Physics of --- Amorphous Semiconductors

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Published by

Imperial College Press
57 Shelton Street
Covent Garden
London WC2H 9HE

Distributed by

World Scientific Publishing Co. Pte. Ltd.
P O Box 128, Farrer Road, Singapore 912805
USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661
UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

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ISBN 981-02-1381-6

This book is printed on acid-free paper.

Printed in Singapore by Uto-Print

Preface

This book is intended to be an introduction to physics of amorphous semiconductors for students in physics, chemistry, materials science or engineering and beginning engineers starting to work in applications of amorphous semiconductors. Amorphous semiconductors have now wide applications, for example, solar cells, thin film transistors, light sensors, optical memory devices, vidicons, electrophotographic applications etc. For further development of applications, it would be required to understand fundamental items which these applications are made on the basis of. I attempt to describe fundamental items in the light of physics of disordered systems, which are described in chapters 2 – 8. In chapters 9 – 12, the subject of matter in these chapters is described from my viewpoint although other ideas and interpretations are presented as widely as possible.

Amorphous materials have an important feature, namely, their anisotropic properties are averaged out, so that it is very difficult to clarify definitely their electronic properties. In crystalline semiconductors, for example, the nature of the localized centres can be clarified on the basis of measurements of electron spin resonance(ESR) and electron-nuclear double resonance(ENDOR) by taking data as a function of magnetic field direction with respect to the symmetry axis, while, in amorphous semiconductors, it is generally difficult for ENDOR measurements to lead us to a definite conclusion, because the ENDOR spectra do not consist of sharp lines, instead broad lines reflecting the distribution of the symmetry axes arising from disordered networks. From such situations,

we have many issues to be controversial, for example, the nature of trapping and recombination centres, the recombination processes, and the light-induced defect creation in a-Si:H. So, in chapters 9 – 12, those experimental results which seem important to understand the above-mentioned issues are presented and then several models reported so far are described to account for the experimental results. For the light-induced phenomena, emphasized is the role of electron-phonon interactions, so that a chapter concerning this subject is included.

At present, much attention is paid on artificial materials made from crystalline semiconductors from the viewpoints of physics and applications. Amorphous semiconducting artificial materials have also been fabricated since 1982. Chapter 13 is devoted to the description of these materials with a hope for them to be further developed as promising materials for the future devices. This field is also of particular interest from physics of disordered systems in the sense that there is an interplay between the periodic superstructure and the random arrays of atoms.

This book is also intended to be useful for researchers working in the field of amorphous semiconductors. For this purpose, chapter 14 is devoted to summarize principal properties of amorphous silicon and related materials and also of chalcogenide glasses, particularly on their electronic properties. It also includes up to date data, particularly on amorphous silicon and related materials as widely as possible, but, of course, it is impossible to include everything. Thus the reader is referred to Proceedings of 17th International Conference on Amorphous and Microcrystalline Semiconductors held in Budapest, 1997 that has been published in Journal of Non-Crystalline Solids Vol. 227 – 230, 1998.

I am particularly grateful to C. Ogihara for the preparation of the manuscript in the form of LaTeX along with index. Discussions with H. Hikita, K. Murayama, C. Ogihara, K. Shimakawa, M. Yamaguchi and F. Yonezawa were extremely helpful to write the book, to whom I wish to thank. The subject of matter of this book, particularly a-Si:H and related materials was dealt with over twenty years together with my many colleagues and students in Institute

for Solid State Physics, University of Tokyo. Particular thanks go to I. Hirabayashi, N. Kishimoto, M. Kondo, Y. Li, C. Ogihara, H. Ohta, Y. Sano, H. Takenaka, M. Yamaguchi, H. Yokomichi and M. Yoshida. The collaboration with many visiting scientists to ISSP, particularly Y. Fujita, D. Han, H. Hikita, Y. Kimura, S. Kugler, S. Nitta, S. Nonomura, K. Shimakawa, K. Takeda, K. Yatabe and F. Yonezawa is gratefully acknowledged. I would like to extend my gratitude to B. C. Cavenett and I. Solomon for stimulating discussions and collaborations and last, but definitely not least, I am particularly grateful to S. Nitta for suggesting me to write a book on amorphous semiconductors and for mediating its publication to the publisher.

