at different angles of incidence and reflection in crystals $CuGaS_2$.

In these experiments, the polarization of radiation remained unchanged but changes the direction of the wave vector K with respect to the crystal axes. The amplitude of the contour of the reflection spectra were calculated using the dispersion relations (solid curves in fig.2). Figure 2 shows that increasing the angle between the crystal axis b and the wave vector k the gradient of the long-wave amplitude of the reflection spectra of the shoulder is reduced. This means that the reduced value of the translational mass M Γ_4 exciton (Table 1). Increasing the angle between the axis of the crystal a and wave vector k in the reflection spectra with the surface (b×c) leads to approximately the same changes in the mass M.

TABLE I. PARAMETERS OF EXCITON POLARITONS AT CHANGE THE DIRECTION OF PROPAGATION OF THE LIGHT WAVE K.

Surface	Phase, ϕ^o	ε_b	ω_0, eV	ω_{L}, eV	Γ, mev	M, m_o
(bxc) from kIIa at 45°	3°	8,3	2,501	2,503	0,3	2,2
	30°	8,3	2,501	2,804	0,3	2,3
	45°	8,3	2,502	2,505	0,4	2,5
Surface (axc) from KIIc at 65°	4°	8,8	2,502	2,504	1,3	2,5
	15°	8,8	2,502	2,504	1,6	2,4
	30°	8,8	2,502	2,503	1,9	2,4
	50°	8,8	2,500	2,502	2,5	2,3
	65°	8,8	2,499	2,502	2,8	2,2

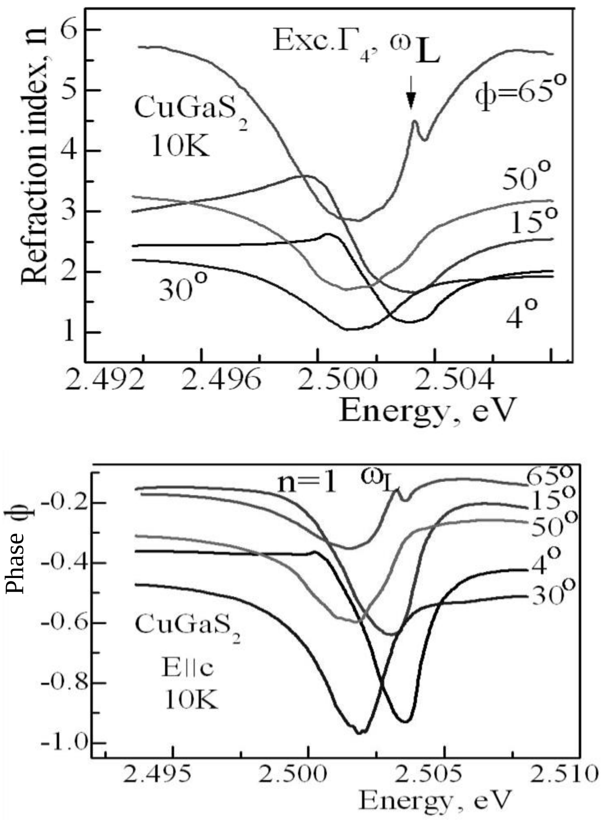
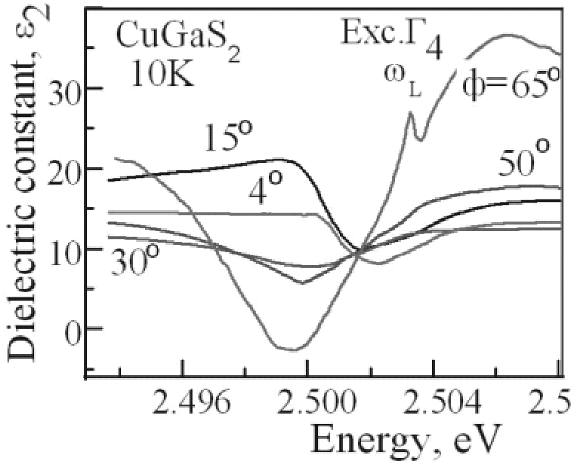


Fig.3. The spectral dependence of the refractive index n and the phase of ϕ the reflected light in crystals $CuGaS_2$ for Γ_4 excitons at different angles of incidence and reflection of the light on the surface of the crystal (i.e, depending on the direction of the wave vector K).



