Materials Science in Microelectronics I: The Relationships Between Thin Film Processing and Structure, *2nd Edition*

E.S. Machlin
(Elsevier, 2005)
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A flux of atoms, molecules, or molecular fragments impinging on a cold substrate will condense to form a thin film, a conformation that is a rich source of topics in materials science as well as being essential to microelectronics and other important technologies. Film growth is a highly nonequilibrium process, so the condensed film will not be a perfect instantiation of the thermodynamically stable crystal structure but may exhibit structure on length scales from nanometers to the macroscopic, including point defects, fibrous voids, grain boundaries, and delamination, for example. This book explicates the nature of thin-film structure and its relation to the processes involved in synthesis. The book is densely packed with insights and careful reasoning about the interaction between important process variables and the nano/microstructures that develop during growth of metal and covalent semiconductor (e.g., Si and Ge) thin films; the growth of films of oxides, organic compounds, and other important materials is not addressed directly. The processes discussed are mainly those involved in physical vapor deposition (e.g., evaporation, sputtering, and laser ablation) rather than chemical vapor deposition, which is the dominant technique used in microelectronics manufacturing. Overall, the book is relatively narrow in scope and deep in treatment, though not quite a monograph.

This book is not suitable as the basis for a first course on thin-film materials science, since it presumes a substantial level of background knowledge. An introductory book, such as Ohring's *The Materials Science of Thin Films* (Academic Press, 2002), would be more suitable for that purpose. Tu, Mayer, and Feldman's *Electronic Thin Film Science for Electrical Engineers and Materials Scientists* (Macmillan, 1992) develops some of the same material as the present book, but with a more quantitative and pedagogical approach (and is unfortunately out of print). The present book is probably best suited to students in a program leading to a master's degree in engineering or practitioners in the field who would like a deep and functional understanding of the development of structure in metal and covalently bonded semiconductor thin films.

This book is an update of the 1995 first edition; it is about 15% longer than the first edition and includes a new short chapter on surface structure, updated references and discussions, and some minor corrections. While it collects and presents a great deal of information, in some places the discussion is obscure or vague. For example, the discussion of "high-dielectric constant" oxides (Appendix 2 of Chapter VII) employs the term "effective oxide thickness" without defining it, which could have been accomplished with a trivial equation. The book is well organized (with up to five heading levels, perhaps excessively so) and well produced, although I must complain about the multiparagraph chapter summaries that are printed in a low-legibility (italic) font.

By shunning a rigorous quantitative treatment of many of the included topics, the book incurs some pedagogical weakness, but perhaps it realistically reflects the state of thin-film technology, which is still as much an empirical art as it is an engineering discipline.

Reviewer: *R. Bruce van Dover is a professor of materials science and engineering at Cornell University. His research, including 22 years at Bell Laboratories, has focused on the synthesis and properties of superconductor, semiconductor, magnetic, dielectric, and optical thin films.*

Handbook of Ellipsometry

Harland G. Tompkins and
Eugene A. Irene, eds.
(William Andrew, 2005)
870 pages; $235.00
ISBN 0-8155-1499-9

Despite its roots in the work of Drude in the 19th century, ellipsometry remained a little understood and obscure tool until the past two decades. Since then it has blossomed into a powerful and versatile analytical technique for surface and thin-film characteristics. These recent developments are largely the result of the availability of modern, capable commercial instruments and computerized data acquisition and analysis. The technique remains a challenge for many researchers, however, because of the formidable mathematical basis of the properties of polarized light and its interaction with materials, and the unfamiliar methods needed to make precise measurements. For these reasons, it is essential to have a high-quality, up-to-date reference available for both the expert and the knowledgeable user. Tompkins and Irene have produced such a volume in the *Handbook of Ellipsometry*. They have assembled an impressive group of expert contributors who cover all aspects of ellipsometry: the fundamental theory of polarized light, optical properties of materials, components and configuration of modern ellipsometers, data analysis techniques, a survey of critical applications, and emerging areas of interest.

This volume fills a void that has existed for some years. The classic but imposing *Ellipsometry and Polarized Light* by Azzam and Bashara (Elsevier, reprinted 2003) has long been the standard reference source, geared toward experts, but is now dated on techniques and applications. Tompkins has produced two volumes in the meantime that are geared more toward users from other fields of expertise and lack the detail and fundamental grounding necessary for a comprehensive reference. The current book remedies this situation by providing both the theory and applications in an approachable manner without sacrificing rigor.

Nearly half of the book is dedicated to ellipsometer configurations, data acquisition, sources of error, and methods of analysis. This emphasis on the technique is particularly useful to the researcher in selecting the proper measurement and extracting the most accurate information from the measurement. Since ellipsometric data analysis is inherently model-dependent, proper choice and understanding of optical models are essential to effective use of the technique.

The book presents a comprehensive review of applications of ellipsometry in the measurement of SiO_2 films, growth, and interfacial properties. This is appropriate, since for most of the last half-century, the primary use of ellipsometry has been to measure SiO_2 films for microelectronic devices. Other common applications are treated in much less detail, if at all, and perhaps the book could have benefited from a broader selection of examples. The chapters on emerging areas of application should be very welcome to researchers in these fields who will find a powerful new tool at their disposal.

This book should appeal to both the specialist in optical properties of materials as well as those in other fields wishing to take advantage of the unique capabilities of ellipsometry.

Reviewer: *Thomas M. Mayer is a technical staff member at Sandia National Laboratories in Albuquerque, New Mexico. He has long been interested in surface science of thin-film growth and etching, including* in situ *applications of ellipsometry in these studies.*