YU ISSN 0015—3206
FZKAAA 20 (2) 207 (1988)

LETTER TO THE EDITOR

ELECTRICAL AND OPTICAL STUDIES ON $Cd_x Zn_{1-x}S$

MOHAMED MOUNIR*

Department of Physics, Faculty of Science, Cairo University, Egypt

AHMED A. EL-ASMY*

Department of Chemistry, Faculty of Science, Mansoura University, Egypt

Received 27 January 1988

UDC 538.95

Original scientific paper

$Cd_xZn_{1-x}S$ ternary alloys were prepared by evaporating a homogeneous mixture of ZnS and CdS powder with different alloy compositions x. The electrical conductivity increases with alloy composition x. At $x < 0.8$ the electrical conductivity of the ternary alloys $Cd_xZn_{1-x}S$ is independent of temperature. The dependence of the energy gap of the system $Cd_xZn_{1-x}S$ on its composition factor x was determined. The infrared spectra of the system $Cd_xZn_{1-x}S$ was measured in the range 4000—600 cm^{-1}.

Wide-gap II—IV compounds are the subject of much interesting investigations[1,2]. These materials are attractive because of low cost and efficient heterostructure can be simply made with reproducible technology. Ternary systems of II—VI compounds have been studied mainly as single crystal or epitaxial layers. Films of $Cd_xZn_{1-x}S$ have interesting applications in optical devices such as solar cells, light emitting diodes and photoconductive devices[3]. The knowledge of the optical properties of $Cd_xZn_{1-x}S$ is important due to numerous technological applications. The ternary systems $Cd_xZn_{1-x}S$ alter the band gaps from 2.4 to 3.9 eV[4]. The electrical and optical properties can be suitably tailored for optimum device performance by choosing the desired compositions. The aim of this work is to study the energy gap as well as the electrical conductivity of the ternary systems as a function of the composition x.

* Present address: Physics Department, Faculty of Science, Sana'a University, Yemen AR.

$Cd_xZn_{1-x}S$ of various composition were prepared by evaporating a homogeneous mixture of ZnS and CdS powder from molybdenum boat onto mica substrates in a vacuum of about 10^{-4} Pa. Film thickness in the range 1 to 30μm have been achieved for a series of mixture ratios. The compound changed in colour from transparent to yellow with increasing the mole fraction of CdS. A regulated electrical oven was used to control the ambient temperature. The measurements were carried out at a rate of about 0.5 °C/min. The conduction current was measured using an electrometer type 610C-KEITHLY instruments. The visible spectral measurements were carried out using a Pye Unicam SP 8800 spectrophotometer. Infrared spectra were recorded on a Pye Unicam 2000 spectrophotometer.

Fig. 1 shows the temperature dependence of the conductivities of $Cd_xZn_{1-x}S$ alloys for six different compositions. The conductivity of the pure compound at $x = 1$ (i. e. CdS) was found to be strongly dependent on the temperature where the conductivity increases with a rise in temperature. The curve at $x = 1$ shows two slopes or two conduction mechanisms with activation energies 1.04 and 1.38 eV. This confirms the measurements obtained for CdS[5]. At $x = 0.98$, the variation

