STUDY OF SOME PHYSICAL PROPERTIES OF SEMICONDUCTING $Sb_X Se_{1-X}$ THIN FILMS

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STUDY OF SOME PHYSICAL PROPERTIES OF SEMICONDUCTING

Sb_xSe_{1-x} THIN FILMS

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بسم الله الرحمن الرحيم

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سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

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ABSTRACT

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In this work, an attempt had been made to give a complete picture of the behaviour of $Sb_x Se_{1-x}$ alloys where $(0 \leqslant x < 1)$ and the variation of its physical properties with the composition x.

Chapter I and II give a brief survey of the previous work about the structural, electrical and optical properties of Sb-Se system and theoritical background of the transport and optical properties of semiconductors.

Chapter III is a brief accounts on the preparation of the bulk and thin films of Sb_xSe_{1-x} with different compositions x $(0 \leqslant x < 1)$. Also the optical and electrical set up for measuring the reflection R and the transmission T at normal incidence, the conductivity and thermoelectric power S. Sb_xSe_{1-x} alloys were prepared by direct fusion of spec-pure antimony and selenium in sealed evacuated silica tubes ($5x10^{-5}$ torr) in a temperature controlled furnace at 800$\pm$5°C for 10h. Binary Sb_xSe_{1-x} amorphous thin films with $0 \leqslant x < 1$ and thickness ranging from 40-320 nm were prepared by thermal evaporation of Sb_xSe_{1-x} bulk material under vacuum (10^{-5} torr).

Chapter IV represents the results of the structural properties of $Sb_x\ Se_{1-x}$ thin films ($0 \leqslant x < 1$). Electron microscopic and X-ray diffraction techniques were used to detrmine the crystallinity and lattice parameters for these structures. The results showed that $Sb_x\ Se_{1-x}$ alloys with (X = 0, 0.1, 0.7 and 0.9) have hexgonal structure and orthorhombic crystal structure for (X = 0.3, 0.4 and 0.5). The $Sb_x\ Se_{1-x}$ films transformed from the amorphous state to polycrystalline structure on annealing at 423K and the crystallinity increased with increasing the annealing temperature.

Chapter V deals with the results of the transport properties of $Sb_x\ Se_{1-x}$ thin films in the temperature region from 70-473K. The conductivity of the $Sb_x\ Se_{1-x}$ films was found to be in the order of $10^{-12}\ \Omega^{-1}.cm^{-1}$ to $10^{-2}\ \Omega^{-1}.cm^{-1}$ for the selenium rich compositions and $10^{-5}\ \Omega^{-1}.cm^{-1}$ to 10 $\Omega^{-1}.cm^{-1}$ for the antimony rich compositions. Two processes of the d.c. conductivity in the $Sb_x\ Se_{1-x}$ films were observed in plots of $\ln \sigma$ against $\frac{1}{T}$. The activation energy as calculated from these plots was given as 0.15 eV for X=0.9 and 1.044 eV for X = 0 (Selenium) thin films.

The resistance was found to decrease by increasing the temperature. The temperature coefficient of resistance decreased from $14x10^{-2}$ to $4x10^{-2}$ C^{o-1} as X increased from X=o to X = 0.9.

The value of the thermoelectric power (S) was found to be 120 µV/degree for pure selenium and was always positive for 0<X<0.4 and 0.6<X<1, showing the majority carriers to be holes i.e., p-type conduction. For 0.4 < X < 0.6 the thermoelectric power appeared to be negative and equals to -440 µV/degree for X = 0.5 i.e. n-type conduction.

Chapter VI represents the optical measurements. The optical transmission and reflection at normal incidence of the Sb_x Se_{1-x} films were measured in the wavelength range (500-1300 nm). From the obtained data, the absorption coefficient α , refractive index n, absorption constant K, the optical energy gap E_g, the density of valence band (g) and the dielectric constants ε' and ε'' of the films were deduced. The variation of these parameters with composition and annealing temperatures in the range 300-473K were investigated.

The absorption edges for both the as deposited and annealed films indicated indirect transitions for (X = 0.1, 0.4, 0.5, 0.7 and 0.9) and forbidden direct transition for (X = 0.3). A linear dependence of the optical energy gap of the Sb_x Se_{1-x} films on the composition was observed. The energy gap was found to vary from 0.24 eV (X = 0.9) to 1.92 eV (X=o).

Annealing the films causes a decrease in the optical energy gap E_g^{opt}. The general behaviour of the variation of the optical constants n,k, ε' and ε'' with the photon energy was almost the same. These constants were found to be independent of film thickness but, vary with the composition. At the end of this work, we give a general conclusion which throw light on the obtained physical properties of Sb_x Se_{1-x} $(0 \leqslant X < 1)$ alloys and the effect of annealing on these properties.

INTRODUCTION

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Studies of electrical and optical properties of amorphous semiconducting thin films have been largely stimulated by many attractive microelectronic device applications as well as the possibility of getting an insight into the electron transport process even for the bulk material[1]. It is well known that the optical gap of amorphous semiconducting films strongly depends on their composition[2,3]. Also the conditions of thin film preparation and the thermal annealing of the films may be exploited to influence the kinetics of the film-growth stages and thereby obtain films with structures ranging from a completely disordered (amorphous) to a highly ordered form. Such a wide range of properties makes it possible to prepare a new semiconductor with specific properties required for certain applications, and hence the performance of certain devices which could not be achieved otherwise with a simple elemental or compound semiconductor.

Antimony triselenide Sb_2Se_3, a semiconducting chalcogenide of the VB and VIB groups of elements, has been of considerable interest in the course of the last few years, due to its good photoconducting properties and high thermoelectric power, which allow possible applications for optical and thermoelectric cooling devices. A number of attempts have been made by different workers[4-10] to investigate the electrical and optical properties of bulk Sb-Se alloys.

Among the outstanding features of Sb_x Se_{1-x} alloys, the continuous variation of energy band gap and lattice constant, as well as electrical and optical properties with the variation of the constituent compounds is of particular importance[11]. A few studies on the electrical and optical properties of Sb_2 Se_3[12] and Sb_x Se_{1-x} thin films[13] with $(0.0 < x < 0.5)$ have been done, but the thin films with $0.5 < x < 1.0$ of these alloys have not received much attention and the knowledge concerning the structural properties of these films is not complete.

The aim of this work is to add further studies to structural, electrical and optical properties of the Sb_x Se_{1-x} material with $0 \leq x < 1$ in the form of thin films and to examine the change in physical properties over a wide compositional range and temperatures. These properties could be correlated together to evaluate the compound under investigation as a new semiconducting material with specific properties, to fulfill certain applications.