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VOLUME V
Introduction to Microelectronic Fabrication

RICHARD C. JAEGER
Auburn University

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Foreword

The spectacular advance in the development and application of integrated-circuit technology is unparalleled in our history, and the rapid growth of the IC industry has led to the emergence of microelectronics process engineering as a new discipline. The pervasive use of integrated circuits also requires that a wide range of engineers in the highly competitive electronics industry have an understanding of the design and limitations of integrated circuits. This text presents an introduction to the basic processes common to all IC technologies and provides a base for understanding more advanced processing and what can and cannot be achieved through integrated-circuit fabrication.

The book has evolved from notes developed over the past seven years for a course which introduces seniors and beginning graduate students to the fabrication of solid state devices and integrated circuits. It assumes a basic knowledge of the material properties of silicon, and we use Volume I of this Series as a companion text in the fabrication course. This work also assumes a minimal knowledge of the existence of integrated circuits and of the terminal behavior of electronic components such as resistors, diodes, and MOS and bipolar transistors. In order to contain the scope of the material, we deal only with basic silicon processing.

In our curriculum, other courses cover solid state materials, unipolar and bipolar device physics, and digital and analog integrated-circuit design. The material and device courses use Volumes 1–4 of this Series, and every attempt has been made to make the notation coincide with the earlier volumes, although some differences may have slipped through.

The goal of this book is to present the basic information necessary to prepare the student for more advanced processing and design courses. The special problems of VLSI fabrication are left to advanced processing texts, although a number of problem areas are mentioned throughout the book. Chapters 2–5 focus on the basic processes used in fabrication, including lithography, oxidation, diffusion, ion implantation, and thin-film deposition. Interconnection technology, packaging, and yield, often neglected, are covered in Chapters 7 and 8. It is my belief that the student must also understand the

basic interaction between process design, device design, and device layout. For this reason, Chapters 9 and 10 on MOS and bipolar process integration have been included in this book.

The material of the book is designed to be covered in one semester. On the quarter system at Auburn, we cover Chapters 1–5 and most of the material from Chapters 9 and 10. The problems have been developed to both reinforce and extend the material in the chapters. In our case, the microelectronics fabrication course is also accompanied by a laboratory which strongly reinforces the classroom material. The test chip of Fig. 2.7 is fabricated and tested during this laboratory, and a few of the problems are related to characterization of structures on this chip. We can provide pattern generator data for this mask set or can supply wafers fabricated by previous classes on an "as-available" basis.

I must also recognize a number of previous books which have obviously influenced the preparation of this text. These include *The Theory and Practice of Microelectronics* and *VLSI Fabrication Principles* by S. K. Ghandhi, *Basic Integrated Circuit Engineering* by D. J. Hamilton and W. G. Howard, *Integrated Circuit Engineering* by A. H. Glaser and G. E. Subak-Sharpe, *Microelectronics Processing and Device Design* by R. A. Colclaser, and *Semiconductor Devices—Physics and Technology* by S. M. Sze.

I thank my family for putting up with the countless hours of work which have gone into the preparation of this book. In particular, I want to thank my wife Joan for the many hours that she spent in the library tracking down and verifying errant references. During preparation of this text, we found that the references in many popular, recently published books were virtually useless because they contained so many errors. We have done our best to ensure that this is not the case with this text.

Thanks also must go to my colleagues who have helped with this book, especially to Jim L. Davidson for his suggestions, and to our laboratory managers, Walter Power and Charles Ellis, who have been instrumental in developing the processes for the microelectronics class chips.

Richard C. Jaeger

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