TABLE 2
Recommended Reading Materials

- Raymond B. Landis, "An Academic Career: It Could Be for You," American Society for Engineering Education (1989)
- Philip C. Wankat and Frank S. Oreovicz, "The Graduate Student's Guide to Academic Job Hunting," *Chem. Eng. Ed.*, **17**(4), 178 (1983)
- Christopher N. Bowman, "Teaching in the First Few Years: From the Perspective of a New Faculty Member," *Chem. Eng. Ed.*, **28**(4), 280 (1994)
- Deborah Olsen and Mary Deane Soprcinelli, "The Pretenure Years: A Longitudinal Perspective," *New Directions for Teaching and Learning,* **50,** 15 (1992)
- Jeff Meade, "Life Before Tenure," *ASEE Prism,* November (1992)
- "How to Write a Scholarly Paper," *ASEE Prism,* February (1994)
- "Survival Kit for New Engineering Educators," *ASEE Prism,* October (1994)
- Anne Eisenberg, *Effective Technical Communication,* McGraw-Hill (1982)
- Philip C. Wankat and Frank S. Oreovicz, *Teaching Engineering,* McGraw-Hill (1993)
- Kenneth E. Eble, *The Craft of Teaching,* 2nd ed., Jossey-Bass (1988)
- Cliff I. Davidson and Susan A. Ambrose, *The New Professor's Handbook,* Anker Publishing (1994)
- "Survival Skills for Scholars," a series of fourteen volumes published in 1993-94 by Sage Publications, Inc., covering a wide range of topics related to an academic career. Some examples are: Volume 1, Improving Your Classroom Teaching; Volume 5, Coping with Faculty Stress; Volume 8, Getting Tenure; Volume 11, Successful Publishing in Scholarly Journals

"I would like to thank you and all the guests for sharing your experiences. It is always rewarding to be reminded that graduate school is not only confined to science."

SUMMARY

It has often been said that being a university professor is the only profession that requires no formal training. While this may be an overstatement, it does underscore the fact that almost the entire graduate education is geared toward preparing our students to be research scholars, which is just one of the many roles a faculty member plays. Even though such preparation is indeed critically important, it should not preclude development of other skills. After all, as most people would agree, having content expertise is a necessary but insufficient condition for being an effective teacher.

Our seminar series is a small step, but in our view a step in the right direction, toward making our students aware of both the multifaceted nature of a faculty career and the wide array of skills that are necessary to succeed in it. Together with the college and university programs mentioned earlier, we have made available to our students ample resources that will better prepare them to become the next generation of chemical engineering educators.

As a result of our positive experience, we intend to offer the same seminar series in the future, most likely once every two years, so that different groups of students can participate. It is my hope that this article will lead to the development of similar activities in other chemical engineering departments.

ACKNOWLEDGMENT

The seminar series described in this article was supported by a W. M. Keck Foundation Engineering Teaching Excellence Award. ❐

ChE book review

PROCESS ENGINEERING ANALYSIS IN SEMICONDUCTOR DEVICE FABRICATION

by S. Middleman and A.K. Hochberg
McGraw Hill, New York, NY; $60.50 (1992)

Reviewed by
Bridget R. Rogers; Timothy S. Cale
Motorola, Inc.; Arizona State University

The authors of this text state that their goal is to demonstrate that chemical technology plays a central role in microelectronic device fabrication. The text fulfills this stated purpose and is relatively complete for use in an undergraduate course focused on process analysis. It not only provides focus for a course, but also helps convince the reader/student that chemical engineering fundamentals can and should be applied in the microelectronics industry. The demand for courses that introduce students to microelectronic devices, industrial terminology, and the unit operations associated with device fabrication has increased as more and more chemical engineering graduates are employed in the microelectronics industry.

