Preface

This book is an outgrowth of the first IMAPS (International Microelectronics and Packaging Society) Advanced Technology Workshop on RF/Microwave Packaging, held September 16–18, 2008 in San Diego, California. Wireless technologies have undergone tremendous growth in the last decade and the interest in packaging for high-frequency applications has grown as well. Over 30 invited speakers gave presentations on select advanced topics in RF, microwave, millimeter-wave and broadband packaging.

The motivation behind this conference, however, goes beyond the obvious areas of utility. When referring to fundamental engineering limits to very high speed electronics, packaging and interconnect constraints figure significantly. Ever increasing data rates are transforming digital technologies into what are essentially RF systems. The once arcane tools of the RF discipline are becoming increasingly applicable to electronic systems in general, motivating many new considerations. RF systems, despite their small device count, have traditionally been voracious, inefficient consumers of power, creating significant challenges for packaging engineers to deal with heat dissipation. Most digital devices have been much more frugal, but speed and high levels of integration turn these devices into significant heat sources as well. In light of these evolutionary trends, a sampling of the workshop participants were asked to submit chapters on these fascinating areas of development for the work at hand.

Given the diversity of voices at this workshop, and the highly interdisciplinary nature of the topics discussed, this work ranges broadly. Authors include academics, students, large industrial concerns and small entrepreneurial ventures covering a variety of areas such as performance fundamentals, design considerations, novel structures, manufacturing methods, and advanced materials. Although some of the information included here may be of particular use to those studied in a specific discipline, an effort has been made to convey large portions of the information in a way accessible to an audience with general knowledge of electronic packaging.

Chapter 1 introduces the topic with a look at the fundamentals underlying design and performance trade-offs and the additional complexities encountered at microwave and millimeter wave frequencies. In these regimes, even simple interconnects like wire bonds must be considered as complex circuit elements.
Chapter 2 introduces a new interconnect approach that allows low-cost high-volume packaging philosophies to be translated into the high-frequency domain. This development will have implications for digital electronic packaging as well.

Chapter 3 shows a possible path for making millimeter wave passive components with a high-volume production approach. This innovation may enable much more pervasive penetration of millimeter wave systems into consumer and other cost sensitive applications.

Chapter 4 gives some pointers on how low cost is achieved through chip-on-board integration and packaging for millimeter wave electronics and then discusses the particular problems of millimeter-wave circuit performance.

Chapter 5 presents the design and development of thin-film liquid crystal polymer (LCP) surface mount packages for $X$, $K$, and $Ka$-band applications. Constructed using multi-layer LCP films, the packages are surface mounted on a printed circuit board (PCB). Packages include a typical low pass feedthrough design, as well as a new bandpass feedthrough design.

Chapter 6 reviews the design options and the materials available to make portable products and discusses ways to meet packaging density and performance needs. The material discussion focuses on types of organic materials used in portable products and techniques to make PWBs thinner, lighter and cost effective.

Chapter 7 shows how advances in ceramic materials and processing are permitting the creation of increasingly complex multi-layer structures. Going beyond simple routing structures, these ceramics become device elements, and critical packaging for micro-electro-mechanical RF systems.

Chapter 8 discusses Laminated Waveguides, characterizing them numerically, and addressing issues in material and process tradeoffs arising when considering interconnects on a common substrate at mm-wave frequencies with regards to insertion loss and isolation between interconnects. Numerical simulations illustrate the trade-offs using laminated waveguide or common stripline in the same material set.

Chapter 9 shows the latest developments in both simulation and fabrication of LTCC for RF/MW packaging applications. It reviews current LTCC fabrication methods and discusses the trend for RF/MW System in Package modules, high bandwidth design and integrated antenna.

Chapter 10 discusses advances in thermally dissipative composite materials. The discussion covers constituents such as carbon nanotubes, diamond composites, and puts some new spin on well-known materials such as aluminum nitride and beryllium oxide.

Chapter 11 reviews the heat sink material fabrication, application and development for RF/MW packaging. The discussion covers the traditional, second and third generations of heat sink materials.

Chapter 12 reviews the latest development of AlN 3D MCM technology for RF/MW packaging. The discussion covers the AlN HTCC process, matching with various tungsten pastes, impact of firing profiles and other practical design and manufacturing issues.

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