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OPTICAL PROPERTIES OF TIN MONOSULPHIDE AND TIN MONOSELENIDE SINGLE CRYSTALS

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ABSTRACT

Optical absorption in SnS and SnSe single crystals has been measured at room temperature in the spectral range 550nm-2500nm. Absorption near the fundamental edge was found to be due to direct allowed transition and the optical band gap corresponding to this transition has also been determined. By using the values obtained from optical absorption measurements optical absorption coefficient, extinction coefficient, refractive index and real and imaginary parts of complex dielectric constant are calculated.

Keywords : *Optical absorption, Optical Constants, Tin monosulfide and Tin monoselenide*

INTRODUCTION

Among the IV-VI semiconductor compounds, tin sulphide (SnS), tin selenide (SnSe), germanium sulphide (GeS) and germanium selenide (GeSe) have the layered orthorhombic structure with eight atoms per unit cell forming biplanar layers normal to the largest c axis [1-3]. In unit cell of SnS and SnSe, atoms in a single layer are joined to three nearest neighbors by covalent bond which forms zigzag chains along the b axis while there is only Van der Waals bonding between the layers. This material shows a wide variety of interesting anisotropic optical and electrical properties, which make them interesting materials intermediate between two dimensional and three-dimensional semiconductors. These compounds have attracted considerable attention because of their optoelectronic properties [5], useful in applications like holographic recording systems [5,6], electronic switching [7,8] and infrared production and detection.

EXPERIMENTAL

Single crystals of SnS and SnSe have been grown by direct vapour transport method. For the growth process, the charge was transferred into thoroughly cleaned quartz ampoule. This ampoule with charge of material was evacuated at 10-5 torr and sealed. The ampoule was then inserted into a two-zone horizontal furnace. The front zone (reaction zone) of the furnace was maintained at 1073 K while the back zone (growth zone) was kept at 1023 K for the growth of SnS and SnSe single crystals. The room temperature absorption spectra of SnS and SnSe of thickness 100μm have been taken using UV-VIS-NIR spectrophotometer (Make: Perkin Elmer, lambda-19) in the wavelength range of 550nm-2500nm with the incident beam normal to the basal plane of as grown crystals i.e along c-axis of the grown crystals.

RESULTS AND DISCUSSION

Figures 1 and 2 show the absorption, reflectance and transmission spectrum of SnS and SnSe single crystals. A careful study of these spectra reveals the presence of an absorption edge in the spectral range 815nm to 905nm for SnS and 1190nm to 1250nm for SnSe. To analyze the results in the vicinity of the absorption edge on the basis of three dimensional models, value of α were determined at step of 1 nm.

The interpretation of experimental results, in terms of the direct and indirect transition is most often performed with the help of the following equation

$$\alpha h\nu = A(h\nu - E_g)^r \quad (1)$$

for direct transition and

$$\alpha h\nu = \sum_j B_j (h\nu - E_g` \pm E_{pj}) \quad (2)$$

for indirect transition.

Figures 3 and 4 show the spectral variation of $(\alpha h\upsilon)2$ and the value of direct band gap obtained from the extrapolation of the straight line portion [9-10]. Obtained values of direct band gap of SnS and SnSe are shown in Table 1 while Figures 4 to 8 display the variation of extinction coefficient, refractive index, real and imaginary part of complex dielectric constant with wavelength for SnS and SnSe single crystals. Using the value obtained from optical absorption, reflectance and transmittance measurements optical absorption coefficient is calculated using the formula

$$T = (1 - R)^2 e^{(-\alpha t)} \quad (3)$$

The extinction coefficient (K) and refractive index (n) have been calculated using relations

$$K = \alpha\lambda/4\pi \quad (4)$$

$$R = \frac{(n-1)^2 + K^2}{(n+1)^2 + K^2} \quad (5)$$

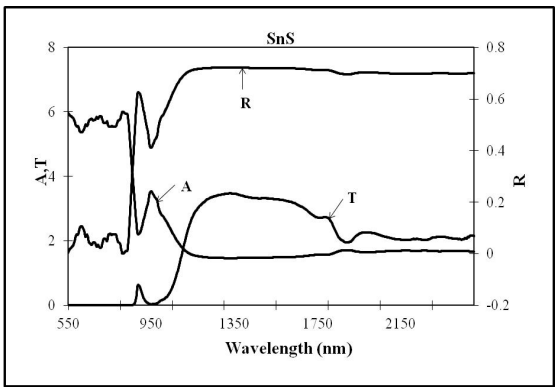

Fig. 1 Optical absorption, transmittance and reflectance spectrum of SnS single crystals.

