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## VLSI technology: fundamentals and applications

Yu. V. Gulyaev and Yu. L. Kopylov

Usp. Fiz. Nauk **156**, 552–553 (November 1988)

**Y. Tarui.** *VLSI Technology: Fundamentals and Applications*, (Ed.). Y. Tarui, Springer-Verlag, Berlin; Heidelberg; New York; Tokyo, 1986. Pp. 450 (Springer Series in Electrophysics V. 12)

The desire to increase the reliability of electronic de-

vices and to lower their cost by restricting them to a single function to be performed, has led to the development and construction of large and superlarge integrated circuits (VLSI) which combine millions of components in a single crystal. VLSI technology has required widespread investiga-

tions in the field of micro- and nanolithography, in the methods of dry highly productive etching, and on methods of testing structures with a complex topology at the intermediate and final stages of a technological process. The large volume of different kinds of information concerning the VLSI technology has been brought together in the book under review which is the twelfth volume of the well-known series on electrophysics. This publication is the English translation of the book by Yasuo Tarui which was published in Japanese in 1981 and in a Russian translation under the title "Fundamentals of VLSI technology" (edited by V. G. Rzhakov) in 1985 by the publishing house "Radio i svyaz".

The author is a well-known Japanese scientist, a member of the Joint Institute of VLSI Technology. He has concentrated the principal attention on problems of forming a topological design with submicron dimensions of the elements.

The material being presented is subdivided in the book in the following manner.

The first chapter gives as an introduction a brief historical outline of the approach to the idea of creating VLSI, and also classifies the principal modern methods of forming a microdesign on a crystal as one of the most important aspects of the VLSI technology.

The importance of this is particularly emphasized by the content of the second chapter in which electron-beam lithography is described. Without claiming to be exhaustive this chapter nevertheless encompasses all the aspects of tracing a microdesign by electron-beams. The principles of construction of different electron-beam apparatus are described, as well as the present status in the development of specialized sources of electrons and of electron-optical systems. The principal factors are examined in detail which determine the accuracy and speed of the lithographic process, and also the methods of correcting aberrations and decreasing the influence of the "proximity effect" by means of suitable software. Much attention is devoted, and this is very valuable, to software; in particular, structural schemes of the lithographic process are given for the principal methods of exposure. At the end of the chapter a description is given of the electron-beam apparatus manufactured in Japan.

The third chapter is devoted to methods of transferring microdesigns onto silicon plates. Practically all the modern methods using far ultraviolet and x-ray radiations as well as electron beams are touched upon. In contrast to the second

chapter the author here restricts himself primarily to describing the principles of construction and technological parameters of existing apparatus. At the end of the chapter information is given on commercially available resists for microlithography.

The fourth chapter is devoted to methods for checking masks prepared by using electron-beam apparatus. A detailed classification is given of methods and their possibilities for checking geometrical dimensions of masks and the defects present in them. Construction of modern optical and electron-optical apparatus for automated checking of masks under conditions of mass production is described.

The fifth chapter is devoted to obtaining crystals for VLSI. The principal attention is devoted to defects in crystals, to causes leading to their appearance, to modern methods of discovering and identifying them.

The sixth chapter brings together information on the technology of forming microelements on a crystal. However only some of the technological processes, such as dry etching for obtaining microdesigns, laser annealing of implanted layers, methods of obtaining insulating and conducting films are touched upon.

The seventh chapter examines problems of checking and testing integrated circuits, in particular checking and testing at the stage of design of VLSI, the principles of analysis and checking of parameters of large integrated circuits and testing VLSI as a complex system.

The concluding eighth chapter is devoted to problems of designing and constructing VLSI. The content of this chapter is interesting because here a discussion is given of the fundamental limits to the increase of the degree of integration and definite predictions are made of possible improvements in the parameters of apparatus. Here also are given examples of a number of basic structures of modern integrated circuits.

In spite of the fact that the author does not touch upon a number of new directions in technology, for example, such as ion-beam lithography, the latest achievements in MOS hydride and molecular-beam epitaxy, the book is useful because it gives a unified overview of the VLSI technology. It is of definite interest for scientists and engineers engaged in the development and technology of making integrated circuits. The book is useful for graduate students and senior undergraduate students as a textbook.