Semiconductors and Semimetals

Edited by J. I. Pankove

(Volume 21 Hydrogenated Amorphous Silicon, Part A Preparation and Structure, 1984, Academic Press)

Hyrdrogenated amorphous silicon (a-Si:H) is a semiconductor with many scientific applications. In this volume, the preparation of a-Si:H by glow discharge, sputtering and chemical vapor disposition (CVD) is discussed along with the characteristics of the silane plasma and the resultant atomic and electronic structure. New preparation methods recently developed are also introduced. The reader can readily understand the preparation and the structure of a-Si:H through discussion based on extensive experimental data in Chapters 2-14.

There are many ways to prepare a-Si:H. They are discussed in detail in Chapters 2-7. The most common method is the glow discharge decomposition of silane. Chapters 2 and 3 discuss the rf and dc methods, respectively. Chapter 4 describes sputtering. Sputtering is a well-developed industrial process capable of fast deposition. Chapter 5 describes the ion beam deposition method. This method is designed to condense the Si vapor into aggregates whose size is on the order of 100-1000 atoms. Chapter 6 describes CVD. The pyrolytic decomposition of silane at 450°C produces an amorphous film that contains a small concentration of (~2 at %) of hydrogen. At ~600°C, a microcrystalline layer is obtained and above ~700°C the material becomes polycrystalline. Chapter 7 introduces HOMOCVD. A-Si:H prepared by this method have a high concentration of hydrogen (up to 40%).

An electric field in the glow-discharge decomposition is used to produce a plasma containing ions, radicals and other species, which condense on a heated substrate to form an amorphous solid. Chapter 8 reviews the interaction of ions and other reactive species contained in plasma. Inside a plasma a rich set of chemical reactions takes place. SiH_4 is broken into SiH_3, SiH_2, SiH and Si, but these fragments can combine to form Si_2H_6, Si_3H_8, $(SiH_2)n$, etc. Chapter 9 suggests that SiH_3 may be an important intermediate that binds to dangling bonds at the surface of the film before losing its hydrogen. Mass spectroscopy and Langmuir probe measurements available to characterize a plasma are discussed in Chapter 10.

A knowledge of the structure of a-Si:H is important before one can proceed with an interpretation of optical and electrical properties of the material and before one can design variable devices. The structures are discussed in Chapters 11-14. Chapter 14 introduces the details of the many possible bonding configurations in a strained amorphous structure. Strained related defects can be frozen into the structure during deposition and form localized states that lie deep inside the energy gap.

This volume is useful to any scientist or engineer who is interested in the preparation and the structure in a-Si:H. This is a part of a four-volume miniseries devoted entirely to a-Si:H. The people who hope to understand optical properties, electronic and transport properties and device applications should study other volumes, Parts B, C, and D.

Reviewer: Kazuro Murayama, Department of Physics, Faculty of Science, University of Tokyo, Bunkgo-Ku, Tokyo, Japan.

Methods of Experimental Physics

Edited by Robert L. Park and Max G. Lagally

(Vol. 22. Solid State Physics: Surfaces, Academic Press, 1985)

The field of experimental surface physics is providing a cornucopia of research opportunities that is flowing over from the most fundamental and abstract realms into highly practical, applications-oriented areas. The rapid expansion and maturation of the field has been followed by the unwieldy growth of a copious literature. Periodic reviews that focus on particular developments are always welcome in such an atmosphere. This latest volume in the Celotta and Levine Methods series meets that need and provides a superbly executed tutorial treatise emphasizing the mainstream experimental techniques used by the modern surface scientist.

The volume is organized into nine chapters written by an impressive roster of 13 contributors, who are generally well known in their subfields. The areas represented are electron diffraction and spectroscopic techniques, ion scattering and sputtering techniques, field-emission and field-ion microscopies, work-function measurement techniques, and thermal, electron- and photon-stimulated desorption techniques. In addition to providing a solid base of information, including well over 200 figures and 1,000 references to the primary literature, an abundance of practical advice can be found, such as in an ion-scattering subsection (by H. Heiland and E. Taglauer) entitled: "To buy or not to buy, that is the question."

For those seeking a different level of poetry, there is the E. W. Muller quote that opens the high-field microscopies chapter (by J. A. Panitz): "It seems as if the evasive atoms still hide from the curious eye of the casual sightseer...." For the less casual student, more than half the volume is

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devoted to scholarly exposition on electron scattering and spectroscopic techniques. Included are extensive treatments of low-energy electron diffraction (by M. G. Lagally), valence-band photoemission, including synchrotron-radiation techniques (by G. Margaritando and J. H. Weaver), core-level techniques, including x-ray photoelectron and Auger spectroscopies (by R. L. Park), and surface vibrational spectroscopic techniques (by W. H. Weinberg).

