Some Physical Properties of $Se_{75}Ge_{25-X}As_X$ Chalcogenide glass system

Thesis

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ADEL OMAR MOHAMED AHMED

(B.Sc.& Ed. - G. Deploma - Sp. Deploma)

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Faculty of Education
Ain Shams University

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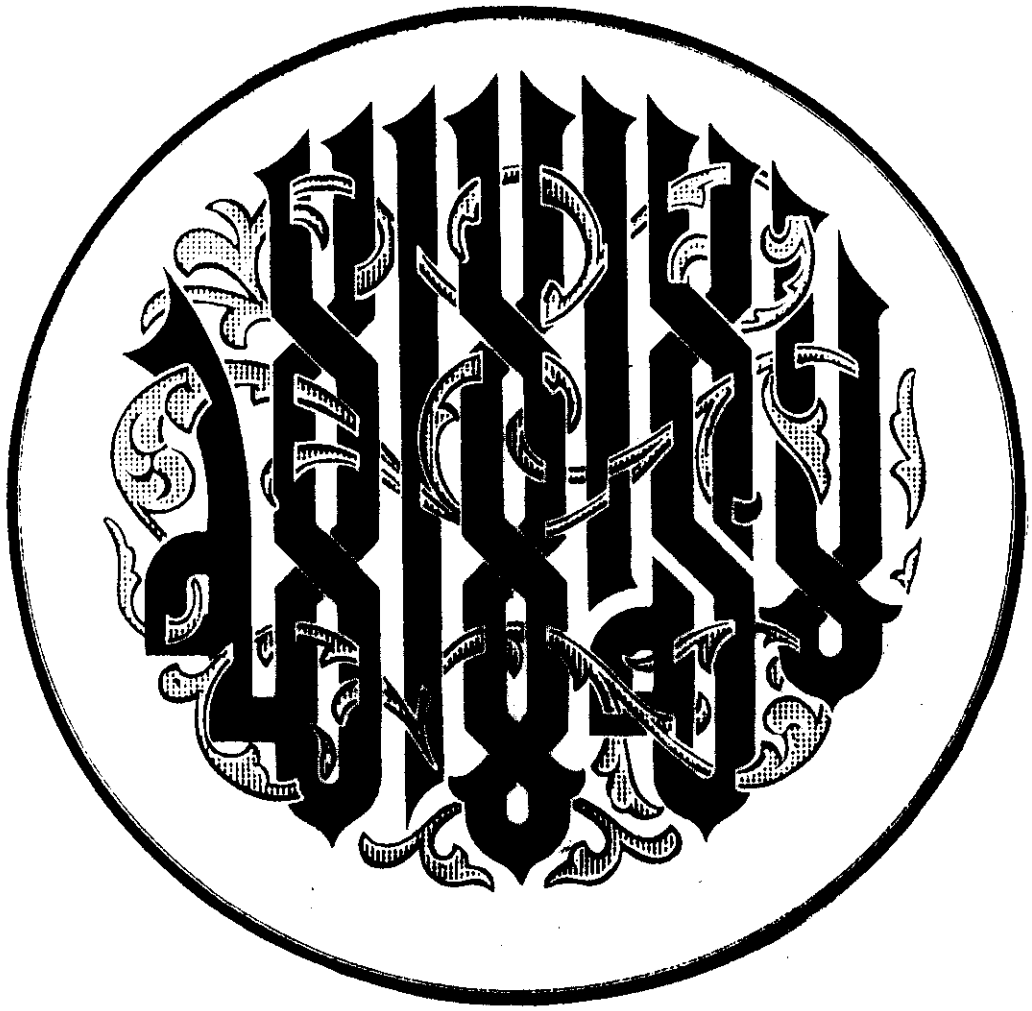

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Contents

CONTENTS

ABSTRACT

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Four different compositions of $Se_{75}Ge_{25-X}As_X$ chalcogenide glass system were prepared with atomic percentage X-5,10,15 and 20.

X-ray diffraction patterns of bulk and thin film samples of all the investigated compositions indicated its amorphous structure. Moreover, X-ray diffraction patterns of thin film samples, annealed for 1h at different elevated temperatures up to 150^{o}C showed that all samples remained in amorphous state after annealing. Differential thermal analysis of the investigated compositions showed that T_g decreased with the increase of As-content in the range (295-148^{o}C).

