BOOK REVIEWS

Integrating Reliability into Microelectronics Manufacturing

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REFERENCE: *Integrating Reliability into Microelectronics Manufacturing*, Aris Christou, John Wiley & Sons, West Sussex, England, 1994. 349 pages.

Integrating Reliability into Microelectronics Manufacturing is one of the books in the John Wiley Series on *Design and Measurement in Electronic Engineering*. The objective of the book is to explain and examine the principles, processes, and materials of reliability manufacturing. The intended audience is the students and technologists who will be applying reliability principles to manufacturing, as well as researchers of materials and processes.

The treatise begins with a brief introduction to the past history of device development and a roadmap leading to the year 2000, and a mention of the tools available for resolving the issues for manufacturing yield, reliability and quality as applied to microelectronics, including the use of fishbone diagrams. The author discusses, as a part of the introduction (Chapter 2), the *modus operandi* and concepts within the Department of Defense and other Government agencies to achieve quality in electronic products. He puts forth his belief that without technological leadership, industry cannot be expected to produce affordable high quality, reliable electronic and communication systems. The present approaches have been serial, for example, the development of material and device technology, design, processing, testing, and packaging in the initial phases, followed by an "affordable manufacture" phase, and then an insertion phase using a small pilot line production, rather than making use of the commercial practices of computer integrated manufacturing.

The author describes the causes of yield losses to be (1) wafer related defects, particles, and surface inhomogeneities, (2) device processing effects, mainly stressing the photolithography defects, and (3) circuit sensitivities, such as threshold voltage and channel length variations. The failure mechanisms in device processing could be one-to-many, and the calculation of failure rate gets complicated because of the existence of more than one failure mechanism, and each of these mechanisms may be governed by a non-normal distribution. The author tries to explain this by giving typical examples and equations applicable to the yield factor, acceleration factor, mean-time-to-failure etc. The reader may have to stretch to grasp many concepts covered in a few pages.

After summarizing the concepts of reliability in the first three chapters, the author describes the material processing and device fabrication techniques. Starting from crystal growth theory and epitaxial deposition methods, he discusses the thermal-mechanical stresses in the semiconductor materials and very-complex equations for the calculations of tensile forces, shear stresses, moments, and flexural rigidity are given without derivations. Failure mechanisms based on the existence of microstructural damage, microcracks, and fractures have been a topic of research for a number of years. This topic along with the fatigue failure mechanism is thoroughly discussed in the book.

A short description of the oxidation and nitride processes is provided. Chemical vapor deposition is discussed briefly. A mention is made of the redistribution of impurities during oxidation, and charge stabilities caused by ionic drift and other anomalies. Diffusion physics and material damage introduced by ion implantation are briefly discussed. The yield issues relating to these two processes are not covered, however. The lithographic procedures and the quality problems associated with these procedures are discussed, as are metallization techniques. Failure mechanisms related to contamination as a title in §9.2.1 should have really been "Analysis and characterization techniques related to contamination," as this section discusses the various analytical techniques to characterize the contamination. The metallization failure modes and electromigration principles are well discussed.

The book discusses in detail packaging processes and related issues. Packaging has always had a significant impact on the reliability of semiconductor devices and integrated circuits, specially with the trend being for shrinking of the feature sizes, and for the increasing complexity of the chip structures. There is a good description of the techniques utilized to characterize the problems of manufacturing and reliability. A large number of device failures are known to occur at the surface or at interlayer interfaces. The surface and interface analysis can, therefore, be the key factor in assuring reliability. The processing of plastic packages, molding, and package mounting is described in Chapter 11. Although the process description is thorough, the issues of device reliability as related to packaging are not sufficiently dealt with.

Finally, the book covers the manufacturing of microelectromechanical systems, electronic packaging by industrial robots, and microwave substrates for the packaging of monolithic microwave circuits. These topics must be of special interest to the author, because they are well outside the overall scope of the subject matter of the book as defined by its title and preface.

Looking at the treatise and its comprehensiveness, the scope was well defined, although the author was influenced by his interests in semiconductor processing techniques to the degree that at times he drifted from the main topic of reliability. Reading the book, it is difficult to say whether he met the needs of his intended audience. The intended audience will, probably, use the book for reference. It would have been better if it was arranged in two parts: (1) Microelectronics Manufacturing and (2) Integrating Reliability. If so, the material, device and package processes could have been described in Section 1, and the reliability issues could have been discussed in detail in Section 2. Chapters 12, 13, and 14 do not really belong in the book and should not have been included. The space could have been utilized to discuss reliability issues in greater detail.

Nevertheless, it is a good book and gives a comprehensive coverage to topics hard to find elsewhere in one place. It is well written, concise, and informative. Every attempt has been made by the author to give proper credit to the work he refers to in the book. The index is sufficiently comprehensive, and the hard cover with soothing colors is delightful.

BOOK REVIEWS

Engineering Materials 3: Materials Failure Analysis (Case Studies and Design Implications)

Reviewed by C. G. Scott and A. T. Riga, research engineer and senior research chemist, respectively, The Lubrizol Corporation, Wickliffe, OH 44092.

REFERENCE: Jones, D. R. H., *Engineering Materials 3: Materials Failure Analysis (Case Studies and Design Implications)*, Pergamon Press, New York 1993, ISBN: 0-08-041905-4, $36.00.

Students, technicians and professionals with a broad range of engineering backgrounds will find this book a valuable reference and "workbook" on failure analysis. A diverse and well-organized collection of case histories is assembled to illustrate the importance of engineering failures and their analysis to the design process. The individual studies presented involve real-world problems and have been carefully selected to underscore the close relationship between materials properties and engineering function. Failures involve a wide variety of components and systems, ranging from mountain climbing rope to steam boilers.

The book consists of case histories and a set of appendices. Case histories are divided into sections based on the general category of failure. Categories of failure represented include elastic and plastic deformation, creep, fast fracture, brittle fracture, fatigue, and environmentally assisted failure. The final section highlights some of the great engineering failures that have been documented over the years. Each individual study contains a wealth of supporting details including background information, operating conditions, pertinent formulas and supporting calculations, diagrams, materials properties, and design considerations. The appendices provide an accompanying "workshop" on failure analysis as it relates to engineering design. Applicable tools, in the form of formulas and data, are summarized in the first appendix. Together, the second and final appendices provide working examples and their solutions, respectively, to help emphasize the books objectives and key principles. Individual references throughout the book are also valuable.

International Advances in Nondestructive Testing

Reviewed by C. G. Scott and A. T. Riga, research engineer and senior research chemist, respectively, The Lubrizol Corporation, Wickliffe, OH 44092.

REFERENCE: *International Advances In Nondestructive Testing*, McGonnagle, W. J., Ed., Gordon and Breach Science Publishers, USA, 1994, 396 pages.

International Advances in Nondestructive Testing is Volume 17 in a series on nondestructive testing science and engineering. The book consists of 22 loosely organized papers covering a wide spectrum of technologies and their application. Its objective is to communicate the latest advances in the field, with practicing scientists and engineers as the primary audience. The first two papers deal with general communication and educational related issues that are important to the advancement and application of nondestructive testing. The remaining papers cover specific topics that range from ultrasonic holography to neutron radiography. All papers provide references for additional information.

The objective of the series as a whole is clearly stated in the preface. However, the addition of an introduction to Volume 17, specifically, would be helpful in differentiating it from the other volumes that are not well referenced or identified in the beginning of the book. Papers are adequately supported by appropriate tables, diagrams, formulae and photographs. Affiliations are missing for several authors. Overall, the book provides a good reference for the latest advances in nondestructive testing and evaluation.