Filters with Optical Isotropic Wavelength

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***Abstract* — In the present work it is presented the construction of Band-Pass-Mode Filter and Band –Elimination-Mode Filter used for decreasing the track of the excitation lines 536.7nm and 632.8nm, respectively, for Ar^+ and He-Ne lasers. Experimental research of $CuGa_xAl_{1-x}S_2$ solid compounds in totality with Galan-Thompson polarization prisms has been carried out in order to construct the devices.**

***Index Terms* — Band-Pass-Mode filter, Band–Elimination-Mode filter, isotropic wavelength.**

I. INTRODUCTION

Double or triple monochromatic spectrometers are used to measure the Raman scattering and resonant Raman scattering. Such equipment is rather huge and expensive, but posses the necessary parameters – low level of scattered light. The scattered light part is especially important in the near region of laser excitation, because the Raman frequencies of scattered light can be positioned near the excitation lines.

II. EXPERIMENTAL RESULTS

In other scientific papers and works it is discussed the usage of ordinary monochromators with shortwave filters with optical isotropic wavelength [1 - 3]. In the present work it is presented the construction of Band-Pass-Mode Filter and Band –Elimination-Mode Filter used for decreasing the track of the excitation lines 536.7nm and 632.8nm, respectively, for Ar^+ and He-Ne lasers. Experimental research of $CuGa_xAl_{1-x}S_2$ solid compounds in totality with Galan-Thompson polarization prisms has been carried out in order to construct the devices.

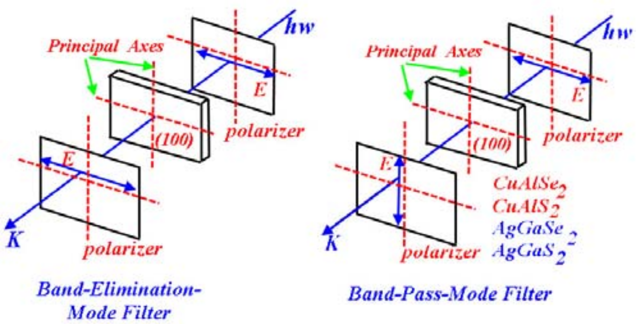

FIG. 1 NARROW-BAND FILTERS BASED ON CHALCOPYRITE MATERIALS USED FOR RAMAN SPECTROSCOPY

The optical filter for narrowing laser lines are consisted of birefringent optical active crystal and two polarization devices (figure 1). The filter possesses a narrow track at λ_o wavelength of the optical isotropic crystal. Semiconductor crystals with chalcopyrite structure can be used as materials for manufacturing such crystals. The manufacturing of such filters is possible basing on crystals which posses an isotropic point, i.e. λ_o wavelength for which the dissemination speed of ordinary and extraordinary light rays is the same. The dispersion from the short wavelength part of λ_o has a positive birefringence ($+\Delta n=n_e - n_o$) and is determined by the selection rules of electronic transitions in the minimum of interband interval. The dispersion id determined by the deformational lattice distortion $|(1-c/2a)|$ from the longwave part of λ_o and possesses negative birefringence ($-\Delta n=n_e-n_o$), where the c and a are the parameters of crystal lattice, and n_e, n_o are the refractive indexes for ordinary and extraordinary rays. The birefringent optical active crystals with isotropic wavelength can be successfully applied as optical filters with narrow transparency band. These optical filters are narrowing the radiation line of the excitation laser, which allows measuring the Raman scattering at frequencies near the excitation lines. The main particularity of such filters is the unique narrow band. The filter's transparency band can be changed by changing the crystal composition and temperature. Semiconductor crystals with chalcopyrite structure posses a birefringence greater than crystals with wurzite structure. The difference between the wavelength of the λ_o optical isotropy and the fundamental absorption boundary in semiconductors with chalcopyrite structure is greater than for wurtzite semiconductors. Plates based on $AgGaS_2$ crystals with λ_o wavelength of optical isotropy ("null wavelength" plates) had been used for manufacturing Lyot filters and Scholtz filters [1, 2]. The experimental results show that $CuAlS_2$ posesses optical isotropic wavelength at 376 nm, and $CuAlSe_2$ crystals posses an isotropic point at 536.7 nm (figure 2). The λ_o wavelength is different for each crystal of the chalcopyrite group $CuAlS_2$, $AgAlS_2$, $CuAlSe_2$, $AgAlSe_2$, $AgAlTe_2$ and $AgInS_2$.

