VLSI ELECTRONICS

Microstructure Science

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Edited by
NORMAN G. EINSPRUCH

VLSI Electronics Microstructure Science

Volume 1

Edited by

Norman G. Einspruch

School of Engineering and Architecture
University of Miami
Coral Gables, Florida

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Contributors

J. M. Ballantyne
D. K. Ferry
Jay H. Harris
Patrick E. Haggerty
R. W. Keyes
Michael C. King
M. P. Lepselter
W. T. Lynch
Bruce R. Mayo
Charles H. Phipps
Fred W. Voltmer
E. D. Wolf

To
EDITH
with love

List of Contributors

Numbers in parentheses indicate the pages on which the authors' contributions begin.

J. M. Ballantyne (129), National Research and Resource Facility for Submicron Structures, Cornell University, Ithaca, New York 14853

Myles G. Boylan (265), Division of Policy Research and Analysis, National Science Foundation, Washington, D.C. 20550

W. Murray Bullis (265), Electron Devices Division, National Bureau of Standards, Washington, D.C. 20234

John O. Dimmock (265), Physics Division, Office of Naval Research, Washington, D.C. 20301

D. K. Ferry (231), Department of Electrical Engineering, Colorado State University, Fort Collins, Colorado 80523

George Gamota (265), Office of the Undersecretary of Defense for Research and Engineering, Department of Defense, Washington, D.C. 20301

Patrick E. Haggerty* (301), Texas Instruments Incorporated, Dallas, Texas 75265

Jay H. Harris† (265), Division of Electrical, Computer, and Systems Engineering, National Science Foundation, Washington, D.C. 20550

William A. Hetzner (265), Division of Policy Research and Analysis, National Science Foundation, Washington, D.C. 20550

James A. Hutchby (265), Energy and Environmental Research Division, Research Triangle Institute, Washington, D.C.

R. W. Keyes (185), Thomas J. Watson Research Center, International Business Machines Corporation, Yorktown Heights, New York 10598

Michael C. King (41), Microlithography Division, The Perkin-Elmer Corporation, Norwalk, Connecticut 06856

* Deceased.

† Present address: College of Engineering, San Diego State University, San Diego, California 92182.

M. P. Lepselter (83), Bell Telephone Laboratories, Murray Hill, New Jersey 07974

W. T. Lynch (83), Bell Telephone Laboratories, Murray Hill, New Jersey 07974

Bruce R. Mayo (301), Texas Instruments Incorporated, Dallas, Texas 75265

Charles H. Phipps (301), Texas Instruments Incorporated, Dallas, Texas 75265

Stanley Pogrow (265), Division of Policy Research and Analysis, National Science Foundation, Washington, D.C. 20550

Robert I. Scace (265), Electron Devices Division, National Bureau of Standards, Washington, D.C. 20234

Fred W. Voltmer (1), Intel Corporation, Santa Clara, California 95051

E. D. Wolf (129), National Research and Resource Facility for Submicron Structures, Cornell University, Ithaca, New York 14853

Preface

Civilization has passed the threshold of the second industrial revolution. The first industrial revolution, which was based upon the steam engine, enabled man to multiply his physical capability to do work. The second industrial revolution, which is based upon semiconductor electronics, is enabling man to multiply his intellectual capabilities. VLSI (Very Large Scale Integration) electronics, the most advanced state of semiconductor electronics, represents a remarkable application of scientific knowledge to the requirements of technology. This treatise is published in recognition of the need for a comprehensive exposition that describes the state of this science and technology and that assesses trends for the future of VLSI electronics and the scientific base that supports its development.

These volumes are addressed to scientists and engineers who wish to become familiar with this rapidly developing field, basic researchers interested in the physics and chemistry of materials and processes, device designers concerned with the fundamental character of and limitations to device performance, systems architects who will be charged with tying VLSI circuits together, and engineers concerned with utilization of VLSI circuits in specific areas of application.

This treatise includes subjects that range from microscopic aspects of materials behavior and device performance—through the technologies that are incorporated in the fabrication of VLSI circuits—to the comprehension of VLSI in systems applications.

The volumes are organized as a coherent series of stand-alone chapters, each prepared by a recognized authority. The chapters are written so that specific topics of interest can be read and digested without regard to chapters that appear elsewhere in the sequence.

