شبكة المعلومات الجامعية

بسم اللّه الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

بعض الوثائق الأصلية تالفة

Ain Shams University
Faculty of Education
physics Department

" Study of some physicl properties for Ge-Se-X ,where X= Bi, As and Sn chalcogenide glass compositions"

Thesis

Submitted for the Degree of Master of Teacher's
Preparation in Science (Physics).

By

Makram Ibrahim Ismail Gomaa
B.Sc. and Education, Gen. Diploma (Physics)
and Spec. Diploma (Physics).

To

Physics Department
Faculty of Education
Ain Shams University

2009

Approval Sheet

" Study of some physicl properties for Ge Se X ,where X= Bi, As and Sn chalcogenide glass compositions "

Candidate : Makram Ibrahim Ismail.

Degree of Master of Teacher's Preparation in Science (Physics).

Board of Advisors

Approved by Signature

1. **Prof. Dr/ M. A. Afifi.**
   Physics Department, Faculty of Education, Ain Shams University
2. **Prof.Dr/ *N.A. Hegab*.**
   Physics Department, Faculty of Education, Ain Shams University
3. **Dr/ H. E. Atiya.**
   Physics Department, Faculty of Education, Ain Shams University

Date of presentation / /2009

Post graduate studies :

Stamp : / / Date of approval : / /

Approval of Faculty Council : / / 2009

Approval of University Council : / / 2009

ACKNOWLEDGEMENT

Before all and above all, many thanks
to Allah, the lord of all being.

The author indebted with his utmost thanks to Prof. Dr/ ***M.A.Afifi the head of the semiconductors Lab.*** for continuous supervision, valuable suggestions, encouragement and fruitful advice through this work.

Deepest gratitude to Prof. Dr/ ***N.A.Hegab*** for her advice, valuable help and encouragement during this study and fruitful advice throughout this work.

The author wishes to thank Dr / ***H.E.Atiya*** for her valuable help, encouragement and fruitful advice throughout this work.

The author wishes to express his sincere gratitude to Prof. Dr/ ***Souzan Mohamed Slah El-Deen***, Head of Physics Department, Faculty of Education, Ain Shams University for rendering facilities.

Finally, the assistance of the staff members and colleagues of semiconductor laboratory, thin film laboratory are highly appreciated.

Contents

Page

List of Figures 1
List of Tables 7
Abstract 8
Introduction 10

Chapter I

Theoretical Background and Literature Review.

1.1 Semiconducting materials. 16
1.1.1 Classification of semiconductors. 17
1.2 Band models of amorphous semiconductors. 18
I.3 Electrical conduction in amorphous semiconductors. 23
1.3.1 Dc conduction in amorphous semiconductors. 23
1.3.2 Ac conduction in amorphous semiconductors. 27
1.3.3 Models for ac conduction. 35
1.3.4 Dielectric properties of amorphous semiconductors 43
1.3.5 Dielectric loss of amorphous semiconductors. 45
1.4 Switching and memory effects in amorphous chalcogenide semiconductors. 47
1.5 Previous works on some glass semiconductors 55

Chapter II

Experimental Techniques.

2.1 Synthesis of bulk samples 59
2.1.1 Powder sample preparation 61
2.1.2 Description of the oscillatory furnace 61
2.2 Preparation of thin film samples 62
2.2.1 Cleaning of substrates 62
2.2.2 Evaporation technique 63
2.2.3 Evaporation sources and materials used 63
2.3 Methods for film thickness measurements 66
2.3.1Quartz crystal thickness monitor method 66

2.3.2 Interferometric method **66**
2.4 Structural identification of the investigated compositions **69**
2.4.1 X-ray diffraction XRD method **69**
2.4.2 Differential thermal analysis DTA method **69**
2.4.3 Energy dispersive X-ray analysis EDX method **73**
2.5 Electrical properties measurements **73**
2.5.1 Dc conductivity measurements **73**
2.5.2 Switching phenomenon measurements **75**
2.5.2a Dynamic I-V characteristic curve **75**
2.5.2b Static I-V characteristic curve **75**
2.5.2c The vertical furnace **79**
2.5.3 Ac conductivity and dielectric measurements **79**

Chapter III

Structural Identification, Dc conductivity and Switching Phenomenon of $Ge_{15}Se_{60}X_{25}$,(X=As,Bi&Sn) Compositions.

