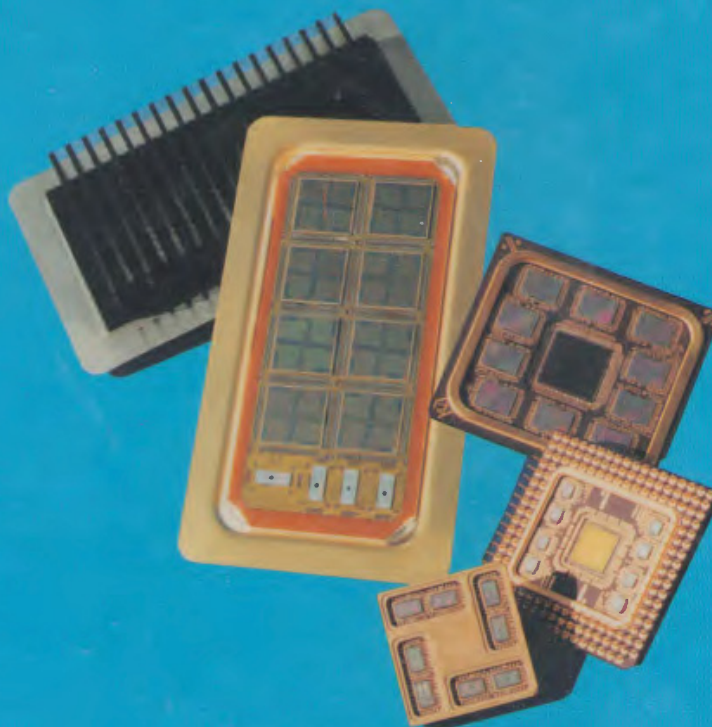

Multichip Module Technologies and Alternatives

THE BASICS



EDITED BY
Daryl Ann Doane Paul D. Franzon

MULTICHIP MODULE TECHNOLOGIES AND ALTERNATIVES:

THE BASICS

Edited by:
Daryl Ann Doane
Paul D. Franzon

Robinson. The top MCM is the latest MCM-D technology AB connections. The bottom with conventional wire bond described in Chapter 14.



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This book is dedicated
to the 42 authors who
made suggestions and
to form the content
Without their diligence
patience
for additional or
there would

Dr. Doane presently serves as Director of Technical Marketing for the IEEE-CHMT (Components, Hybrids & Manufacturing Technology) Society. She also is an elected member of the Board of Governors of the National CHMT Society. She served previously as Chairman of the San Diego Chapter of the CHMT Society.

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FOREWORD

Far from being the passive containers for semiconductor devices of the past, the packages in today's high performance computers pose numerous challenges in interconnecting, powering, cooling and protecting devices. While semiconductor circuit performance measured in picoseconds continues to improve, computer performance is expected to be in nanoseconds for the rest of this century - a factor of 1000 difference between on-chip and off-chip performance which is attributable to losses associated with the package. Thus the package, which interconnects all the chips to form a particular function such as a central processor, is likely to set the limits on how far computers can evolve.

Multichip packaging, which can relax these limits and also improve the reliability and cost at the systems level, is expected to be the basis of all advanced computers in the future. In addition, since this technology allows chips to be spaced more closely, in less space and with less weight, it has the added advantage of being useful in portable consumer electronics as well as in medical, aerospace, automotive and telecommunications products. The multichip technologies with which these applications can be addressed are many. They range from ceramics to polymer-metal thin films to printed wiring boards for interconnections; flip chip, TAB or wire bond for chip-to-substrate connections; and air or water cooling for the removal of heat.

While there are several books now on packaging, these books deal with the subject of multichip modules as part of packaging in general, or they treat a particular multichip module technology or they are at an advanced level. What is needed, therefore, is a *comprehensive book at the basic level*, structured so that anyone entering the field can quickly learn about the technologies, understand the tradeoffs, review the product examples, and make systems level decisions.

Such a book has been provided by Daryl Ann Doane and Paul D. Franzon. They have worked with an outstanding team of packaging experts from industry and universities. Together they have produced **Multichip Module Technologies and Alternatives: The Basics**, an outstanding book for both industry and university use. It is equally appropriate as an introduction to the multichip module technologies for those just entering the field, and as an up-to-date basic technical book for those currently practicing in it.

The book deals with the subject of multichip modules along three parts: systems level perspectives including packaging technology options and costs, the basics of ceramic, thin film and printed wiring board technologies as well as chip and module level connections; thermal and electrical design considerations including electrical testing; and finally product examples illustrating how multichip modules have been useful.

The basic and integrated nature of the book clearly reflects the dedication and the hard work of the editors and the authors.

Rao R. Tummala
IBM Fellow

PREFACE

Welcome!

Welcome to our book. We feel it is a unique book in the field of packaging and we hope you find it both useful and enjoyable. We (editors and authors) have certainly enjoyed bringing it to you!

Uniqueness of the Book

This is a very unique book! Its uniqueness comes about in two ways: first in the approach to the subject, and second, in the approach to the writing of the book.