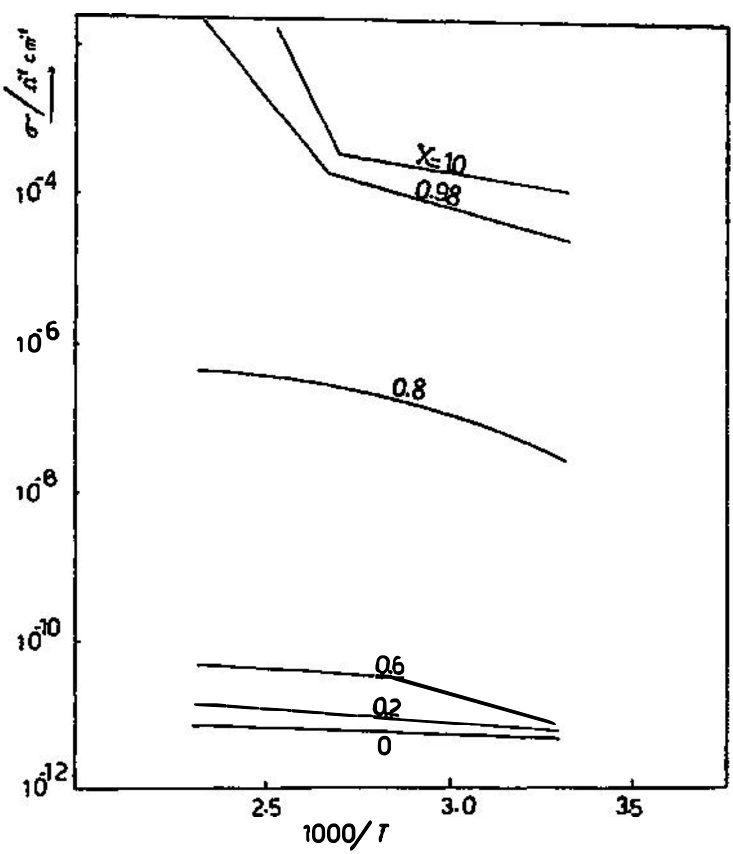

Figure 1. Temperature dependence of electrical conductivities for $Cd_xZn_{1-x}S$ with different compositions.

is still like pure CdS but with different slopes. The temperature dependence of conductivity at $x > 0.9$ was determined by the variation of carrier concentration with temperature. At $x = 0.8$ the conductivity measurements of the system $Cd_xZn_{1-x}S$ were found to be independent of temperature. This may be due to a high band gap for these compounds.

Fig. 2 shows the electrical conductivity as a function of composition factor x for $Cd_xZn_{1-x}S$ compounds at room temperature. The electrical conductivity of the system $Cd_xZn_{1-x}S$ at $0.6 < x < 1$ increases sharply from 7×10^{-12} to 3×10^{-4} $(\Omega\ cm)^{-1}$ and remain constant at 7×10^{-12} $(\Omega\ cm)^{-1}$ at $0 < x <$ < 0.6.

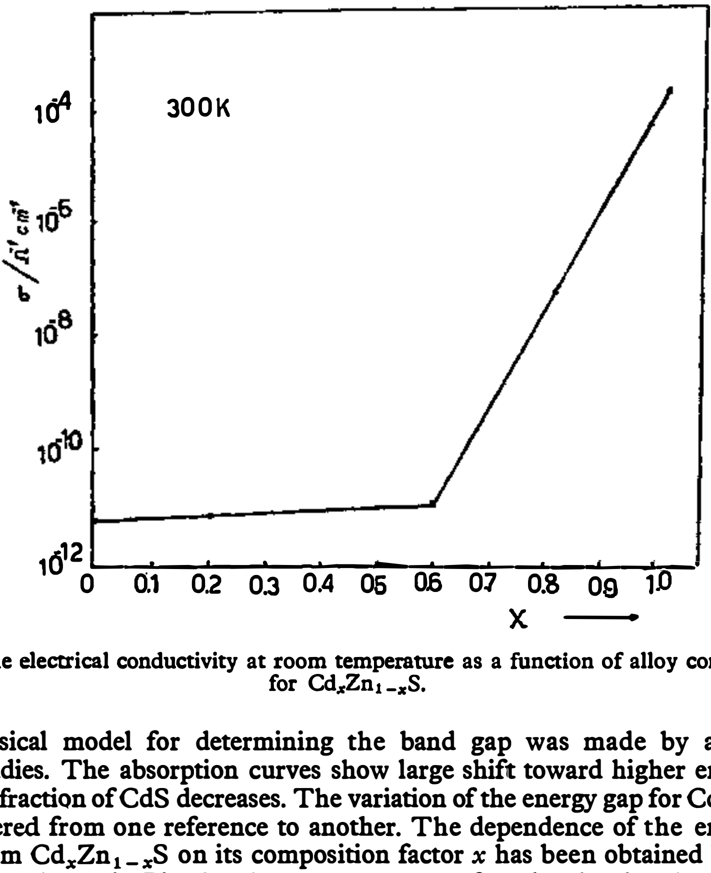

Figure 2. The electrical conductivity at room temperature as a function of alloy composition x for $Cd_xZn_{1-x}S$.