3.1 Structural identification **82**
3.1.1 Density of bulk glasses **82**
3.1.2 X-ray diffraction XRD analysis of the investigated films **82**
3.1.3 Energy dispersive X-ray spectroscopy EDX of the investigated compositions **84**
3.1.4 Differential thermal analysis DTA of the investigated compositions **84**
3.2 Electrical properties of $Ge_{15}Se_{60}As_{25}$, $Ge_{15}Se_{60}Bi_{25}$ and $Ge_{15}Se_{60}Sn_{25}$ thin films **90**
3.2.1 Temperature dependence of the dc conductivity for the investigated films **90**
3.3 Switching properties for the investigated films **95**

3.3.1 Dynamic and static I-V characteristics **95**
3.3.2 Thickness dependence of the mean value of the threshold voltage. **97**
3.3.3 Temperature dependence of the mean value of the threshold voltage $\overline{V}_{th}$. **101**

Chapter 4

Ac Conductivity and Dielectric Properties of $Ge_{15}Se_{60}X_{25}$, (X=As or Bi or Sn) films.

4.1 Ac conductivity. **116**
4.1.1 Temperature and frequency dependencies of the ac conductivity for the investigated films. **116**
4.2 Dielectric properties for the investigated films. **129**
4.2.1 Temperature and frequency dependencies of dielectric constant $e_1(w)$ for film compositions. **129**
4.2.2 Temperature and frequency dependencies of the dielectric loss $e_2(w)$ for $Ge_{15}Se_{60}X_{25}$ films **137**

Conclusion **149**
Summary **153**
References. **157**
Arabic Summary

List of Figures

Subject **Page**

Fig.(1.1): Density of states and mobility as a function of energy in amorphous semiconductors. **20**

Fig.(1.2):Schematic illustration of the temperature dependence of the dc conductivity including four different conduction mechanisms (a, b ,c and d). **26**

Fig.(1.3):Schematic illustration of the frequency dependence of ac conductivity including three different conduction mechanisms (a ,b and c) . **31**

Fig.(1.4): Parameters for the CBH hop between states 1 and 2. **41**

Fig.(1.5):I-V characteristic curve for amorphous semiconductor thin film . **(a)** Threshold switch. **(b))** Memory switch **50**

Fig.(1.6): (a) The change with time of current passing through a threshold switch using a square wave pulse of duration t , t_d - delay time and t_s- switching time. **51**

(b) The relation between current passing through the sample and the corresponding growth of the memory filament.

Fig. (2.1): Schematic representation for the oscillatory furnace **60**

Fig. (2.2): The coating unit. **64**

Fig.(2.3): Resistance heaters. **65**

Fig.(2.4): [a] Fizeau fringes across a step on the substrate. **67**

[b] Optical system for measuring film thickness.

Fig. (2.5): [a] Principle components diagram of the DTA apparatus. **72**

List of figures

Subject **Page**

[b] A typical DTA thermogram.

Fig.(2.6): (a) Arrangement for Aluminum film electrode and silver paste with the investigated sample. **74**

(b): Arrangement for the electrode of thin film electrical conductivity measurement

Fig.(2.7):[a] A schematic representation of the cell used for the I-V measurements. **77**

[b] The circuit used for measuring the dynamic I-V characteristics **78**

[c] The circuit used for measuring the static I-V characteristics.