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Acknowledgement

We wish to acknowledge the permission of the publishers of the following journals and the authors to reproduce copyright materials: *Advances in Physics* (Figs. 7.19, 7.20, 7.21, 8.17); *Annalen der Physik* (Fig. 11.8(a)); *Applied Physics Letters* (Figs. 11.1, 11.10, 11.16); *Japanese Journal of Applied Physics* (Figs. 10.4, 10.5, 10.6, 10.9, 11.7, 11.18, 12.1, 12.2, 14.5, 14.38); *Journal de Physique* (Fig. 14.4); *Journal of Applied Physics* (Figs. 9.21, 14.36); *Journal of Non-Crystalline Solids* (Figs. 2.9, 4.6, 4.7, 4.13, 4.14, 4.15, 4.18, 5.6, 5.7, 7.11, 7.15, 8.12, 8.14, 9.23, 9.25, 9.28, 11.5, 11.17, 11.25, 14.25, 14.26, 14.27, 14.39, 14.40, Table 14.6); *Journal of Physics C* (Fig. 7.16); *Journal of the Physical Society of Japan* (Figs. 5.11, 8.11,); *Journal of Physics and Chemistry of Solids* (Fig. 2.6); *Journal of Vacuum Science & Technology* (Fig. 13.3); *Kotai Butsuri (Solid State Physics)* (Figs. 6.7, 8.13, 11.22); *Optoelectronics* (Fig. 4.19); *Philosophical Magazine* (Figs. 7.12, 7.22, 14.29, 14.41, 14.44(a)); *Philosophical Magazine Letters* (Fig. 9.25); *Physica B* (Figs. 11.3, 14.1, 14.6); *Physical Review* (Figs. 4.9, 4.12, 4.20, 4.21, 5.3, 5.5, 6.4(a), 8.6, 8.19, 8.23, 9.11, 9.17, 9.22, 9.29, 10.8, 11.19, 11.20, 11.21, 11.22, 11.23, 11.24, 12.4, 12.5, 12.9, 12.10, 12.11, 12.12, 12.13, 12.14, 14.2, 14.9, 14.27, 14.30, 14.42, 14.44(b)); *Physical Review Letters* (Figs. 4.2, 4.8, 4.17, 5.2, 6.16, 6.18, 6.19, 8.5, 8.8, 8.9, 8.10, 9.24, 12.3, 12.8, 13.8, 13.9, 14.31); *Scientific American* (Fig. 6.17); *Solar Energy Materials* (Figs. 7.8, 8.1, 8.3); *Solid State Communications* (Figs. 8.26, 14.45, 14.46); *Solid State Phenomena* (Fig. 14.37); *Zeitschrift der Physik und Chemie, Neue Folge B* (Figs. 2.7, 2.8).

We are also grateful to the following publishers and the authors for permission to reproduce copyright materials: Academic Press, from *Semiconductors and Semimetals*, Vol. 21, Part A (Fig. 14.43), Part B (Figs. 8.7, 14.11), and Part C (Fig. 7.17), and from *Solid State Physics*, Vol. 45 (Fig. 2.5); Clarendon Press, from *Electronic Processes in Non-Crystalline Materials*, Second edition (Figs. 8.1, 8.3, Table 8.1); Heywood & Company, from *Progress in Semiconductors*, Vol. 6 (Fig. 4.10); Japanese Society of Applied Physics, from *Extended Abstract of 1996 International Conference on Solid State Devices and Materials* (Fig. 10.7); Materials Research Society, from *Materials Research Society Symposium Proceedings*, Vol. 118 (Fig. 12.6) and Vol. 258 (Fig. 11.8(b)); North Holland Publishing Company, from *Current Topics in Amorphous Materials* (Figs. 3.2, 14.15); Springer-Verlag, from *Amorphous Semiconductors* (Fig. 9.26) and from *Excitonic Processes in Solids* (Figs. 10.1, 10.2, 10.3); The United States Atomic Energy Commission, Division of Technical Information, from *Proceedings of 10th International Conference on Physics of Semiconductors* (Figs. 4.1 and 4.2); World Scientific, from *Amorphous Silicon and Related Materials* (Fig. 14.34) and from *Transport, Correlation and Structural Defects* (Figs. 2.10 and 2.11).

We wish to thank also the following individuals for providing us with their unpublished materials; M. Ichihara and K. Suzuki (Figs. 1.2 (a) and (b)); H. Hikita (Fig. 11.14).

