

Microelectronics Packaging Handbook Semiconductor Packaging Technology Drivers Pt 1

With contributions by numerous experts

“Microsystems and Nanotechnology” presents the latest science and engineering research and achievements in the fields of microsystems and nanotechnology, bringing together contributions by authoritative experts from the United States, Germany, Great Britain, Japan and China to discuss the latest advances in microelectromechanical systems (MEMS) technology and micro/nanotechnology. The book is divided into five parts – the fundamentals of microsystems and nanotechnology, microsystems technology, nanotechnology, application issues, and the developments and prospects – and is a valuable reference for students, teachers and engineers working with the involved technologies. Professor Zhaoying Zhou is a professor at the Department of Precision Instruments & Mechanology, Tsinghua University, and the Chairman of the MEMS & NEMS Society of China. Dr. Zhonglin Wang is the Director of the Center for Nanostructure Characterization, Georgia Tech, USA. Dr. Liwei Lin is a Professor at the Department of Mechanical Engineering, University of California at Berkeley, USA.

Microelectronics packaging and interconnection have experienced exciting growth stimulated by the recognition that systems, not just silicon, provide the solution to evolving applications. In order to have a high density/performance/yield/quality/reliability, low cost, and light weight system, a more precise understanding of the system behavior is required. Mechanical and thermal phenomena are among the least understood and most complex of the many phenomena encountered in microelectronics packaging systems and are found on the critical path of nearly every design and process in the electronics industry. The last decade has witnessed an explosive growth in the research and development efforts devoted to determining the mechanical and thermal behaviors of microelectronics packaging. With the advance of very large scale integration technologies, thousands to tens of thousands of devices can be fabricated on a silicon chip. At the same time, demands to further reduce packaging signal delay and increase packaging density between communicating circuits have led to the use of very high power dissipation single-chip modules and multi-chip modules. The result of these developments has been a rapid growth in module level heat flux within the personal, workstation, midrange, mainframe, and super computers. Thus, thermal (temperature, stress, and strain) management is vital for microelectronics packaging designs and analyses. How to determine the temperature distribution in the electronics components and systems is outside the scope of this book, which focuses on the determination of stress and strain distributions in the electronics packaging.

With topics ranging from epitaxy through lattice defects and doping to quantum computation, this book provides a personalized survey of the development and use of silicon, the basis for the revolutionary changes in our lives sometimes called “The Silicon Age.” Beginning with the very first developments more than 50 years ago, this reports on all aspects of silicon and silicon technology up to its use in exciting new technologies, including a glance at possible future developments.

The days of troubleshooting a piece of gear armed only with a scope, voltmeter, and a general idea of how the hardware works are gone forever. As technology continues to drive equipment design forward, maintenance difficulties will continue to increase, and those responsible for maintaining this equipment will continue to struggle to keep up. The Electronic Systems Maintenance Handbook, Second Edition establishes a foundation for servicing, operating, and optimizing audio, video, computer, and RF systems. Beginning with an overview of

reliability principles and properties, a team of top experts describes the steps essential to ensuring high reliability and minimum downtime. They examine heat management issues, grounding systems, and all aspects of system test and measurement. They even explore disaster planning and provide guidelines for keeping a facility running under extreme circumstances. Today more than ever, the reliability of a system can have a direct and immediate impact on the profitability of an operation. Advocating a carefully planned, systematic maintenance program, the richly illustrated Electronic Systems Maintenance Handbook helps engineers and technicians meet the challenges inherent in modern electronic equipment and ensure top quality performance from each piece of hardware.

This major work has established itself as the definitive reference in the nanoscience and nanotechnology area in one volume. It presents nanostructures, micro/nanofabrication, and micro/nanodevices. Special emphasis is on scanning probe microscopy, nanotribology and nanomechanics, molecularly thick films, industrial applications and microdevice reliability, and on social aspects. Reflecting further developments, the new edition has grown from six to eight parts. The latest information is added to fields such as bionanotechnology, nanorobotics, and NEMS/MEMS reliability. This classic reference book is orchestrated by a highly experienced editor and written by a team of distinguished experts for those learning about the field of nanotechnology.

Im Mittelpunkt stehen Zuverlässigkeits- und Lebensdauerfragen mikroskopisch kleiner Bauteilstrukturen, wie sie für die Aufbau- und Verbindungstechnik der Mikroelektronik bzw. Mikrosystemtechnik typisch sind. Der mikrostrukturelle Aufbau von Werkstoffen, die Werkstoffverformung und die Materialschädigung werden systematisch und detailliert dargestellt. Die methodischen Besonderheiten gegenüber der klassischen Werkstoffprüfung erläutert der Autor anhand zahlreicher konkreter Beispiele.