Fig.(2.8): Cut view of the furnace used for switching and bulk resistance measurements. **80**

Fig. (3.1):X-ray diffraction patterns for $Ge_{15}Se_{60}As_{25}$, $Ge_{15}Se_{60}Bi_{25}$ and $Ge_{15}Se_{60}Sn_{25}$ film samples of nearly the same thickness. . **83**

Fig (3.2a&b): Energy dispersive X-ray analysis EDX for a-$Ge_{15}Se_{60}As_{25}$ and b-$Ge_{15}Se_{60}Bi_{25}$ samples. **85**

Fig (3.2c): Energy dispersive X-ray analysis EDX for $Ge_{15}Se_{60}Sn_{25}$ sample. **86**

Fig.(3.3a):Differential thermal analysis DTA of $Ge_{15}Se_{60}As_{25}$ samples in powder form. **87**

Fig.(3.3.b&c):Differential thermal analysis DTA of :b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$ samples in powder form **88**

Fig. (3.4a): Temperature dependence of the dc-electrical conductivity for $Ge_{15}Se_{60}As_{25}$ films of different thicknesses. **92**

List of figures

Subject **Page**

Fig. (3.4b): Temperature dependence of the dc-electrical conductivity for $Ge_{15}Se_{60}Bi_{25}$ films of different thicknesses. **92**

Fig. (3.4c): Temperature dependence of the dc-electrical conductivity for $Ge_{15}Se_{60}Sn_{25}$ films of different thicknesses. **93**

Fig. (3.5):(A). Dynamic I-V characteristic curve for $Ge_{15}Se_{60}Sn_{25}$ film of thickness 196.4 nm. **96**
(B) Static I-V characteristic curve for $Ge_{15}Se_{60}Sn_{25}$ film of thickness 196.4 nm.

Fig. (3.6(a,b&c)): Room temperature I-V characteristic curves of a-$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$of different thicknesses respectively. **98**

Fig.(3.7(a,b&c)): Plot of $\bar{V}_{th}$ versus the thickness t for a-$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$ film compositions. **99**

Fig.(3.8): Room temperature I-V characteristic curves for film samples of nearly the same thickness. **100**

Fig.(3.9(a&b)):I-V characteristic curves at different temperatures for $Ge_{15}Se_{60}As_{25}$ films . **102**

Fig.(3.10(a&b)):I-V characteristic curves at different temperatures for $Ge_{15}Se_{60}Bi_{25}$ films . **103**

Fig.(3.11(a&b)):I-V characteristic curves at different temperatures for $Ge_{15}Se_{60}Sn_{25}$ films . **104**

Fig.(3.12(a,b&c)): Plots of $\bar{I}_{th}$versus T for a- **105**

List of figures

Subject Page

$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$ films of different thicknesses.

Fig.(3.13(a,b&c)): Plots of ln $\overline{V}_{th}$ versus 1000/T for a-$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$films of different thicknesses. **108**

Fig.(3.14(a&b)): Plots of $\overline{F}_{th}$ versus temperature for $Ge_{15}Se_{60}As_{25}$films of different thicknesses. **110**

Fig.(3.15(a&b)): Plots of $\overline{F}_{th}$ versus temperature for $Ge_{15}Se_{60}Bi_{25}$ films of different thicknesses. **111**

Fig.(3.16(a&b)): Plots of $\overline{F}_{th}$ versus temperature for $Ge_{15}Se_{60}Sn_{25}$films of different thicknesses. **112**

Fig.(3.17(a,b&c)): Plots of ln $\overline{P}_{th}$ versus 1000/T for a-$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$films of different thicknesses . **115**

Fig.(4.1(a&b)): Frequency dependence of the ac conductivity $\sigma_{ac}(\omega)$ for $Ge_{15}Se_{60}As_{25}$ films at different temperatures. **118**

Fig.(4.2(a&b)): Frequency dependence of the ac conductivity $\sigma_{ac}(\omega)$ for $Ge_{15}Se_{60}Bi_{25}$ films at different temperatures. **119**

Fig.(4.3(a&b)):Frequency dependence of the ac conductivity $\sigma_{ac}(\omega)$ for $Ge_{15}Se_{60}Sn_{25}$ films at different temperatures. **120**

Fig.(4.4(a,b&c)): Temperature dependence of the average value of the frequency exponent $\overline{s}$ for a-$Ge_{15}Se_{60}As_{25}$, b-$Ge_{15}Se_{60}Bi_{25}$ and c-$Ge_{15}Se_{60}Sn_{25}$ film samples. **121**