There is a general concern that the base of science that underlies integrated circuit technology has been depleted to a considerable extent and is in need of revitalization; this issue is addressed in the National

Research Council (National Academy of Sciences/National Academy of Engineering) report entitled "Microstructure Science, Engineering and Technology." It is hoped that this treatise will provide background and stimulus for further work on the physics and chemistry of structures that have dimensions that lie in the submicrometer domain and the use of these structures in serving the needs of humankind.

I wish to acknowledge the able assistance provided by my secretary, Mrs. Lola Goldberg, throughout this project, and the contribution of Academic Press in preparing the index.

Contents

Chapter 3 Resolution Limitations for Submicron Lithography

M. P. Lepselter and W. T. Lynch

Chapter 4 Research and Resource at the National Submicron Facility

E. D. Wolf and J. M. Ballantyne

Chapter 5 Limitations of Small Devices and Large Systems

R. W. Keyes

Chapter 6 Physics and Modeling of Submicron Insulated-Gate Field-Effect Transistors. I

D. K. Ferry

Chapter 7 The Government Role in VLSI

Jay H. Harris*

Chapter 8 VLSI, A Major New Tool for Productivity Improvement

Patrick E. Haggerty, Bruce R. Mayo, and Charles H. Phipps

* Section II.A by George Gamota; Section II.B by John O. Dimmock; Section III.A by W. Murray Bullis and Robert I. Scace; Section III.C by James A. Hutchby; Section IV.A by Myles G. Boylan; Section IV.B by William A. Hetzner; Section IV.C by Stanley Pogrow.

Contents of Other Volumes

VOLUME 2

VOLUME 3

Chapter 1

Manufacturing Process Technology for MOS VLSI

FRED W. VOLTMER

Intel Corporation
Santa Clara, California

ISBN 0-12-234101-5

I. INTRODUCTION

The requirements for VLSI manufacturing process technology are defined by the circuit design rules inherent in the implementation of VLSI functions and by the continued decrease in the cost per function. In this chapter, the manufacturing process technology required to implement MOS VLSI designs in production will be described. Emphasis will be placed on the manufacturing aspects of the processes, and research and development will largely be ignored. Although VLSI bipolar integrated circuits are not discussed, many of the primary findings about MOS VLSI can be applied to bipolar circuits also.

The manufacturing of integrated circuits includes die fabrication and die assembly. The entire semiconductor manufacturing process flow is illustrated in Fig. 1. To manufacture VLSI integrated circuits, changes will occur predominantly in the fabrication of the semiconductor die, not in the assembly of the die into a package unit, although some changes will be required in assembly to accommodate the larger die. Thus, only the manufacturing process technology of fabricating the die will be discussed in this chapter. The generally accepted definition for VLSI of 100K gates, or memory bits per circuit, will be used. The chapter will begin with a review of the trends in circuit density, since these trends lead to the definition of the process technology. Methods of achieving the circuit density and performance will be related to both traditional horizontal scaling and emerging vertical scaling. The resultant pervasiveness of low-temperature and dry plasma processing will be summarized.

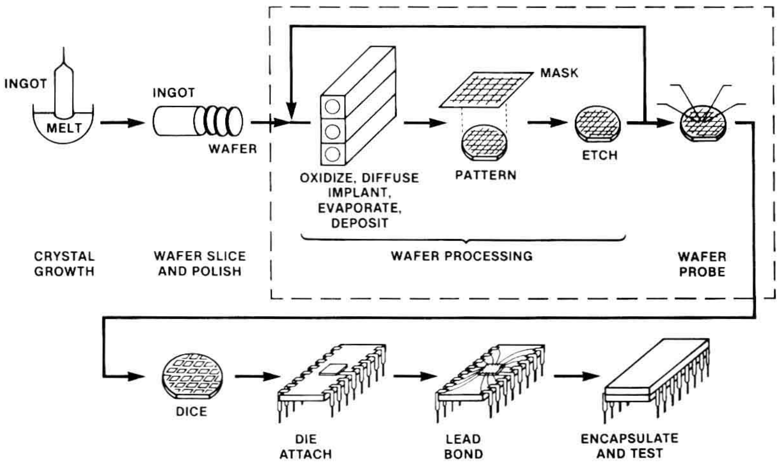

Fig. 1. Integrated circuit manufacturing process flow.