This thoroughly revised and updated three volume set continues to be the standard reference in the field, providing the latest in microelectronics design methods, modeling tools, simulation techniques, and manufacturing procedures. Unlike reference books that focus only on a few aspects of microelectronics packaging, these outstanding volumes discuss state-of-the-art packages that meet the power, cooling, protection, and interconnection requirements of increasingly dense and fast microcircuitry. Providing an excellent balance of theory and practical applications, this dynamic compilation features step-by-step examples and vital technical data, simplifying each phase of package design and production. In addition, the volumes contain over 2000 references, 900 figures, and 250 tables. Part I: Technology Drivers covers the driving force of microelectronics packaging - electrical, thermal, and reliability. It introduces the technology developer to aspects of manufacturing that must be considered during product development. Part II: Semiconductor Packaging discusses the interconnection of the IC chip to the first level of packaging and all first level packages. Electrical test, sealing, and encapsulation technologies are also covered in detail. Part III: Subsystem Packaging explores board level packaging as well as connectors, cables, and optical packaging.

This book on mechanical microsensors is based on a course organized by the Swiss Foundation for Research in Microtechnology (FSRM) in Neuchâtel, Switzerland, and developed and taught by the authors. Support by FSRM is herewith gratefully acknowledged. This book attempts to serve two purposes. First it gives an overview on mechanical microsensors (sensors for pressure, force, acceleration, angular rate and fluid flow, realized by silicon micromachining). Second, it serves as a textbook for engineers to give them a comprehensive introduction on the basic design issues of these sensors. Engineers active in sensor design are usually educated either in electrical engineering or mechanical engineering. These classical educational programs do not prepare the engineer for the challenging task of sensor design since sensors are instruments typically bridging the disciplines: one needs a rather deep understanding of both mechanics and

electronics. Accordingly, the book contains discussion of the basic engineering sciences relevant to mechanical sensors, hopefully in a way that it is accessible for all colours of engineers. Engineering students in their 3 or 4 year should have enough knowledge to be able to follow the arguments presented in this book. In this sense, this book should be useful as textbook for students in courses on mechanical microsensors (as is currently being done at the University of Twente).

Electronics are used in a wide range of applications including computing, communication, biomedical, automotive, military and aerospace. They must operate in varying temperature and humidity environments including indoor controlled conditions and outdoor climate changes. Moisture, ionic contamination, heat, radiation and mechanical stresses are all highly detrimental to electronic devices and can lead to device failures. Therefore, it is essential that the electronic devices be packaged for protection from their intended environments, as well as to provide handling, assembly, electrical and thermal considerations. Currently, more than 99% of microelectronic devices are plastic encapsulated. Improvements in encapsulant materials, and cost incentives have stretched the application boundaries for plastic electronic packages. Many electronic applications that traditionally used hermetic packages such as military are now using commercial-off-the-shelf (COTS) plastic packages. Plastic encapsulation has the advantages of low cost, smaller form factors, and improved manufacturability. With recent trends in environmental awareness, new environmentally friendly or 'green' encapsulant materials (i.e. without brominated additives) have emerged. Plastic packages are also being considered for use in extreme high and low temperature electronics. 3-D packaging and wafer-level-packaging (WLP) require unique encapsulation techniques. Encapsulant materials are also being developed for micro-electro-mechanical systems (MEMS), bio-MEMS, bio-electronics, and organic light-emitting diodes (O-LEDs). This book offers a comprehensive discussion of encapsulants in electronic applications. The main emphasis is on the encapsulation of microelectronic devices; however, the encapsulation of connectors and transformers is also addressed. This book discusses 2-D and 3-D packaging and encapsulation, encapsulation materials including environmentally friendly 'green' encapsulants, and the properties and characterization of encapsulants. Furthermore, this book provides an extensive discussion on defects and failures related to encapsulation, how to analyze such defects and failures, and how to apply quality assurance and qualification process for encapsulated packages. This book also provides information on the trends and challenges of encapsulation and microelectronic packages including application of nanotechnology. Guidance on the selection and use of encapsulants in the electronics industry, with a particular focus on microelectronics Coverage of environmentally friendly 'green encapsulants' Practical coverage of faults and defects: how to analyze them and how to avoid them

Augmented Materials and Smart Objects investigates the issues required to ensure technology platforms capable of being seamlessly integrated into everyday objects. In particular, it deals with the requirements for integrated computation and MEMS sensors, system-in-a-package solutions, and multi-chip modules. On top of this, the publication's 500 pages cover the impact of the trend towards embedded microelectronic electronics sub-systems, novel assembly techniques for autonomous MEMS sensors, and practical performance issues that are key to the Aml concept.

