Micro- and Opto-Electronic Materials, Structures, and Systems

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X.J. Fan · E. Suhir
Editors

Moisture Sensitivity of Plastic Packages of IC Devices

Foreword by C.P. Wong

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films have emerged. As a result, cohesive film rupture may occur due to moisture during reflow. Therefore, one of the major challenges for a practical realization of 3D microelectronics packaging concept is to design materials and meet reliability requirements without cohesive failures subjected to moisture loads.

This book provides information on the state-of-the-art technologies and methodologies related to moisture issues in plastic packages. The book covers the wide aspects including moisture diffusion and desorption, characterization and modeling, hygroscopic swelling, interfacial adhesion degradation, accelerated moisture sensitivity/reflow test, electrical-chemical migration, moisture-aging effect on long-term reliability, and several finely selected real-world case studies on various failure mechanisms due to moisture. This is the first book ever to cover the full spectrum of moisture-induced failure mechanisms in IC packages. It is a timely and important contribution to the technical literature for researchers, engineers, and practitioners both in academia and in electronics industry.

The editors of the book, Dr. Fan and Dr. Suhir, have rich experience in both theoretical development and industrial practice. They have been offering the professional development courses at various IEEE (Institute of Electrical and Electronics Engineers) CPMT (components packaging and manufacturing technologies) Society conferences, and hundreds of participants have attended their lectures. They have succeeded in bringing together well-recognized experts in this field and present a fine collection of papers covering the full spectrum of the related topics. They are to be congratulated for bringing this very important topic forth in a timely manner.

Atlanta, GA C.P. Wong
November, 2009

Preface

Since moisture-sensitive plastic materials were introduced in integrated circuit (IC) device packaging several decades ago, moisture has been one of the major concerns for package designers and reliability engineers. With the recent development of the three-dimensional (3D) microelectronics packaging with through-silicon via (TSV) and multi-die stacking technologies, moisture-induced failures have become even more prominent due to the new materials employed and the overall reduction in package size and thickness. This book provides a comprehensive state-of-the-art and in-depth review of the fundamental knowledge and methodologies in the field of material and structural ("physical") behavior and performance of various types of moisture-sensitive plastic packages of IC devices.

The book consists of 21 chapters divided into six sections: (1) moisture diffusion, absorption and desorption, and adhesion degradation (Chapters 1, 2, 3, and 4); (2) hygroscopic swelling characterization and analysis (Chapters 5, 6, and 7); (3) integrated hydrothermal and thermal stress modeling (Chapters 8, 9, 10, 11, and 12); (4) case studies and applications (Chapters 13, 14, 15, 16, 17, 18, and 19); (5) electro-chemical migration (Chapter 20); and (6) molecular dynamics modeling and characterization (Chapter 21). Brief description of the chapter contents is set forth below.

Chapter 1 presents an overview of moisture-induced failures in plastic packages of IC devices, and illustrates the fundamental characteristics of moisture diffusion, hygroscopic swelling, and adhesion degradation. Chapter 2 describes the latest investigations of anomalous moisture diffusion and the corresponding adhesion behaviors in epoxy molding compounds. Chapter 3 provides a method and detailed analysis for real-time moisture absorption and desorption in thin films. Chapter 4 reviews the existing methodologies of moisture diffusion modeling and whole-field vapor pressure analysis. Chapters 5, 6, and 7 describe several character-

thermo-mechanical stress modeling of IC packages. Chapter 10 describes a failure criterion for moisture sensitivity of plastic packages based on the theory of

Hale, John Segelken, Alan Lyons, Bonnie Bachman, Charles Cohn, Quazi Ilyas, and many other top-notch materials scientists, physicists, chemists, and chemical engineers.

<table>
<tr><td>Beaumont, TX
Santa Cruz, CA
November 2009</td><td align="right">X.J. Fan
E. Suhir</td></tr>
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Series Preface

This title is the second book in the series. The series encompasses a broad area of micro-, opto-electronic, and photonic engineering, with particular emphasis on materials, physics, mechanics, design, reliability, and packaging. The titles in the series feature eminent engineers and scientists as authors and/or editors focused on addressing major issues in the above areas of engineering. Our objective is to have a comprehensive series on the materials, mechanics, physics, packaging, functional performance, and reliability as they pertain to micro- and opto-electronics.

The audience for these volumes are those who work in micro- and opto-electronics and photonics, as well as those in many related areas of applied science and engineering. The expected readers are practitioners and professionals, scientists and researchers, along with senior-level undergraduate and graduate students. These volumes can serve as expanded encyclopedias in the field of the mechanics of micro- and opto-electronic materials and structures. Selected titles could also serve as text-books, reference works, and as general guidance works for those interested in these subjects. The series contains both descriptions of the state-of-the-art developments in particular fields, as well as new results obtained by authors, editors, and their colleagues. The authors also identify and address crucial, but still unresolved, issues that come up when discussing new developments and issues within the discussed topics.

I am thankful to Dr. Fan, the editor of this title, who did the major work by bringing together an excellent team of experts and by putting together many outstanding chapters in this title. It has been a pleasure working with him.

I would also like to take this opportunity to thank the authors and editors of the books that are now in the process of being written as well as those authors who have already completed their volume for this series. Potential authors, editors, and those specialists interested in making contributions to the current state of knowledge in a particular field of engineering or applied science within the scope of this book series are invited to send their book proposals to me.

Santa Cruz, CA

E. Suhir, Ph.D.
Series Editor

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