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Preface

Although exploratory and developmental activity in electron beam testing (EBT) had already been in existence in research laboratories for over 25 years, it was not until the beginning of the 1980s that it was taken up seriously as a technique for integrated circuit (IC) testing. While ICs were being fabricated on design rules of several microns, the mechanical needle probe served quite adequately for internal chip probing. This scenario changed with growing device complexity and shrinking geometries, prompting IC manufacturers to take note of this new testing technology. It required several more years and considerable investment by electron beam tester manufacturers, however, to come up with user-friendly automated systems that were acceptable to IC test engineers. These intervening years witnessed intense activity in the development of instrumentation, testing techniques, and system automation, as evidenced by the proliferation of technical papers presented at conferences. With the shift of interest toward applications, the technology may now be considered as having come of age.

At this juncture, the time seems ripe for a comprehensive volume on the subject of EBT of ICs. This book is primarily intended to be a reference work that draws together in a coherent text both background material and recent developments from numerous publications on, or related to, the subject area. It also aims to serve a didactic function, by catering to readers unfamiliar with the technology. As such, the text is divided into three parts. Part I (Chapters 1 and 2) is introductory, explaining why such technology has achieved its current status in IC testing, and its basic principles. Part II (Chapters 3-8) is the reference section, which discusses the fundamental elements of the subject; it will be of principal use to those employing EBT equipment who wish to become more familiar with one or more of its aspects. Part III (Chapters 9-11) concentrates on the practical and implementational aspects of the technology, such as test automation and device handling, and includes case studies.

Chapter 1 introduces the subject against the background of IC design and testing, recognizing that EBT cannot be placed in proper perspective without first having defined its application. As a tutorial chapter, Chapter 2 is self-contained. Starting from a brief background to the scanning electron microscope, it takes the reader on a tour of the fundamentals of EBT, instrumentation, and related topics, where the electron probe is actively used to modify IC operation.

In Chapter 3, geometrical electron optics is presented at a level that enables a novice to grasp the underlying theory of electron-optical design of electron beam testers. In recognition of its important contribution to the overall performance of a tester, the electron gun is discussed in some detail. Chapter 4 discusses the interaction of the electron beam with a device, covering bulk interactions, electron emission, electron-beam-induced current, contamination, and device damage. On the basis of their relevance to EBT, these topics have been selected from the general and vast subject area of electron beam–specimen interaction. Voltage measurement with electron spectrometers is the subject of Chapter 5. Practical spectrometers and their underlying design philosophies are first described before developing theoretical aspects of voltage measurement. Chapter 6 considers the measurement of dynamic waveforms, and discusses sampling schemes, electron pulse production, and instrumentation issues. The latter part of this chapter focuses on the measurement of ultra-high-speed waveforms in the picosecond time regime. Continuing this theme, Chapter 7 describes photoemission probing for picosecond measurements. Unlike other contactless optical-probing techniques, photoemission probing shares many common elements with EBT, thereby providing an alternative, and a suitable comparison, when advantages common to both techniques are sought. Chapter 8 discusses in detail the fundamentals of sampling and recovering measurements via signal processing. Image processing and manipulation are also discussed.

Chapter 9 considers the issues involved in automating test procedures by exploiting device CAD data. It also discusses the latest achievements in fully automated electron beam diagnosis. Practical aspects of using an electron beam tester constitute Chapter 10. Topics covered include driving the device, device handling, and vacuum cleanliness, with many practical suggestions given. Finally Chapter 11, which comprises a number of case studies, rounds out the volume by exemplifying EBT usage in different industrial environments.

I would like to thank contributors to this volume for their willingness to make major changes in their chapter contents, sometimes involving several revisions, for the sake of overall continuity and uniformity. I would like to acknowledge the assistance of Dr. Simon Garth at the initial stages of planning the book format. I am very grateful to Dr. Graham Plows and Bernie and Jane Breton for their helpful comments on the manuscript, and I would also like to express appreciation to the series editor, Dr. Ivor Brodie, and Plenum Press for their forbearance during the production of the manuscript.

J. T. L. Thong

Singapore

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