The first two chapters serve to introduce solid state physics and its application to solid state device operation and performance. These chapters motivate much of the processing analyzed in the remainder of the text, and the basic bipolar process flow presented emphasizes the complexity

of semiconductor device fabrication. These chapters also help chemical engineering students learn more of the terminology used in the industry. The material covered is important to chemical engineering graduates who enter the microelectronics industry; they will be expected to know the basics of device operation. Considering the brevity of these chapters, supplemental material from other books should be used; for example, material from selected volumes in the Modular Series on Solid State Devices edited by G.W. Neudeck and R.F. Pierret (Addison-Wesley).

Chapter 3 is a quick review of undergraduate transport phenomena particularly relevant to microelectronic materials processing. It also tells the reader that the text is oriented toward (at least simple) mathematical models of processes. Material in this chapter can be referred to as needed while covering other material. In addition to being useful as a review, this chapter also provides some (much needed) discussion on modeling and its role in process development.

Chapters 4 and 5 deal with the cleanliness of the fabrication environment and generation, transport, and removal of particles, while Chapter 6 deals with chemical purity. These three chapters are interesting, and much of the material presented will be new and/or enlightening to chemical engineering majors. But they are not as important to an entry-level process engineer as the last eight chapters.

The remaining eight chapters of the text discuss some of the unit operations used in manufacturing microelectronic devices, as indicated in the Table of Contents listed below. These chapters form the core of a course on process engineering analysis of semiconductor device fabrication. The material in these chapters can be supplemented by a text such as *Silicon Processing for the VLSI Era: Vol. 1. Process Technology,* by Wolf and Tauber (Lattice Press), which provides more detailed process as well as materials properties and performance information.

Table of Contents

1. Some Background in the Physics of Solids
2. Device Background
3. Process Modeling
4. Cleanliness and Purity in the Process Environment: Filtration of Particulates
5. Particle Deposition and Removal
6. Production and Maintenance of Purity on Process Chemicals
7. Silicon Production
8. Oxidation of Silicon
9. Microlithography
10. Doping
11. Etching
12. Chemical Vapor Deposition
13. Ion Implantation
14. Metallization

The authors provide helpful guidance in their lists of references at the end of each chapter; however, they list very few references more recent than 1989, with only three references more recent than 1990. This is adequate for a text designed to introduce students to some of the chemistry in microelectronics processing and to many unit operations currently used in mass production. Thus, with supplemental material, it is useful for graduates who enter a production facility.

The text certainly serves as an introduction to engineering analysis of semiconductor device fabrication for graduate students. Because they are more likely to work in process development and perhaps even research, much of the coverage is out of date and many currently hot topics are not addressed; *e.g.,* conformality or step coverage of deposited films and high-density plasmas. In addition, photoresist exposure and wavelength trends in lithography and wafer cleaning are not addressed. On the other hand, the material that is covered in some detail is generally well presented, and there are good problems which support the learning process.

The authors devoted considerable effort to developing relevant and useful examples and problems that demonstrate the application of the theory presented in the text. A solutions manual is available; however, it presents solutions to less than half of the problems, and some of the solutions are cursory. As the book is adopted for courses, the solutions manual should become more complete. A nice feature of the solutions manual is that it contains errata to the text.

Whether the emphasis of an introductory course is on process engineering analysis or on process materials science, the two topics should not be taught separately. Skill in engineering analysis and knowledge of processes and materials are essential to semiconductor materials process engineers. Whereas previous texts have fallen short on engineering analysis, this text falls short on processes and materials. For example, the space allotted to metal deposition by evaporation and production of high-purity chemicals might be more effectively used for information on specific processes and materials properties and performance.

The text has been adopted for use in the introductory semiconductor materials processing class offered in the Department of Chemical, Bio, & Materials Engineering at Arizona State University for the fall of 1995. This is a three-semester-hour course designed for undergraduate and graduate students. Students with majors other than chemical engineering also take the course, particularly students majoring in materials engineering. Wolf and Tauber's text has been used as the class text in previous semesters, with supplemental notes covering process engineering analyses. In the fall 1995 semester, Wolf and Tauber and instructor notes will provide information on specific processes and materials properties. Having the more mathematically oriented information provided in the reviewed text should be particularly beneficial and enlightening to the non-chemical engineering majors in the class. ❐