Film Deposition by Plasma Techniques

By Mitsuharu Konuma, Springer-Verlag, 1992, 221 pp.

This monograph reviews the fundamentals and applications of low-pressure, electric gas discharge plasmas for the deposition of thin solid films and for surface modification. Applications of this technology are focused primarily on the electronic, optical and related materials processing fields. It is organized with several chapters at the beginning reviewing some of the basic principles of low-pressure, nonequilibrium discharge plasmas. The later chapters cover various technological applications.

Chapter 1 presents a few of the basic plasma phenomena including Debye lengths, electron plasma frequency, and various sorts of gaseous plasmas as characterized by plasma density and electron temperature. Chapter 2 summarizes some fundamentals of collisional processes including electron-neutral and ion-neutral cross sections, potential energy diagrams, and electron and ion transport characteristics in low-pressure gases. The treatment is not deep, but covers most of the basic principles including some data.

Chapter 3 describes some discharge phenomena. There is a brief survey of direct current (dc), radiofrequency (rf), and microwave discharges. There is no attempt to be quantitative, and there is no discussion or even mention of the growing literature on discharge modeling and simulation. I found this to be an unfortunate omission, since a great deal of progress has been made in this area in the last five years and has helped tremendously in putting the field on a more quantitative basis.

Chapter 4 reviews discharge diagnostics. This material is covered more completely than the section on discharge phenomena. This may be due to the fact that most of the described techniques were fairly well known by about the mid-1980s. Optical techniques mentioned include laser-induced fluorescence, laser absorption, optical emission, coherent anti-Stokes Raman, and optogalvanic spectroscopies. Langmuir probes, electron spin resonance and microwave interferometry round out the chapter. Unfortunately, the author chose not to include any film characterization techniques in the review of diagnostics. This is perhaps the single biggest omission in the book. Indeed, the author mentions the importance of film characterization techniques in his preface. One can often obtain unique film properties from plasma-deposited films. The use of appropriate film characterization methods is essential in any plasma deposition or surface modification program.

Surface processes are reviewed in Chapter 5, including adsorption, reaction, and sputtering. This chapter leads into the applications chapters, starting with physical vapor deposition. Sputtering, reactive sputtering, ion plating techniques, and some discussion of the reactor types used in each application are presented. Chapter 7 consists of a survey of films deposited, gas chemistries used, and reactor configurations employed in plasma-enhanced chemical vapor deposition (PECVD). Finally, Chapter 8 concludes the book with various surface modification technologies using plasmas such as nitriding and carbiding metals, and anodization of semiconductors.

In summary, the treatment of all material is at an elementary level with a rather cursory coverage in most cases. The restriction to deposition eliminates the etching literature, which is much broader and deeper than the deposition literature, and contains many insights into plasma processing that is also relevant to deposition technologies. Major drawbacks are a lack of any mention of the recent progress on discharge modeling and any discussion of film characterization techniques. In spite of these limitations, I find this to be a useful addition to the existing literature, which is far from extensive. There are a few collections of chapters from various authors available that cover some of the same material, but these collections typically suffer from a variable level of quality and depth of coverage. Considering the current state of the literature, this book is a useful contribution to the field of nonequilibrium plasma materials processing.

David B. Graves
Dept. of Chemical Engineering
University of California-Berkeley
Berkeley, CA 94720

Chaotic and Fractal Dynamics—An Introduction for Applied Scientists and Engineers

By Francis C. Moon, John Wiley & Sons, New York, 508 pp., $59.95.

This book is an extension of the author's popular book *Chaotic Vibrations* by the same publisher in 1987. The added materials include more recent experiments on chaos, including J. Ottino's experiments on chaotic mixing, a more in-depth introduction to the concept of fractals and a new chapter on the fashionable topic of spatio-temporal chaos and automata simulations. The content and style of the book, however, remain similar to the earlier book, and most of the comments below apply to both books.

It is a valuable reference on chaotic dynamics from the physical (experimentalists') perspective. A large fraction of all experiments on chaos are carefully categorized and explained in the most rudimentary mathematical language. Simple numerical experiments and curio-shop toys that can pique the curiosity of an intelligent science and engineering major are also detailed. As such, it offers a bridge between the highly mathematical treatises on nonlinear dynamics, such as the classic by Guckenheimer and Holmes, and the popular science paperbacks that recently appeared on the *New York Times'* best-seller list. It belongs on the shelf of every researcher in the field and is an especially informative primer for a graduate student or someone interested in entering the field. It is unsuitable as a text, however, because of its lack of mathematical details. Nevertheless, most mathematical theories on chaos are addressed in a cursory manner such that an interested reader can get a flavor of the physical and geometric concepts behind the mathematics and pursue the details elsewhere. It is hence an excellent reference for a course on nonlinear dynamics.