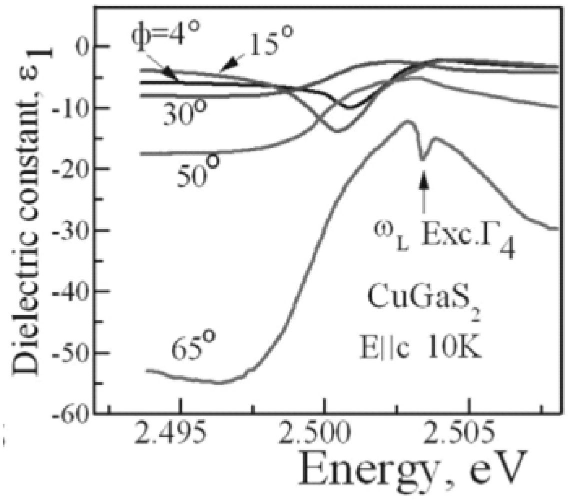


Fig.4. The spectral dependence of the real ε_1 and imaginary ε_2 parts of the complex dielectric constant of Γ_4 excitons in $CuGaS_2$ crystals at different angles of incidence and reflection of the light on the surface of the crystal (i.e., depending on the direction of the wave vector K).

For Γ_4 excitons in $CuGaS_2$ crystals at different angles of incidence and reflection of the light on the surface (a×c) of the crystal (i.e., depending on the direction of the wave vector k) varies as the spectral dependence of the refractive index n and the phase of the reflected light ϕ, fig. 3. The spectral dependence of the real ε_1 and imaginary ε_2 parts of the complex dielectric constant of Γ_4 excitons in $CuGaS_2$ crystals at different angles of incidence and reflection of the light on the surface (a×c) of the crystal (i.e., depending on the direction of the wave vector K) also varies significantly, and especially when angles of 65 °, fig.4.

The use of filters based on isotropic wavelength give a definite advantage when measuring Raman spectroscopy. For widespread use of narrowband filters in Raman spectroscopy and in other areas of optical spectroscopy to find semiconductor crystals with isotropic wavelength λo which coincides with the emission lines of the existing lasers. The dependence of the isotropic wavelength λo (center bandwidth) filter made of solid solutions $CuGa_xAl_{1-x}S_2$ the parameter X is shown in Fig. 5.

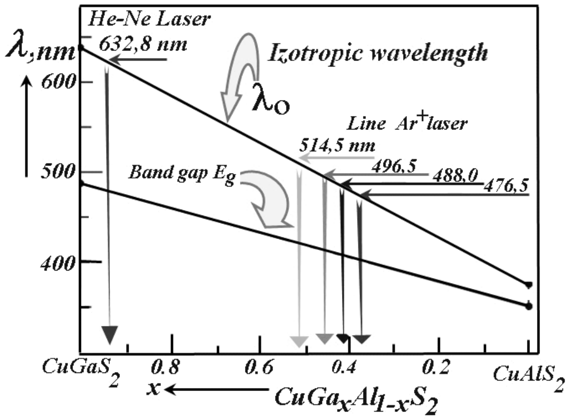


Fig. 5. Dependence of λo and Eg at X parameter in solid solution $CuGa_xAl_{1-x}S_2$

This figure also shows the wavelength of the emission line Ar^+ and He-Ne lasers and needed a solid solution that will have an isotropic wavelength λo appropriate wavelength lasers. For the wavelength 632,8 nm can be used near the solid solution composition $CuGa_{0.95}Al_{0,05}S_2$. The thickness of the plates determined from the experimental results of the birefringence and optical activity. Thickness and composition was adjusted so that the filter has a maximum transmission lines corresponding to the laser. Filters narrowing bands Ar^+ laser radiation can be made of the composition X = 0.35-0.53.

CONCLUSION

Filters made on the basis of solid solutions $CuGa_xAl_{1-x}S_2$ will measure Raman scattering near the line of emission lines Ag^+ and He-Ne lasers and Raman spectroscopy used to single monochromator instead of a double or triple spectrometer. Such filters are critical narrow broad band lasers.

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