

R

PERPUSTAKAAN UNIVERSITI MALAYA

ACH-6684
INVC.....

**“OPTICAL AND ELECTRICAL CHARACTERISATION OF
CRYSTALLINE AND AMORPHOUS SEMICONDUCTORS”**

BY

S.Sunita TK1871-99 A4SSun

A dissertation submitted to the Institute of Post graduate studies and Research,
University Malaya In partial fulfillment of the requirement for the degree of
Master of Technology (Material Science).

University Malaya

October, 1998.



Dimitrofiskan pada..... 27.09.2000
No. Mikrofis..... 14911
Jumlah Mikrofis..... 2

HAMSI AH BT. MOHAMAD ZAHARI
UNIT REPROGRAFI
PERPUSTAKAAN UTAMA
UNIVERSITI MALAYA

UPR

R

PERPUSTAKAAN UNIVERSITI MALAYA

ACH-6684
INVC.....

**“OPTICAL AND ELECTRICAL CHARACTERISATION OF
CRYSTALLINE AND AMORPHOUS SEMICONDUCTORS”**

BY

S.Sunita TK1871-99 A4SSun

A dissertation submitted to the Institute of Post graduate studies and Research,
University Malaya In partial fulfillment of the requirement for the degree of
Master of Technology (Material Science).

University Malaya

October, 1998.



Dimitrofiskan pada..... 27.09.2000
No. Mikrofis..... 14911
Jumlah Mikrofis..... 2

HAMSI AH BT. MOHAMAD ZAHARI
UNIT REPROGRAFI
PERPUSTAKAAN UTAMA
UNIVERSITI MALAYA

UPR

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor Dr. D.K Roy for his invaluable advice, criticism, guidance and patience given to me throughout this work. I am greatly indebted to my co-supervisor Associate Prof. Saadah Abdul Rahman for her time and guidance given to me especially for the amorphous part. I am also thankful to her for her constructive criticism, concern and advice given through out the work in spite of her busy schedule.

My sincere thanks also goes to Prof. Muhammad Rasat Muhammad for his permission to use the Solid State Laboratory at the Physics Department and Prof. S. Radhakrishna for his permission to use the Material Science lab at IPSP.

I also express my sincere thanks to Namaoui Mohamed for his assistance and help during various part of this work. Many thanks also goes to all members of the Solid State Laboratory for their timely co-operation and friendly environment. My special thanks to Saedah bte Harun and Izdiyar for their technical assistance.

I am also grateful to University Malaya for providing a seat to pursue my higher studies and to IRPA for the financial assistance received under the PASCA scheme.

Last but not the least I express my gratitude to my beloved parents and brother for their prayers and support at home. My thanks also go to my granny for her encouragement throughout this work. I also express my deepest gratitude to my friends Lekshmi, Sundar , Sufian and Krishnan for their moral support.

Abstract

The aim of this project is to study optical and electrical properties of two different structures, namely crystalline and amorphous semiconductors. The samples studied are crystal silicon, crystal germanium and hydrogenated amorphous silicon. X-ray diffraction technique was used to confirm the crystallinity and amorphous natures of the samples. Fourier-Transform and infrared measurements were carried out on crystalline semiconductors to determine mainly the purity of the sample where as in the case of amorphous semiconductors it was used as a tool to determine the bonding configurations in which the hydrogen atom was incorporated into the amorphous silicon film. Electrical measurements on crystal germanium were done using the Four Point Probe instrument. The conductivity and energy gap of the material was determined. The conductivity of the crystal silicon was too low to be determined by the Four-Probe instrument and as such transverse aluminum electrodes were deposited on the sample and DC conductivity measurements were carried out using Keithley 236 Source Measurement Unit. From the electrical measurements the conductivity and the activation energy of the sample was determined. The optical transmission spectroscopic measurement was also carried out on crystal silicon to determine the absorption coefficient and the optical energy gap. In the case of hydrogenated amorphous silicon, the effects of annealing on the electrical and optical properties of the sample were studied. The film was annealed at temperatures of 100°C, 200°C, 300°C, 400°C and 500°C. DC-conductivity measurements on the film were carried out using lateral aluminum electrodes, at measurement temperatures ranging from liquid nitrogen temperature to room temperature. The conductivity of the film, the extended state activation energy and the density of states at the Fermi level were computed from the electrical measurements. The optical properties of the a-Si:H film was studied by optical transmission spectroscopic technique. From the optical measurements, the refractive index, the thickness of the film, the optical absorption coefficient, and the optical energy gap were calculated. Finally, the role of annealing temperature and the hydrogen content in hydrogenated amorphous silicon were analyzed.

Table of contents:

Chapter I	Introduction	1
1.1	Introduction	1
Chapter II	Theory of Crystalline and Amorphous Semiconductors	5
2.1	Introduction	5
2.2	Crystalline Semiconductors	6
2.3	Band Structure of Crystalline Semiconductors	7
2.4	Electrical Properties	8
2.5	Optical Properties	10
2.6	Amorphous Semiconductors	11
2.7	Band Structure of Amorphous Semiconductors	12
2.7.1	The Cohen-Fritzsche-Ovshinsky (CFO) Model	13
2.7.2	Davis-Mott Model	14
2.8	Electrical Transport Properties	15
2.8.1	Extended State Conduction	15
2.8.2	Conduction in Band Tails	18
2.8.3	Conduction in Localized State at the Fermi level	19
2.9	Optical Properties	23
2.10	Hydrogenated Amorphous Silicon and Dangling Bonds	29
Chapter III	Experimental Techniques and Calculations	31
3.1	Introduction	31
3.2	Techniques of Characterization of Materials	32

3.9	Annealing Process	61
Chapter IV	Experimental Results and Discussions	63
4.1	Introduction	63
4.2	XRD Results	63
4.3	Electrical results of crystalline Semiconductors	67
4.3.1	Direct-Current Electrical Characterization of a-Si:H	68
4.4	Fourier Transform Infra-red Spectroscopy	74
4.5	UV-VIS Optical Transmission Spectroscopy	76
4.5.1	Optical results of a-Si:H	77
Chapter V	Analysis of experimental Results	82
5.1	Introduction	82
5.2	Analysis of Crystalline Semiconductors	82
5.2.1	Crystalline Germanium	82
5.2.2	Crystalline Silicon	86
5.3	Analysis of Optical Characterization Results	
	of Hydrogenated Amorphous Silicon	93
5.3.1	Effect of Annealing on Hydrogen Content	93
5.3.2	Effect of Hydrogen Content on Thickness	97
5.3.3	Effect of Hydrogen Content on the Refractive index of the Sample	97
5.3.4	Effect of Annealing Temperature on the Optical Energy gap	101
5.3.5	Effect of Hydrogen Content on the Optical energy gap	103

5.4	Analysis of Electrical Characterization results of a-Si:H	105
5.4.1	Effect of Annealing on the Conductivity of a-Si:H	105
5.4.2	Effect of Annealing temperature on the Activation Energy	107
5.4.3	Effect of Annealing Temperature and Hydrogen Content on the Density of states at the Fermi level	109
Chapter VI	Conclusion	115
Appendix A		119
Appendix B		126