The writing style is concise and clear, a welcome departure from the overly flowery language of some chaos expositors. Colorful graphics, a must for a book on chaos, are also present but they are mercifully kept to a bare minimum. The exercises after some chapters are rather simplistic and are probably unnecessary for this kind of book.

All in all, I enjoyed reading the book and strongly recommend it to beginning researchers, especially those interested in the physical aspects of chaos.

Hsueh-Chia Chang
Dept. of Chemical Engineering
University of Notre Dame
Notre Dame, IN 46556

Granular Matter: An Interdisciplinary Approach

Edited by A. Mehta, Springer-Verlag, New York, 306 pp., 1994.

This book compiles a collection of interdisciplinary approaches for studying granular matters, with focus on the physics of granular matters. For instance, discussions on self-organized criticality and the lack of characteristic time and length scales at the critical state are useful to those who can benefit from viewing these phenomena as "generic examples" and derive implications for their specific granular systems. The same comment also applies to several other topics covered in this book, such as the entropy of a powder and the hard-sphere model for colloidal suspensions. Some intriguing experimental and computer simulation results are presented. These include pattern formation in a hopper flow, packing geometry as a function of vibration, and mixing and segregation of different size granular solids. Mathematical modeling for these phenomena is still in its embryo and thus only sketched in this book. The last chapter of the book offers a view that is closer to the traditional engineering concept of granular matters than the rest of the book. It discusses the possibility of modeling a granular matter as a continuum using the Mohr-Coulumb description or plastic theory with brittle and ductile fracture, as well as friction at walls. An overview of how to utilize micromechanics in the above three continuum modeling is also provided.

In summary, this book captures highlights of our current understanding of the physics of granular matters. Every chapter is written with great insight. It is a useful reference for those who are interested in knowing the complexity of granular matters, as well as our present approach in describing some complex phenomena arising from granular matters. It, however, is not for design engineers who handle granular matters.

Hayley Shen
Dept. of Civil & Environmental Engineering
Clarkson University
Potsdam, NY 13699

Polymeric Gas Separation Membranes

By R. E. Kesting and A. K. Fritzsche, Wiley Interscience Publishers, New York, 1993, XI + 416 pp.

When reviewing a book, I try to decide if I would be willing to spend my own money to buy it. My willingness to open my wallet increased as I progressed through this book. On p. 1, I encountered the statement: "We feel, furthermore, that in the case of rigid glassy polymers, particularly those with high glass transition temperature (*Tg*), a gas separation model incorporating the concept of fixed micropores is worthy of consideration. It is our contention that the related field of reverse osmosis has suffered from the widely held, but nevertheless debatable, concept that a given polymer exhibits intrinsic permeability and selectivity."

From a quick glance at this 416-page book, I anticipated some painful reading, since I am one of those people who suffer from this widely held concept. Fortunately, after this initial shocking statement, I found that the book was not extreme and contained useful data on new materials, membrane structures, and even complete module systems. The information on module systems was covered better than most other treatments of the topic; since it was the last chapter, I closed the book with the feeling that it was worth adding to my library.

The information on materials, properties, and methods for making membranes was useful, but a bit questionable in places. I felt the authors ascribe too much importance to "transient templates" and the nonequilibrium nature of the glassy state compared to the intrinsic chemical backbone nature. They note that their perspective was biased by their experience in which a "new" material approach to membrane development was beaten by the program they helped pioneer at Monsanto, which has come to be known as the "prism α." Their highly successful membrane formation work produced a three- to fourfold improvement in productivity with no loss in selectivity.

In my opinion, the competing "new material" program they compare to was *not* actually a new material in the normal sense of the word, but rather a partially chemically modified old material. Truly new materials have properly selected novel backbone structures derived from well-defined monomers. This is quite different from an *ad hoc* chemical post treatment modification of an already-formed asymmetric membrane such as that referred to by these authors. In fact, *both* new materials and new membrane formation processes are critical for continued advances in the gas separation field.

Despite their stated tendency to favor membrane formation and processing in the pursuit of advances in gas separation systems, the authors have done a nice job in summarizing the tremendous amount of data on new materials. They have also provided some useful insights and interpretations with regard to the effects of molecular structure on permeation and separation properties. From my perspective, however, a problem does exist with some of the discussions in Chapter 4 regarding "nodules" and microvoids. The authors stretch the bounds of polymer physics beyond where I personally feel comfortable in interpreting nonequilibrium aspects of glassy films and membranes. Discussions of the source of the nonequilibrium nature of glasses are confounded with the existence of highly questionable nodular structures supposed to exist in liquid solutions and even in the amorphous solid state. Thus, read these sections with a critical eye and with the understanding that some of the