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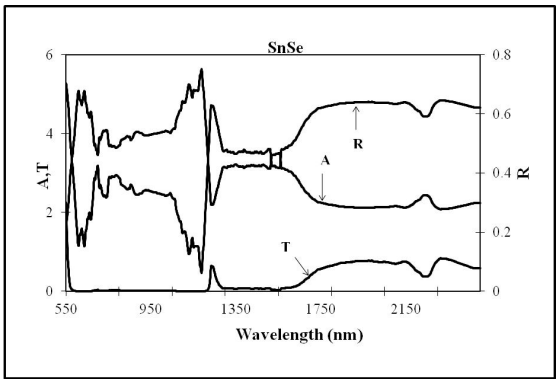

Fig. 2 Optical absorption, transmittance and reflectance spectrum of SnSe single crystals.

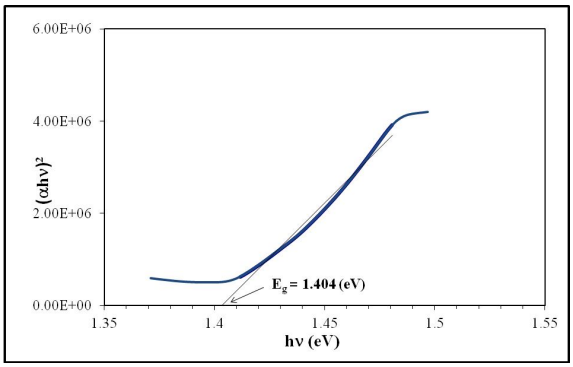

Fig. 3 Plot of $(\alpha h\upsilon)^2$ Vs $h\upsilon$ of SnS single crystals.

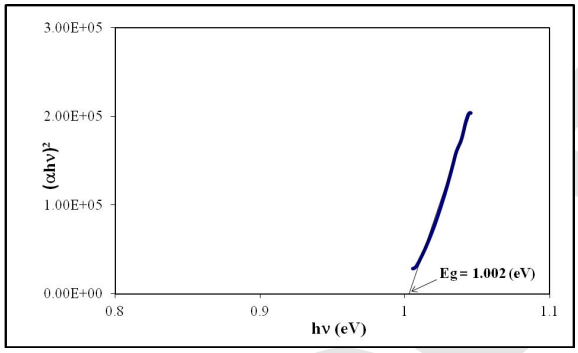

Fig. 4 Plot of $(\alpha h\upsilon)^2$ Vs $h\upsilon$ of SnSe single crystals.

Furthermore, real and imaginary parts of complex dielectric constant are determined through the following equations

$$\varepsilon_r = n^2 - K^2; \quad \varepsilon_i = 2nK \qquad (6)$$

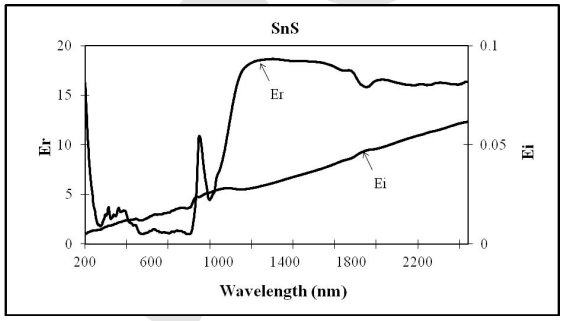

Fig. 5 Wavelength dependence of real and imaginary part of complex dielectric constant for SnS.

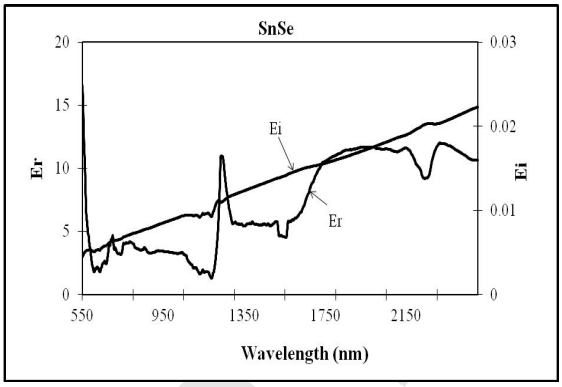

Fig. 6 Wavelength dependence of real and imaginary part of complex dielectric constant for SnSe.

