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# INVESTIGATION OF OPTICAL INTERFERENCE BY A PHOTOACOUSTIC METHOD

D. M. Todorović, P. M. Nikolić

University of Belgrade, P.O.Box 816

Abstract:

Photoacoustic method is more and more used for investigation of the layered and thin film samples as a complementary method to the optical absortion method. In this paper photoacoustic spectra of a layered semicondactor - GaSe and thin film compaund $CdGa_2S_4$ are investigated. Photoacoustic spectra of GaSe shown interference for some frequency of modulation of light beam and some particular ticknesses of the samples. Similar results are also obtained for thin film of $GdGa_2S_4$. These results are pointing at interference appearance conected to thermal waves generated in the sample. It has been shown that these results were complementary with optical interference spectra. Photoacoustic method is getting important for characterization layered and thin film samples whith a small reflectivity and transmission.

## Introduction

The photoacoustic effect is a phenomenon of generation of acoustic waves in a material which absorbes modulated electromagnetic radiation or a modulated energy beam (electrons, ions, etc). The generated acoustic signal depends on optical thermal and elastic properties of the material. The photoacoustic signal can be detected using several different measuring configuration. The sample - gas - microphone detection configuration imposes that the sample is in a closed cell filed with gas, called a photoacoustic cell. Modulated radiation through a window of the PA cell, reaches the sample which absorbes the radiation and localy heats and cools (photothermal effect). This thermal energy can directly produce acoustic signal (thermoelastic effect) or can be transfered to the sample surface by means of diffusion (thermodiffusion effect). Periodical heating of the

sample-gas boundary surface can produce periodical expansion and contraction of gas i.e. variation of pressure (acoustic response). The generated acoustic signal has the frequency which is equal to the frequency of modulation of the incident radiation.

Benett and Patty /1/ have inverstigated carbon using the PA method and they have noticed that the change of the PA signal with the frequency of modulation is not in agreement with theory anticipation. They have explanined these differences as beeing due to interference of thermal waves which were generated in the sample which thickness was smaller than the thermal diffusion length. Todorović and Nikolić /2/ have experimentaly studied interference of thermal waves in semiconductor - GaSe. The PA spectra of GaSe were measuring as a function of modulation frequency and the sample thickness. The thermal wave interference was clearly noticed. An optical interference, i.e. periodical change of the PA signal as a funcition of wave length was noticed. The optical interference was observed for a particular modulation frequency of incidentd radiation and sample thickenss. This implies that the thermal phenomena are conected to the optical interference. Similar results were experimentaly observed for thin semiconducting film of $CdGa_2S_4$. Mandelis et al. /3/ investigated thin films of $SiO_2$ on Si substrate and have reached similar conclusions.

## Experimental results

The PA amplitude spectra were measured for layered semiconducting GaSe and thin films of $CdGa_2S_4$ using a standerd PA spectometer GILFORD R-1500 in the range between 400 and 800 mm. The PA amplitude spectra for GaSe in the range of absortion edge are given in Fig. 1 for several different sample thickenss. On the contrary, for a particular sample thickness the Pa.spectra measured for various modulation frequencies were measured. Fig. 2 gives such a diagram for a GaSe sample which was 28$\mu$m thick. In Fig 1, for a sample 488$\mu$m thick, periodical variation of the PA signal as a function of wavelength is noticable. A similar case can be noticed in Fig. 2 for the modulation frequency of 215 Hz.

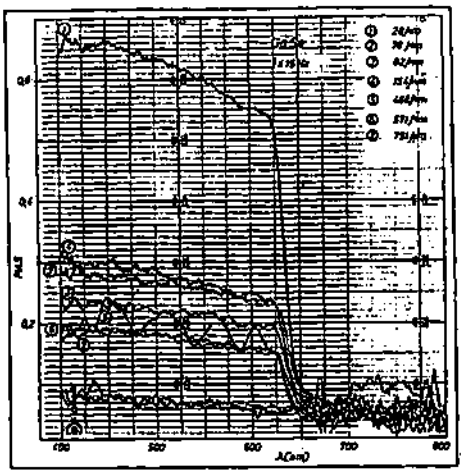

Fig. 1.

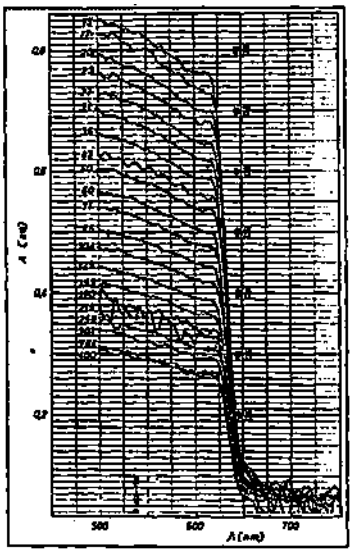

Fig. 2.

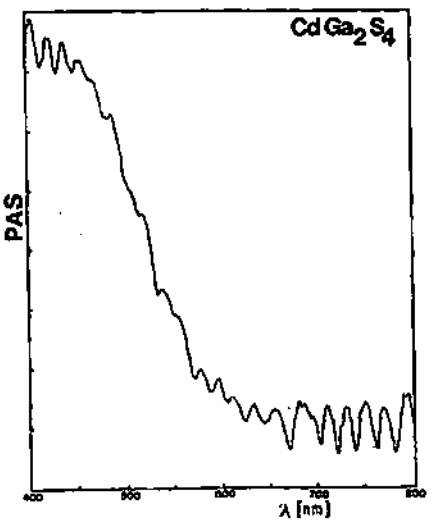


Fig. 3.

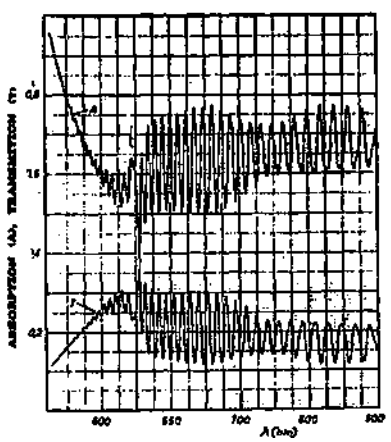

Fig. 4.

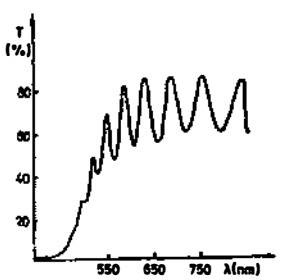


Fig. 5.

Fig. 3 shows an amplitude PA spectrum for thin film $CdGa_2S_4$ sample for modulation frequency of 42 Hz. The thin film was evaporated on a quartz substrate and which was 1.2μm thick /4/.

## Discussion

The experimental results, given in Fig. 1 and 2 direct us to a optical interference appearance. This conclusion can be also made if we compare the PA spectra with similar optical absorption spectra. Fig. 4 shows transmission and absorption spectra for GaSe when the thickness of the sample was 6.6μm. In Fig. 5 a transmission diagram, as a function of wavelength, for a thin film sample of $CdGa_2S_4$ is given. There is a noticible similarlity of shape and positions of interference maxima and minima of both PA and optical spectra.

A theoretical analysis of this problem is in progress.

## Conclusion

In this paper it has been shown that the optical interference can be studied by using the PA method. The PA method is especially useful when the samples are optically opaque. It was also shown that the interference conditions can be obtained even for rather thick almost massive samples. Beside optical properties and thermal properties can be analysed by investigation the interference PA spectra. It is also possible to obtain the thickness of various layers in a multilayer sample by using the PA method, practically with a nondestructive method.

## Literature

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