Study of the Structural , Optical and Transport Properties of SnSe Thin Films

Thesis

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By

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ABSTRACT

ABSTRACT

This work represents the study of structural, optical and electrical properties of SnSe thin films in the thickness range of 30 nm - 400 nm .The SnSe films were prepared by thermal evaporation as well as by flash evaporation techniques in vacuum of 10^{-5} Torr. The rate of deposition in both cases was kept constant at 60 nm/min . Two different kinds of substrates were used .Quartz substrates were used for investigating the optical properties while glass substrates were used for studying structural and transport properties.

Our studies on the structural properties of SnSe films involved both X-ray diffraction and electron diffraction techniques to check the crystallinity of the film, the transmission electron microscopy (TEM) was used to determine the grain size of microcrystallites . From this study it was found that :

1- X-ray diffraction patterns carried out for all films showed that these films are polycrystalline of orthorhombic structure.

2- The grain size increases with increasing the film thickness.

3- The films prepared either by thermal evaporation or by flash evaporation techniques have polycrystalline nature of orthorhombic structure with the same lattice parameters.

4- Increasing the substrate temperature during the deposition process as well as increasing the annealing temperature improves the degree of crystallinity of the films.

The transport properties including the dark electrical resistivity and thermoelectric power were investigated. It was found from the dark electrical resistivity measurements of SnSe films in the temperature range of 150 K - 400 K. that they behave as a semiconducting material and decreases exponentially with increasing the film thickness. Graphical representation of log $\rho = f(1000/T)$ yields one straight line in the above mentioned temperature range indicating one mechanism for electrical conduction. Thermal activation energies were calculated and it was seen that they decrease from 0.271 eV to 0.232 eV as film thickness increased from 30 nm to 305 nm . The free charge carriers concentration was found to be about 10^{15} cm^{-3}. Thermoelectric power measurements showed that, SnSe films are P-type semiconductor.

The optical properties were studied for SnSe thin films of different thicknesses using throughout two groups of SnSe films . The first group was prepared at T_s= 300 K, and the other group was prepared at T_s= 573 K. The optical constants (refractive index n , absorption index k and absorption coefficient α) of SnSe films were determined in the spectral range of 760 nm - 2200 nm. It was found that both n and k are independent on the film thickness. The obtained values of n and k were used to calculate both the real and imaginary parts of the dielectric constants, as well as the surface and volume energy loss functions. The linearity of the two relations $(\alpha h\nu)^2$ and $(\alpha h\nu)^{1/2}$ versus the photon energy $(h\nu)$ showed the existence of optical direct and indirect transitions. The direct and indirect energy gaps for the first group (prepared at 300 K) were found to be 1.27 eV and 0.895 eV respectively, while the direct and indirect energy gaps for the other group (prepared at 573 K) were found to be 1.23 eV and 0.895 eV respectively.

INTRODUCTION

INTRODUCTION

Stannous Selenide (SnSe) is a semiconductor with a band gap of about 1 eV which can be an efficient solar material[1-4]. Also thin films of SnSe have great potential because of their application as memory switching devices[5]. Recently attention has been focused on the optical properties of layered semiconductor SnSe, notably because of its use in holographic - recording systems[6]. The direct band gap has been studied by means of electroreflectance and thermoreflectance measurements[7,8] as will as by absorption measurements[9,10]. The latter technique has also been used to observed indirect transitions[9,11-15]. However considerable scatter is found among the proposed values for the electronic transition thresholds.

According to X-ray structural analysis[16-18] SnSe crystallizes in an orthorhombic lattice with a = 4.46 Å, b = 4.19 Å and c = 11.57 Å. However, according to Mikolaichak et al[19,20] as well as Palatnik et al.[21] thin films of SnSe also contain a cubic modification with the NaCl Structure. The appearance of NaCl structure in SnSe films has not been confirmed as reported by Avilov et al.[22].

These considerations induced us to undertake a systematic study of structural, electrical and optical properties of stannous selenide (SnSe) in thin film form Therefore, the aim of the present work was to investigate:

1- The structural properties of SnSe thin films.
2- The electrical resistivity as well as the thermoelectric power of SnSe thin films.
3- The optical properties of SnSe thin films.

CHAPTER (I)
LITERATURE REVIEW

CHAPTER I
LITERATURE REVIEW

The present chapter deals with the literature review concerning the structural, electrical and optical properties of stannous selenide either in a bulk form or in a thin film form.

I-1) Structural properties of SnSe.

Stannous selenide (SnSe) compound has an orthorhomobic crystal structure and belongs to the D_{2h}^{16}-Pcmn space group with the lattice constants: a = 4.46 Å, b = 4.19 Å and c = 11.57 Å[17,24] or belongs to the D_{2h}^{16}-Pnma space group with the lattice constants: a = 11.42 Å, b = 4.19 Å and c = 4.46 Å[22] or belongs to the D_{2h}^{16}-Pbnm space group with the lattice constants: a = 4.46 Å, b = 11.57 Å and c = 4.19 Å[25,26].

Palatnik and Levitin[21] studyied the structure of Sn-Se films, observed that stannous selenide had a structure of NaCl type of a = 5.99 Å.

Monocrystal SnSe prepared by Zhdanova[26] has an orthorhmibic lattice with space group D_{2h}^{16}-Pcmn . Measuring thermal expansion coefficient along the three axes, he found that there were a relative elongations along the a,b and c