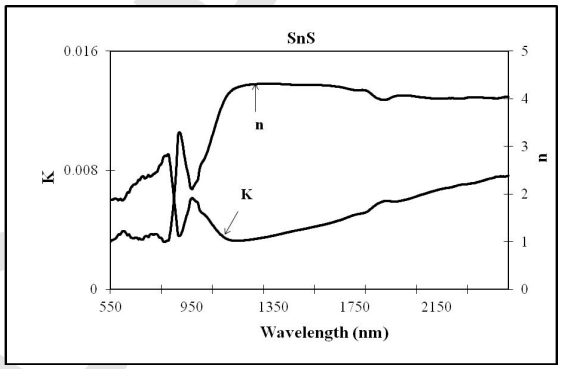

Fig. 7 plot of k,n Vs wavelength for SnS single crystals.

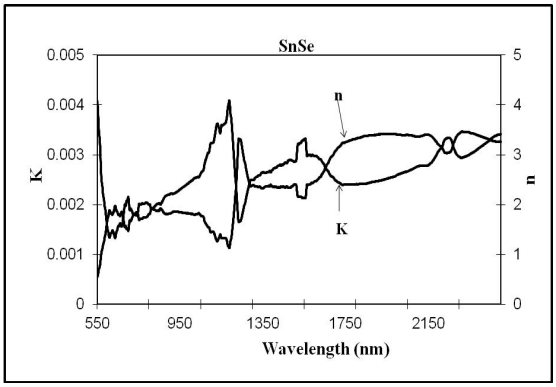

Fig. 8 Plot of k,n Vs wavelength for SnSe single crystals

Table 1 Value of direct band gap for SnS and SnSe single crystals.

	SnS	SnSe
Direct band gap	1.404 (eV)	1.002 (eV)

CONCLUSIONS

Single crystals of SnS and SnSe have been grown by direct vapour transport method. It is found that crystals studied in present case show direct symmetry allowed transitions leading to a good account of the optical absorption edge in SnS and SnSe single crystals. The band gap of nearly 1.4 eV for SnS is quite promising for it to be used as a solar material. Nearly flat response of both SnS and SnSe above 1400 nm may make them useful for optical coating.

REFERENCES

[1] Okazaki (1958) The crystal structure of germanium selenide, *J. Phys. Soc. Japan*, **13**: 1151- 1155.

[2] Logothetidis, S. and Polatoglou, H. M. (1987) Ellipsometric studies of the dielectric function of SnSe and a simple model of the electronic structure and the bands of the orthorhombic IV-VI compounds, *Phys. Rev.*, **B36**: 7491-7499.

[3] Valiukonis, G., Gussienova, D. A., Krivaite, G. and Sileika, A. (1986) Optical spectra and energy band structure of layer-type AIV-BVI compounds, *Phys. Stat. Solidi (b)*, **135**: 299-307.

[4] Parentau, M. and Carlone, M. (1990) Influence of temperature and pressure on the electronic transitions in SnS and SnSe semiconductors, *Phys. Rev.*, **B41**: 5227-5234.

[5] Bletskan, D.I., Taran, V.I. and Sichka, M. YU. (1976) Switching effect in layered IV-VI crystals, Ukr. Fiz. Zh., **21**: 1436-1441.

[6] Singh, J.P. and Bedi, R.K. (1990) Tin selenide films grown by hot wall epitaxy, *J. Appl. Phys.*, **68**: 2776-2779.

[7] Lofersky, J.J (1956) Theoretical considerations governing the choice of optimum semiconductor for photovoltaic solar energy conversion, *J.Appl. Phys.*, **27**: 777-784.

[8] Lofersky, J.J (1963) Recent research on photovoltaic solar energy converters, *Proc. I.E.E.E.*, **51**: 667-674.

[9] Elkorashy, A. M. (1986) Optical absorption in Tin monoselenide single crystals, *J. Phys Chem.Solids*, **47**: 497-500.

[10] Dholakiya, A. D., Solanki, G. K., Patel, S. G. and Agarwal, M. K. (2001) Two and Three dimensional models for analysis of optical absorption in Tungsten disulfide single crystals, *Bull. Mater. Sci.*, **24** (3): 291-296.