First, we feel that this book helps define a turning point in the discipline of packaging. The "bottleneck" to increased systems performance is now more often the package than the chip. One effect of this is that suddenly a whole "breed" of engineers need to gain an understanding of how package design affects their systems performance and cost goals. Another effect is the widespread recognition that multichip module packaging technologies are possible solutions to this performance limitation. The attendant explosive growth in the MCM technology alternatives available is a testimony to this recognition.

Until recently, packaging was mainly the domain of mechanical and materials specialists, and furthermore was rarely taught at universities. *This has changed.* Almost overnight, the pressure of high on-chip speeds and high transistor counts meant that packaging became a subject that must be understood by just about any engineer involved in designing a system. When these engineers tried to establish their understanding they found themselves in a virtual "Tower of Babel." First, often the same terms were used for different things or, just as bad, different terms were used for the same thing. Second, as this was the domain of specialists, significant background was required in each discipline in order to understand it. This book turns the discipline of packaging into a subject accessible to the generalist rather than just one accessible to the specialist. Common terms are defined and crosslinked to the terms in current usage. Each discipline is presented in such a way that is both understandable to all and is useful. In providing this book, we help turn packaging into a discipline in which anyone can participate. We also present a book highly suited for teaching within a university.

The book also is unique in how it was created! Packaging is a multidisciplinary subject. We realized that no two people can claim mastery of all the disciplines needed and involved in the subjects we wished to cover. We also realized that rapid writing was important. Thus an edited text was called for. But edited texts are often poorly lacking in terms of understandability and flow. Usually an editor relies on selecting appropriate experts and then accepting what each expert writes with minor alterations.

This book is very different. It could be called a "closely edited" text. Each chapter has had the heavy hand of development of both editors in it. This happened in several forms. Often we spent many hours with individual authors defining what we thought was appropriate and guiding them in the actual writing. In all cases, as well as seeking outside reviewers, we wrote "anonymous" reviews ourselves. In some cases, we directly adjusted the text after it was submitted. Thus we are responsible for the final product as much as each chapter author is.

The result, we feel, is a book that has the authority that comes with a book written by a team of experts, but has the understandability, completeness and flow of a book written by a single author. At least we hope that the book comes as close to that ideal as possible!

Audience

For whom is the book intended? This book is for everyone! The emphasis in the book is on understanding the fundamentals and the reporting of real

experiences rather than including a huge amount of data. It is intended for those who need a broad exposure to the concepts underlying the design, fabrication, packaging, assembly, manufacturing of multichip modules and the costs associated with alternative packaging technologies. The book is intended for applications, manufacturing and design engineers as well as for technical decision makers and managers who are confused about MCM issues but who wish to understand the fundamentals and basics. Specifically, it will be useful to

- **engineers** in design, processing, fabrication, manufacturing, assembly and test who need to choose a packaging technology for specific product and application goals;
- **managers** determining technology alternatives for new systems needs;
- **marketing; sales technologists** who need a working knowledge of the alternative MCM technologies.

The book also is a suitable text for advanced undergraduate and graduate students in design, electrical, mechanical and systems engineering as well as for students in the applied sciences as discussed further on in this Preface.

Philosophy of the Book

What are the key decisions needed when considering using MCM technologies? There are four perspectives: materials, manufacturing, systems performance and cost requirements. The book presents the basics of MCM technologies from these four perspectives with an emphasis on decision-making. How do you choose a packaging technology from a systems performance, cost perspective? What are the fundamental materials and manufacturing issues that need to be considered? Is the packaging strategy appropriate to the design goal?

This book is applications-oriented in the sense that it discusses

- **Examples of MCMs** and the products and systems in which they have been used,
- **Examples of equipment and processes** used to design, build and test MCMs,
- **Actual case studies and insights** provided by leading companies themselves rather than a summary of reported results.

"...a comprehensive book at the basic level, structured so that anyone entering the field can quickly learn the technologies, understand the tradeoffs, review the product examples, and make system level decisions...an outstanding book for both industry and university use.

—Rao R. Tummala, IBM Fellow (from his Foreword)

"I welcome (this book) as a valuable addition to the growing literature on multichip modules... It provides much useful information that will help the reader to understand the capabilities and constraints of this new technology"

—John W. Balde, IEEE Fellow

What are the key decisions that need to be made when considering the use of MCM technology? There are four perspectives: materials, manufacturing, system performance requirements, and cost requirements. *Multichip Module Technologies and Alternatives* presents the basic of MCM technologies, with an emphasis on decision making.

Using an application-oriented approach, the editors discuss:

- examples of MCMs and the products and systems in which they have been used
- examples of equipment and processes used to design, build, and test MCMs
- actual case studies provided by leading companies including Unisys, DEC, and Hughes

Emphasizing MCM fundamentals and reporting real MCM experiences, *Multichip Module Technologies and Alternatives* is intended for those who need a broad exposure to the concepts underlying the design, fabrication, packaging, assembly, and manufacture of multichip modules and the costs associated with alternative packaging technologies. It is a suitable text for undergraduate and graduate students in design, electrical, and mechanical engineering as well as the applied sciences.

The book will be of use to:

- engineers in design, processing, manufacturing, assembly, and testing who need to choose a packaging technology for specific product and application goals
- managers determining technology alternatives for new system needs
- marketing and sales people needing a working knowledge of MCM technologies and alternatives

ABOUT THE EDITORS

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