Contents

Preface	v
Acknowledgement	ix
1 Introduction	1
2 Disorder and glass transition	7
2.1 Definition of disorder	7
2.2 Glass transition	9
2.3 Glass formation	14
3 Preparation	23
3.1 Rapid quenching from the liquid phase	23
3.2 Rapid condensation from the gas phase	24
3.2.1 Physical vapour deposition	24
3.2.2 Chemical vapour deposition	25
4 Structure	29
4.1 Diffraction pattern	30
4.2 Models for the amorphous structure	33
4.2.1 Tetrahedrally bonded semiconductors: a-Si and a-Ge	33
4.2.2 Chalcogenide glasses	37
4.3 Medium-range order of small-angle X-ray scattering	39
4.4 Computer simulation	42
4.4.1 Monte Carlo method	43

4.4.2	Molecular-dynamics method	45
5	Electronic states	51
5.1	Nature of conduction and valence bands and tail states	51
5.2	Anderson localization	60
6	Gap states and defects	67
6.1	Gap states	67
6.2	Measurements of defects	68
6.3	Dangling bonds in a-Si and a-Si:H	84
6.4	Defects in chalcogenide glasses	92
7	Transport	99
7.1	Electrical conduction near the mobility edge	99
7.2	The scaling theory of Anderson localization	102
7.3	Conductivity taking into account multiple scattering – deviation of conductivity from the Boltzmann conductivity	105
7.4	Transition from localization to delocalization and conductivity	108
7.5	Band conduction	109
7.6	Hopping conduction	114
7.6.1	Nearest-neighbor hopping	114
7.6.2	Variable-range hopping	115
7.7	AC conduction	119
7.8	Hall effect	123
7.9	Thermoelectric power	125
7.10	Relationship between the electrical conductivity and the thermoelectric power	126
7.11	Electron-phonon interaction and electrical conduction	129
7.12	Dispersive transport	130
8	Optical properties	137
8.1	Optical absorption	137
8.1.1	Band to band transition and absorption edge	138
8.1.2	High energy absorption	141
8.1.3	Tail absorption	142

8.1.4	Theoretical approach to the exponential tail	149
8.2	Photoluminescence	153
8.2.1	Intratransition within the localized centre .	153
8.2.2	Photoluminescence due to radiative recombination between electrons and holes	158
8.2.3	Photoluminescence due to radiative recombination of excitons	170
9	Recombination	173
9.1	Geminate pair recombination	173
9.2	Nongeminate pair recombination	174
9.3	Nonradiative recombination	175
9.4	Exciton recombination	178
9.5	Optically detected magnetic resonance (ODMR) .	179
9.6	Photoconductivity	191
9.6.1	Photoconduction	191
9.6.2	Basic processes in photoconduction	193
9.6.3	Temperature dependence of photoconductivity	203
9.6.4	Spin-dependent photoconductivity	210
10	Electron-phonon interaction and self-trapping of carriers	217
10.1	Self-trapping of carriers	217
10.2	Self-trapping of holes in a-SiO ₂ and a-Si:H	220
10.3	Small polarons	227
11	Light-induced phenomena	231
11.1	a-Si:H	231
11.1.1	General aspects of light-induced phenomena in a-Si:H	231
11.1.2	Mechanisms for the light-induced defect creation in a-Si:H	235
11.1.3	Annealing processes of the light-induced defects	247
11.1.4	Light-induced structural change	254
11.2	Chalcogenide glasses	255

11.2.1	General aspects	255
11.2.2	Photodarkening and photostructural change	256
11.2.3	Light-induced metastable defects	259
11.2.4	Light-induced phenomena and amorphous structures	266

12 Thermal equilibrium processes and defect formation mechanisms 269

12.1	Thermal equilibrium processes	269
12.2	Defect formation mechanisms	278
12.3	Relaxation processes for annealing of dangling bonds	288

13 Artificial materials 295

13.1	Introduction	295
13.2	Energy levels in the superlattices and band-edge modulated multilayers	298
13.2.1	Superlattices	298
13.2.2	Band-edge modulated multilayers	300
13.3	Basic properties of the superlattices and the band- edge modulated multilayers	301
13.3.1	Superlattices	301
13.3.2	Band-edge modulated multilayers	310

14 Summary of specific materials 317

14.1	a-Si:H and related materials	317
14.1.1	Hydrogen-related properties	317
14.1.2	General aspects of recombination processes and gap states in a-Si:H	326
14.1.3	Doping	354
14.1.4	Alloys	361
14.2	Chalcogenide glasses	367
14.2.1	General features	367
14.2.2	Electronic properties	368

References 383

Index 411