A classical model for determining the band gap was made by absorption spectral studies. The absorption curves show large shift toward higher energy side as the mole fraction of CdS decreases. The variation of the energy gap for $Cd_xZn_{1-x}S$ with x differed from one reference to another. The dependence of the energy gap of the system $Cd_xZn_{1-x}S$ on its composition factor x has been obtained by optical absorption as shown in Fig. 3. The energy gap was found to be the photon energy where the absorption is steeply increased.

The infrared spectra of all compounds were made in the range 4000—600 cm^{-1} and compared with the spectrum of mica. New bands are observed at 740, 1340, 1620 and 2065 cm^{-1} in the spectrum of the compound at which $x = 0.2$ and some bands are missing. The lowering in the intensity of these bands in the spectrum of $Cd_{0.1}Zn_{0.9}S$ as well as their absence in the pure ZnS spectrum indicates that these bands may be due to the vibrational energies of the cadmium

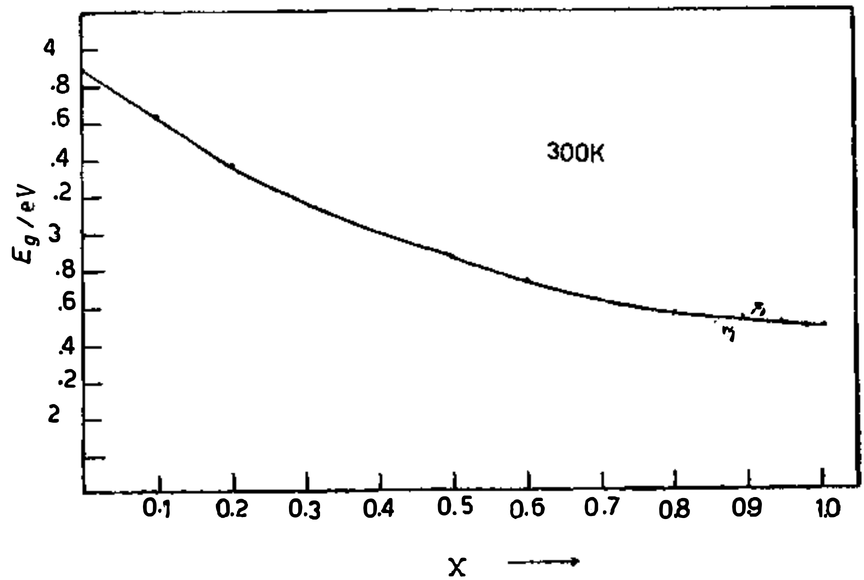

Figure 3. Dependence of energy gap E_g on alloy composition x for $Cd_xZn_{1-x}S$ at room temperature.

bonds. No work was done on the IR spectra of these compounds. Further studies with the analysis of the IR spectra will be conducted.

In conclusion, the electrical conductivity of the compounds $Cd_xZn_{1-x}S$ increases with increasing the alloy composition x. These compounds can be prepared in the form of homogeneous thin films.

Acknowledgement

The authors express their gratitude to Professor W. Rupple of KARLSHRUE institute for supplying the samples.

References

1) E. A. Davis and E. L. Lind, J. Phys. Chem. Solids **29** (1968) 79;
2) J. E. Lewis, I. E. Ture, A. W. Brinkman and J. Woods, Semicond. Sci. Tech. **1** (1986) 213;
3) R. Brain, *II—VI Compounds*, Pergamon Press (1969);
4) D. Bonnet, Phys. Stat. Sol. (a) **11** (1972) K135;
5) Sabura Kitamura, J. Phys. Soc. Jpn. **16** (1961) 2430.

ELEKTRONIČKA I OPTIČKA SVOJSTVA $Cd_xZn_{1-x}S$

MOHAMED MOUNIR

Department of Physics, Faculty of Science, Cairo University, Egypt

AHMED A. EL-ASMY

Department of Chemistry, Faculty of Science, Mansoura University, Egypt

UDK 538.95

Originalni znanstveni rad

Ternarne slitine $Cd_xZn_{1-x}S$ priređene su isparavanjem homogene smjese ZnS i CdS u prahu u odgovarajućem odnosu. Ustanovljeno je da električna vodljivost raste s porastom x. Za $x < 0{,}8$ električna vodljivost ternarne legure $Cd_xZn_{1-x}S$ je neovisna od temperature. Određena je ovisnost energetskog procijepa o faktoru kompozicije x. Infracrveni spektar mjeren je u području 4000—600 cm^{-1}.