While the surface physics field is well known for its abundance of acronyms, even the most avid players of "Trivial Pursuit" amongst the readership might be stumped by "SLEEP" and "FERP." However, the reader of the opening chapter on work-function measurements (by L. W. Swanson and P. R. Davis) will discover that these identify a new wave of measurement techniques.

A limitation of the volume is that largely only the well-established techniques are presented, as opposed to the most-cutting-edge, recent developments that will shape much of the future activity in the field. Certainly inclusion of such material might have easily doubled the size of the volume, and warranted a separate treatise unto itself. But, in all fairness, the present volume is also not totally devoid of such material. In particular, the last chapter on electron- and photon-stimulated desorption (by T. E. Madey and R. Stockbauer) provides the reader with such a glimpse, after the groundwork is prepared in the preceding chapter on conventional desorption techniques (by J. T. Yates, Jr.).

The volume is highly recommended to students and active researchers alike who want a solid reference to the mainstream of experimental surface physics. While the most up-to-date findings tend to be missing, the clarity and completeness of the presentations, and the successful integration of the material ensures the volume of a long useful lifetime.

About the reviewer: S. D. Bader is a surface physicist in the Advanced Materials Section of the Materials Science and Technology Division of Argonne National Laboratory. His current research interests are in the magnetic properties of epitaxial films and monolayers, as studied by electron-spectroscopic, magneto-optic, and insertion-device synchrotron-radiation techniques.

Rapid Solidification Technology for Reduced Consumption of Strategic Materials

J. E. Flynn

(*Noyes Publications, 1985*)

A prospective reader would be well advised to avoid this photo-offset repackaging of a report, originally prepared for the U. S. Bureau of Mines, that bore a different and more appropriate title. The original document undoubtedly served its sponsor fairly well, providing a relatively compact description of the technology of rapid solidification, and a fair assessment of the technical issues. Unfortunately, there doesn't seem to be a legitimate wider audience for a publication that should have been more carefully edited, and which contains a number of technical inaccuracies, one of which is fatal. The hope for a new, strategic element-free family of nickel-base superalloys, processed by rapid solidification, was proven to be futile at least four years ago. Chromium was found to be indispensable for adequate corrosion and oxidation resistance. It is not useful to continue holding up the prospect of reduced strategic element consumption as a potential benefit of rapidly solidifying nickel-base alloys when more recent, contradictory information exists.

There may be a legitimate need for hardbound reproductions of documents that were originally prepared as government reports, particularly in order that a wider audience might be reached. However, such a need ought not to be automatically assumed; rather, it should be very selectively applied, and books such as this one might not be printed.

About the reviewer: Loren A. Jacobson is staff member at Lawrence Livermore National Laboratory and former program manager, Defense Advanced Research Projects Agency.

Current Topics in Photovoltaics

Edited by T. J. Coutts and J. D. Meakin

(*Academic Press, 1985*)

Solar cells are sure to play a significant role in the provision of the future electricity supplies. This volume addresses currently important topics in the photovoltaics in Chapters 1-5.

Chapter 1 deals with theoretical aspects of heterojunctions. The authors pay attention to the advantages and disadvantages of heterojunctions and present a detailed analysis of the individual contributions to the reverse saturation current. Chapter 2 deals with solar cells based on the Cu-ternary compounds and, in particular, with $CuInSe_2$. There is interest in this material because it is one of three systems which in thin film form have yielded device efficiencies greater than 10%.

Chapter 3 deals with a-Si:H-based solar cells. The author indicates the advantages of this material system which are a very high optical absorption coefficient, controllable type conductivity, low-cost and low-energy-intensity material, a very simple growth technique and the potential for economies of scale. Chapter 4 reviews the recent work on advanced high-efficiency concentrator solar cells. Chapter 5 concerns the extensively investigated CdS/Cu_2S cell. The Chapter begins with an historical review of the device from its early relevance to space applications. Useful studies have been made of the copper-sulfur phase diagram and of the diffusion coefficient of copper in CdS.

Each of the chapters intends to represent an up-to-date assessment of the particular topic and be self-contained. This volume is very useful to any engineer and scientist who is interested in the solar cells.

About the reviewer: Kazuro Murayama is a research associate of the University of Tokyo. He was a technical staff member of Bell Laboratories in 1980 and a visiting scientist at MIT in 1981.

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