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SOLID SOLUTION OF $GaS_{1-x}Te_x$ AND THEIR CRYSTALLOGRAPHY AND SOME OPTICAL PROPERTIES

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Single crystal samples with a content of up to 25 mol% GaTe were made. For these samples crystallographic analysis of the change of the lattice parameters with composition was done. The way of change of the energy gap as a function of composition for these samples was studied by measuring the transmission of monochromatic light.

Introduction

Galium chalcogenide compouhds (GaS, GaTe, GaSe) are layered semiconductors. Many papers have been published about them, beginning in 1964 (1) when a work about GeS energy band structure was reported. Optical properties near the absorption edge have been studied for both (GaS, GaTe) compounds (2,3,4,5). Photoconductivity (3,6) Hall effect and electrical resistivity (7,8) thermo (9) and electro reflectance spectra (10) have also been reported. Special interest has been shown in the investigation of the spectra of differential absorption of GaS where the presence of indirect excitons (5) has been reveald. Recently the epxerimental results of reflectivity and photoemission data for GaTe (11) were compared and also its optical properties were reexamined (12) in the visible and ultraviolete ranges.

In this work the possibility of obtaining solid solutions between GaS and GaTe was investigated. Also the change of the optical energy gap has been observed as a function of composition.

Sample preparation and Results

The samples of the layered semiconducting alloys $GaS_{1-x}Te_x$ were made by melting the proper amounts of Ga, S and Te in the previously evacuated quartz ampoules. Using the well known Bridgeman technique the samples with 10, 15, 25, 35, 50 and 75 mol% GaTe were made. The samples with 10 and 15 mol% of GaTe were in single crystal form and could be easily cleaved using either a razor blade or scotch tape. The crystallographic properties were analysed using a Philips diffractometer.

The change of the lattice parameter "C" is given in figure 1 where it is possible to see that a solid solution of GaTe in GaS is obtained at least 25 mol% GaTe.

Transmission measurements of monochromatic light were performed for thinly cleaved layers in the visible range. The samples were between 25 and 150 micrometers thick.

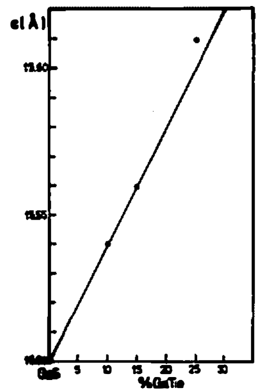

Fig. 1. Variation of lattice parameter (C) with composition

The transmission coefficient was measured in samples of pure GaS, 90 mol% and 85 mol% GaS using a Perkin Elmer 402 spectrophotometer. Diagrams of the absorption coefficient versus energy are given in Figure 2.

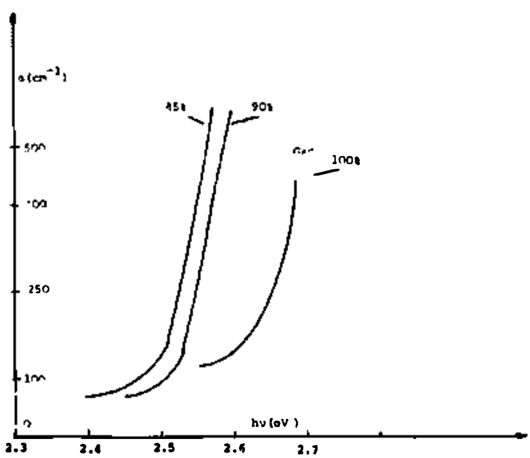

Fig. 2. Absorption coefficient versus energy for samples with 100 mol%; 90 mol% and 85 mol% GaS.

Using the very well known expression:

$$T = \frac{(1-R)^2 \, e^{-\alpha d}}{1-R^2 \, e^{-2\alpha d}} \qquad (1)$$

the values of the absorption coefficient as a function of composition were calculated. In figure 3 the values of the energy gap as a function of composition are given. These were obtained by analysing the way of change of the absorption coefficient.

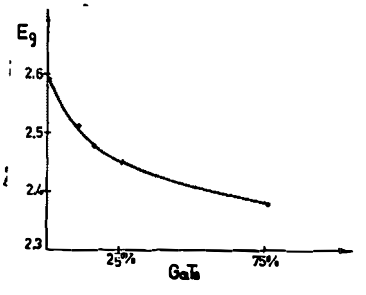

Fig. 3. Variation of room temperature optical energy gap with composition of GaS-GaTe alloy system

Analysis and discussion of results

The change of the coefficient of absorption was analysed using the equation:

$$(h\nu - Eg)^n A = \alpha(h\nu) \qquad (2)$$

where $n = \frac{1}{2}$ for the direct allowed and $n = 2$ for the indirect allowed energy gap. Using this expression it was concluded that the fundamental absorption edge for the alloys with 10, 15 and 25 mol% of GaTe was the consequence of the existence of an indirect allowed energy gap. For a sample with 75 mol% GaTe it was concluded that a direct allowed energy gap was present.

It is interesting to observe that no exciton effect was noticed for either GaS or GaTe when the absorption characteristics were measured although other workers discerned that effect for GaTe even at room temperature (2). To prove the quality of the instruments used, we measured the transmission as a function of wavelength for $GaS_{1-x}Te_x$ alloys. In the case of GaSe a very well exposed exciton effect could be obtained even at room temperature (figure 4).

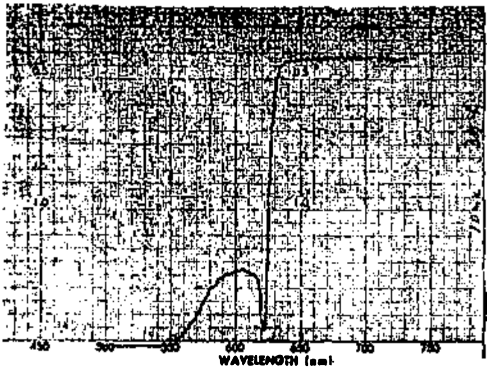

Figure 4. Transmission coefficient versus wavelength for GaSe

This semiconductor was made using the same technological procedure as was used when the other gallium chalcogenide compounds were produced. It is interesting to note that even a commercial monochromator can be used to obtain a well exposed exciton effect for the layered semiconductor GaSe. This means that this material can be used for students laboratory exercises when one wants to demonstrate the exciton effect to students.

Here one should emphasise that for all the other described materials a well exposed exciton effect was always observed at rather low temperatures (at least liquid nitrogen temperatures or below).

In conclusion it is possible to say that $GaS_{1-x}Te_x$ alloys are interesting because of their photoconductivity effects. This study is being continued.

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