The wavelength of the transparency maximum of such filters is determined by the optical isotropic wavelength λ_o. It was already mentioned about the presence of the optic isotropic wavelength λ_o and its temperature dependence at some crystals [1 – 4]. $AgGaS_2$ possesses λ_0 at 497 nm at room temperature, $CuGaS_2$ at 642 nm and $AgGaSe_2$ at 811 nm wavelength [3, 4]. It is necessary to find semiconductor crystals which posses isotropic wavelength λ_o that would match the radiation lines of present crystals for using narrow-band filters of Raman spectroscopy at a wide range and in other domains of optical spectroscopy. The dependence of the isotropic wavelength λ_o (the center of transparency band) of the filter manufactured from solid compounds $CuGa_xAl_{1-x}S_2$ on X parameter is shown in figure 3.

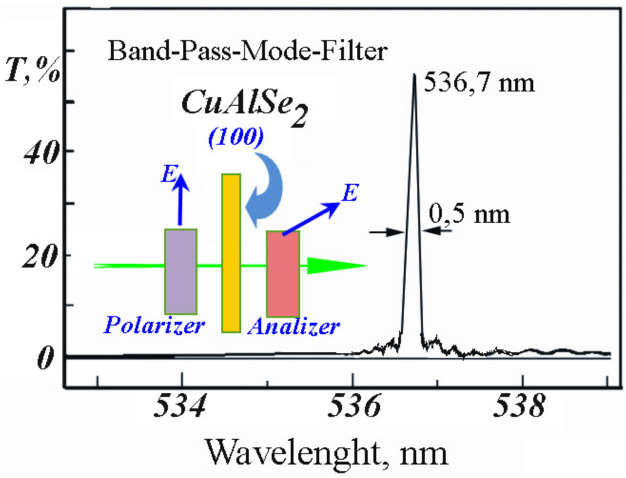

FIG. 2 FILTERING DEVICE BASED ON $CuAlSe_2$ CRYSTALS

The wavelengths of the radiation lines of Ar^+ and He-Ne lasers and the necessary solid compounds that would possess the isotropic wavelength λ_o corresponding to the laser wavelengths are also shown in figure 3. The solid compound $CuGa_{0.95}Al_{0,5}S_2$ can be used for the 632.8 nm wavelength. The thickness of crystal plates is detrmined from experimental birefringence results and optical activity. The thickness and composition had been selected so that the filter would have the transparency maximum corresponding to the laser lines. These filters can be manufactured from compounds like X=0.35-0.53.

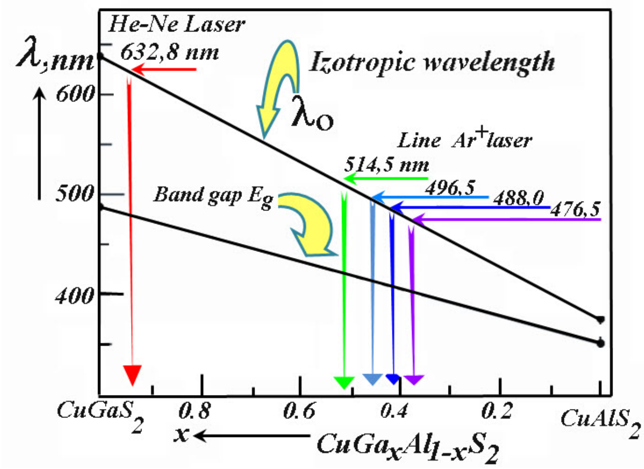

FIG. 3 THE DEPENDENCE OF λ_o AND E_g ON X PARAMETER IN $CuGa_xAl_{1-x}S2$ SOLID COMPOUNDS

III. CONCLUSIONS

The filters for narrowing the radiation lines of Ar^+ lasers will allow measuring the Raman scattering near the radiation lines and use a monochromator for Raman spectroscopy instead of double or triple spectrometer. Such filters are especially important if using them in Raman spectroscopy as excitation sources of high power semiconductor lasers that possess a wide emission band.

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