The electrical conductivity (σ) was measured as a function of temperature for bulk samples of the investigated compositions in the range (293 - 393K). Values of the electrical conduction activation energy E_σ decreased with the increase of As-content in the studied system in the ranges (0.99 - 0.771 eV) and (0.777 - 0.52 eV) for bulk and thin film samples respectively. The observed decrease in E_σ and T_g and the corresponding increase in σ with the increase of As-content in the investigated samples may be due to the corresponding increase in the weak bond density and the decrease in the covalent bond density at the expense of Ge-content in $Se_{75}Ge_{25-X}As_X$ chalcogenide glass system.

The pre-exponential factor C of the electrical conduction relation $\sigma=C \exp [-E_\sigma / KT]$ was obtained by the extrapolation of the obtained line of $\ln\sigma=f(1/T)$ relations to $T^{-1}=0$. The obtained values of C decreased with As-content in the range ($13X10^3$ - $3.14X10^3$ $\Omega^{-1}cm^{-1}$). This indicated conduction by the charge carriers in the extended states. As the intercept C increased the density of localized states decreased according to Mott and Davis. Thus the observed decrease in C with the increase of As-content in the investigated system probably suggests the formation of glass composition with progressively high degree of disorder.

The thermal conductivity ψ for the compositions under test was measured as a function of temperature in a range well below the corresponding T_g (293 - 362K). The coefficient of thermal conductivity increased linearly with the temperature below T_g for the compositions investigated.

Since the calculated electronic and bipolar thermal conductivity are negligibly small as compared with that measured experimentally. Thus, the main contribution of the thermal conductivity is due to lattice (phonon) thermal conductivity. Applying Debye expression for the phonon thermal conductivity, it was found that the increase of As-content at the expense of Ge-content in the investigated system may be due to the increase of phonon velocity.

Both dynamic and static I-V characteristic curves for thin film samples of $Se_{75}Ge_{25-X}As_X$ compositions showed memory switching behaviour. Heat treatment and/or ageing of the prepared samples can stabilize and improve switching parameters. It was found that the mean value of the threshold voltage $\bar{V}_{th}$ increased linearly with the sample thickness in the investigated range. It was observed also that $\bar{V}_{th}$ decreased with the increase of As-content in the investigated system which was in favour with the observed decrease of E_σ and the corresponding increase of the electrical conductivity (σ). The temperature dependence measurements of the $\bar{V}_{th}$ showed that $\bar{V}_{th}$ decreased exponentially with temperature in the investigated range of temperature. The threshold voltage activation energy (ε) decreased with As-content which was in favour with the corresponding decrease of E_σ and the increase of (σ). The obtained mean value of the ratio ε/E_σ (0.483) agrees with that derived **theoretically** (0.5) on the basis of an electrothermal breakdown process.

Values of ΔT (the temperature difference between the inside of the film and its surface) calculated by different equations, derived on the basis of different models are of the same order.

INTRODUCTION

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Semiconducting chalcogenide glasses are of great interest for both researches and technological applications. Among this type of semiconducators a special place is occupied by binary[1-9], mixed binary and ternary systems containing Selenium[10-14]. Most of these works studied the effect of adding different elements as Te, As, Ge, Sb, and S to amorphous Selenium on its electrical and thermal properties as well as on its crystalization kinetics.

In order to understand the nature of the electronic states and charge transport in amorphous solids , both structural analysis and experiments concerned with electrical and optical proprties have been performed on a variety of materials. These solids are charcterized by localized structureless tails of the conduction and valence band states. Several band models have been proposed to explain the electronic structure of these materials[15]. Although information on the properties of a large variety of semiconducting materials has been obtained, there have been few systematic analysis of particular systems. Thus an uncertainty may arise as to whether an observed phenomenonis simply a result of the special composition used, or can be interpreted as a general property of amorphous semiconducors. Moreover, the variation of structural parameters corresponding to compositional changes may give

further information about the influence of the type and degree of disorder on electronic properties. Since Ovshinsky[3] reported switching processes in thin films of chalcogenide glass alloys, there have been many attempts to explain these observations. Either switching or memory effect is observed in a given system of **chalcogenide** glass according to the type of elctronic structure and the percentage of its constituent elements. The switching phenomenon has been explained on the basis of two types of theories (I) thermally initiated[4-6] due to thermal instability and (II) electronically initiated[7-9] due to breakdown of the electronic equilibrium as a results of an applied field. Böer & Ovshinsky[5] have shown that the switching phenomenon is initiated by a thermal process followed by an elctronic process.

The present work is aimed to study the electrical and thermal properties as well as the switching phenomenon of $Se_{75}Ge_{25-X}As_X$ chalcogenide glass system. During this investigation, the effect of As-content on the studied properties was specified.

CHAPTER I

LITERATURE REVIEW