Advanced Flip Chip Packaging presents past, present and future advances and trends in areas such as substrate technology, material development, and assembly processes. Flip chip packaging is now in widespread use in computing, communications, consumer and automotive electronics, and the demand for flip chip technology is continuing to grow in order to meet the need for products that offer better performance, are smaller, and are environmentally sustainable.

This book covers the entire spectrum of assembly, packaging and testing of MEMs (microelectro-mechanical systems) and microsystems, from essential enabling technologies to applications in key industries of life sciences, telecommunications and aerospace engineering.

This book presents the scientific principles, processing conditions, probable failure mechanisms, and a description of reliability performance and equipment required for implementing high-temperature and lead-free die attach materials. In particular, it addresses the use of solder alloys, silver and copper sintering, and transient liquid-phase sintering. While different solder alloys have been used widely in the microelectronics industry, the implementation of sintering silver and transient liquid-phase sintering remains limited to a handful of companies. Hence, the book devotes many chapters to sintering technologies, while simultaneously providing only a cursory coverage of the more widespread techniques employing solder alloys. Addresses the differences between sintering and soldering (the current die-attach technologies), thereby comprehensively addressing principles, methods, and performance of these high-temperature die-attach materials; Emphasizes the industrial perspective, with chapters written by engineers who have hands-on experience using these technologies; Baker Hughes, Bosch and ON Semiconductor, are represented as well as materials suppliers such as Indium; Simultaneously provides the detailed science underlying these technologies by leading academic researchers in the field.

Electronics has become the largest industry, surpassing agriculture, auto. and heavy metal industries. It has become the industry of choice for a country to prosper, already having given rise to the phenomenal prosperity of Japan. Korea. Singapore. Hong Kong. and Ireland among others. At the current growth rate, total worldwide semiconductor sales will reach \$300B by the year 2000. The key electronic technologies responsible for the growth of the industry include semiconductors. the packaging of semiconductors for systems use in auto, telecom, computer, consumer, aerospace, and medical industries. displays. magnetic, and optical storage as well as software and system technologies. There has been a paradigm shift, however, in these technologies. from mainframe and supercomputer applications at any cost. to consumer applications at approximately one-tenth the cost and size. Personal computers are a good example. going from \$500MIP when products were first introduced in 1981, to a projected \$11MIP within 10 years. Thin. light portable. user friendly and very low-cost are. therefore. the attributes of tomorrow's computing and communications systems. Electronic packaging is defined as interconnection. powering, cooling, and protecting semiconductor chips for reliable systems. It is a key enabling technology achieving the requirements for reducing the size and cost at the system and product level.

This book focuses on the assembly and reliability of lead-free solder joints. Both the principles and engineering practice are addressed, with more weight placed on the latter. This is achieved by providing in-depth studies on a number of major topics such as solder joints in conventional and advanced packaging components, commonly used lead-free materials, soldering processes, advanced specialty flux designs, characterization of lead-free solder joints, reliability testing and data analyses, design for reliability, and failure analyses for lead-free solder joints. Uniquely, the content not only addresses electronic manufacturing

services (EMS) on the second-level interconnects, but also packaging assembly on the first-level interconnects and the semiconductor back-end on the 3D IC integration interconnects. Thus, the book offers an indispensable resource for the complete food chain of electronics products.

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Volume 1: Packaging is an authoritative reference source of practical information for the design or process engineer who must make informed day-to-day decisions about the materials and processes of microelectronic packaging. Its 117 articles offer the collective knowledge, wisdom, and judgement of 407 microelectronics packaging experts-authors, co-authors, and reviewers-representing 192 companies, universities, laboratories, and other organizations. This is the inaugural volume of ASM's all-new Electronic Materials Handbook series, designed to be the Metals Handbook of electronics technology. In over 65 years of publishing the Metals Handbook, ASM has developed a unique editorial method of compiling large technical reference books. ASM's access to leading materials technology experts enables to organize these books on an industry consensus basis. Behind every article is an author who is a top expert in its specific subject area. This multi-author approach ensures the best, most timely information throughout. Individually selected panels of 5 and 6 peers review each article for technical accuracy, generic point of view, and completeness. Volumes in the Electronic Materials Handbook series are multidisciplinary, to reflect industry practice applied in integrating multiple technology disciplines necessary to any program in advanced electronics. Volume 1: Packaging focusing on the middle level of the electronics technology size spectrum, offers the greatest practical value to the largest and broadest group of users. Future volumes in the series will address topics on larger (integrated electronic assemblies) and smaller (semiconductor materials and devices) size levels.

