1. Introduction

John D. Joannopoulos and Gerald Lucovsky

For many years it had been thought to be a basic and fundamental fact that an amorphous semiconductor could not be substitutionally doped. Mott had explained, in a simple and intuitive way, that the absence of periodic steric constraints in a disordered system could allow the normal valency of any impurity atom to be completely satisfied. Thus the usual mechanism for introducing extra electrons or holes into a solid could be tremendously impeded.

Nevertheless, in 1975, W. E. Spear and P. G. LeComber demonstrated a new amorphous silicon material which could be doped. It could be doped both n-type and p-type and its room temperature conductivity could be made to vary over more than ten orders of magnitude. It was discovered that a very important feature of this material was that it contained significant amounts of bonded hydrogen. The role of hydrogen in the atomic structure, the electronic structure, and the doping mechanism remains an outstanding problem to be addressed by both theoretical and experimental investigations. Nonetheless, doping of the material opened up possibilities for the fabrication of thin-film electronic devices, including photovoltaic solar cells. These exciting prospects have led to a recent explosion of experimental and theoretical work on hydrogenated amorphous silicon and other closely related materials. These include investigations of the structural, electronic, vibrational, optical, luminescent, magnetic, transport, and photoconductive properties of these materials. The investigations to date have revealed a wealth of interesting and unusual physical and chemical phenomena.

This volume is part I of a two part series presenting an overview of the physics that underlies a virtual industry associated with the study of amorphous silicon and related alloys. Volume I concentrates on the structure, preparation techniques, and device applications of hydrogenated amorphous silicon. Specifically, Chapter 2 by J. C. Knights presents an in-depth discussion of the structural and chemical characterization of the material. Chapters 3, 4, and 5 (by W. E. Spear and P. G. LeComber, M. J. Thompson, and D. Kaplan) describe, respectively, the three most important techniques for depositing thin films of doped amorphous silicon. These include glow-discharge decomposition of silane in the presence of dopant gases, the reactive sputtering of silicon and the chemical vapor deposition (CVD) of silicon followed by post-deposition hydrogenation. These three chapters include detailed discussions of the fundamental and technological aspects of the deposition processes, as well as discussions of some of the important properties of the resultant films. Finally, Chapters 6 by D. E. Carlson and 7 by A. Madan present a thorough overview of the recent applied work that underlies the fabrication of solar cells and other important electronic devices. These chapters draw heavily on the material discussed in the preceding chapters, and also serve as an introduction to the material that follows in the second volume [1.1].

Volume II focuses on the presentation of recent fundamental theoretical and experimental investigations of electronic, magnetic, transport, vibrational, and localization phenomena associated with hydrogenated amorphous silicon and related alloys. The material is complementary to the material presented in this volume. The most important theme connecting the material in the two volumes is the intimate relationship that exists between the deposition technique and the resulting physical properties. This is a manifestation of the non-equilibrium character of the deposition technologies and the metastable nature of the resultant material.

The information contained in both volumes should prove to be quite useful for both scientists and technologists who are working at the frontiers of this field of disordered materials.

Abbreviations Frequently Used in the Text

a-Si	amorphous silicon
c-Si	crystalline silicon
μc-Si	microcrystalline silicon
a-Si : H	hydrogenated amorphous silicon
a-Si : F	fluorinated amorphous silicon
CVD	chemical vapor deposition
PES	photoemission spectroscopy
XPS	x-ray photoemission spectroscopy
UPS	ultraviolet photoemission spectroscopy
EDC	energy distribution curve
DOS	density of states
CRN	continuous random network
RDF	radial distribution function
SCL	space charge limited
SCR	space charge region
ESR	electron spin resonance
LESR	light induced electron spin resonance
NMR	nuclear magnetic resonance
ODMR	optically detected magnetic resonance

PL	photoluminescence
DLTS	deep level transient spectroscopy
EXAFS	extended x-ray absorption fine structure
PDS	photothermal deflection spectroscopy
SIMS	secondary ion mass spectroscopy
GDOS	glow discharge optical spectroscopy
LEED	low energy electron diffraction
SEM	scanning electron microscopy
TEM	transmission electron microscopy
MIS	metal-insulator-semiconductor
MOS	metal-oxide-semiconductor
MS	metal-semiconductor
FET	field effect transistor
FF	fill factor
TCO	transparent conductive oxide
ITO	indium-tin-oxide
SB	Schottky barrier
TSC	thermally stimulated current

Reference

1.1 J. D. Joannopoulos, G. Lucovsky (eds.): *The Physics of Hydrogenated Amorphous Silicon II*, Topics Appl. Phys., Vol. 56 (Springer, Berlin, Heidelberg, New York, Tokyo 1984)