A comprehensive guide to TSV and other enabling technologies for 3D integration Written by an expert with more than 30 years of experience in the electronics industry, Through-Silicon Vias for 3D Integration provides cutting-edge information

on TSV, wafer thinning, thin-wafer handling, microbumping and assembly, and thermal management technologies. Applications to highperformance, high-density, low-power-consumption, wide-bandwidth, and small-form-factor electronic products are discussed. This book offers a timely summary of progress in all aspects of this fascinating field for professionals active in 3D integration research and development, those who wish to master 3D integration problem-solving methods, and anyone in need of a low-power, wide-bandwidth design and high-yield manufacturing process for interconnect systems. Coverage includes: Nanotechnology and 3D integration for the semiconductor industry TSV etching, dielectric-, barrier-, and seed-layer deposition, Cu plating, CMP, and Cu revealing TSVs: mechanical, thermal, and electrical behaviors Thin-wafer strength measurement Wafer thinning and thin-wafer handling Microbumping, assembly, and reliability Microbump electromigration Transient liquid-phase bonding: C2C, C2W, and W2W 2.5D IC integration with interposers 3D IC integration with interposers Thermal management of 3D IC integration 3D IC packaging Significant progress has been made in advanced packaging in recent years. Several new packaging techniques have been developed and new packaging materials have been introduced. This book provides a comprehensive overview of the recent developments in this industry, particularly in the areas of microelectronics, optoelectronics, digital health, and bio-medical applications. The book discusses established techniques, as well as emerging technologies, in order to provide readers with the most up-to-date developments in advanced packaging.

This book offers a comprehensive reference guide for graduate students and professionals in both academia and industry, covering the fundamentals, architecture, processing details, and applications of 3D microelectronic packaging. It provides readers an in-depth understanding of the latest research and development findings regarding this key industry trend, including TSV, die processing, micro-bumps for LMI and MMI, direct bonding and advanced materials, as well as quality, reliability, fault isolation, and failure analysis for 3D microelectronic packages. Images, tables, and didactic schematics are used to illustrate and elaborate on the concepts discussed. Readers will gain a general grasp of 3D packaging, quality and reliability concerns, and common causes of failure, and will be introduced to developing areas and remaining gaps in 3D packaging that can help inspire future research and development.

Modeling Microprocessor Performance focuses on the development of a design and evaluation tool, named RIPE (Rensselaer Interconnect Performance Estimator). This tool analyzes the impact on wireability, clock frequency, power dissipation, and the reliability of single chip CMOS microprocessors as a function of interconnect, device, circuit, design and architectural parameters. It can accurately predict the overall performance of existing microprocessor systems. For the three major microprocessor architectures, DEC, PowerPC and Intel, the results have shown agreement within 10% on key parameters. The models cover a broad range of issues that relate to the implementation and performance of

single chip CMOS microprocessors. The book contains a detailed discussion of the various models and the underlying assumptions based on actual design practices. As such, RIPE and its models provide an insightful tool into single chip microprocessor design and its performance aspects. At the same time, it provides design and process engineers with the capability to model, evaluate, compare and optimize single chip microprocessor systems using advanced technology and design techniques at an early design stage without costly and time consuming implementation. RIPE and its models demonstrate the factors which must be considered when estimating tradeoffs in device and interconnect technology and architecture design on microprocessor performance.

The development and advancement of personalised health management systems requires the consideration of advances in sensor technologies and advanced textiles in addition to nano technologies and evolving information and communication technologies. We are now living in an environment where changes in healthcare structures and requests from patients to have an increased participation in their own healthcare are demanding the availability of affordable and readily available personalised health management systems. Recent research has taken us a step closer in providing such solutions, however, efforts are still required to address the issues of integration of new technologies into existing health care practices, implications of interoperability of services, analysis of results following large scale clinical evaluations and development of technology which is small, reliable and affordable by its users. This publication shows a synergy between research efforts in three diverse areas; sensor technologies, advanced textiles and nanotechnology and computing. It brings together researchers from academia, industry and clinical healthcare provision and emphasises the need for multi-disciplinary collaborations in the future developments of personalised health management systems.

A fully updated, comprehensive guide to electronic packaging technologies This thoroughly revised resource offers rigorous and complete coverage of microsystems packaging at both the device and system level. You will get in-depth guidance on the latest technologies from academic and industry leaders. New chapters cover topics highly relevant to today's small and ultra-small systems. Fundamentals of Microsystems Packaging, Second Edition, discusses the entire field, from wafer to systems, and clearly explains every major contributing technology. The book details emerging systems, including smart wearables, the Internet of Things, bioelectronics for medical applications, cloud computing, and much more. Microelectronics, photonics, MEMS, sensors, RF, and wireless technologies are fully covered. • Covers the electrical, mechanical, chemical, and materials aspects of each technology • Contains examples of all common configurations and technologies • Written by the leading author in the field

LEARN ABOUT MICROSYSTEMS PACKAGING FROM THE GROUND UP Written by Rao Tummala, the field's leading author, Fundamentals of Microsystems Packaging is the only book to cover the field from wafer to systems, including every major contributing

