

Preface

Microelectronics packaging was born out of necessity when the integrated circuit (IC) was invented in 1947. Microelectronics packaging is interdisciplinary in nature and involves physics, chemistry, materials science, mechanical engineering, electrical engineering, and more. Microelectronics packaging refers to the enclosure of electronic devices or ICs according to the requirements of each component to achieve a reasonable layout, assembly, bonding, and connection. It is important since it protects devices from moisture, heat, mechanical stresses, mechanical shock, thermal shock, and chemical erosion/corrosion.

Nowadays the trends in electronics are toward a small footprint, light weight, low cost, high performance, and high reliability. All of these trends have led to highly integrated ICs and sophisticated packaging schemes. When the chip power density increases, it is critically important to dissipate the extra heat efficiently. If the heat is not managed properly, the chip's working environment is worsened, leading to higher chip operating temperatures and unstable device performance. In extreme cases, the chips burn out, resulting in fire and safety hazards. Statistically speaking for semiconductors, for every 18 °C operating temperature increase, chip reliability is reduced by two to three times. Therefore, it is very important to manage the waste heat properly.

Different thermal management materials are used in microelectronics packaging. They typically possess a high thermal conductivity (TC) and a low coefficient of thermal expansion (CTE) and are used mainly to dissipate heat and to provide structural support. Traditionally they are also called heat sink materials.

There are many ways to manage waste heat, such as cryogenic coolers, active chilled water pipes, and cooling fans. Most of these methods focus on external heat management, i.e., on how to dissipate waste heat from the environment. There is another fundamental challenge, which is how to dissipate the heat from the IC active layer itself. This is typically done by conduction using heat sink materials.

Lately there has been a great deal of active research on thermal management materials, especially on dielectrics, metals, and metal matrix composites. Results of current research are typically dispersed in various technical journals and conference

proceedings. Thermal management engineers have been hard pressed to find a comprehensive and practical book to cover both the fundamentals of thermal management and selection guidelines, an issue this book hopes to address.

The main objective of this book is to introduce various thermal management materials and their fabrication methods. Most of the materials covered are based on our 10+ years of direct R&D and manufacturing experience. We hope to provide an effective reference book for thermal management engineers and packaging engineers.

The book is divided into ten chapters. Chapters 1, 2, and 3 cover the basics of thermal management and traditional thermal management materials. Chapters 4, 5, 6, 7, and 8 cover copper- and aluminum-based thermal management materials. Finally, Chaps. 9 and 10 discuss the application of these materials in laser diodes and future development trends.

It is our goal to introduce the reader to thermal management basics, theory, and application. At the same time, we strive to reference as many of the latest research papers as possible so that readers can attain a comprehensive understanding of the current status and future trends of the field. As stated previously, thermal management materials are being actively studied worldwide. We cannot possibly cover all the latest developments and welcome feedback from readers like you.

During the writing of this book, we received generous support from Prof. Renzheng Tang, Prof. Zhifa Wang, and Dr. Yi Gu and from graduate students Hong Wu, Dexin Chen, Jun Zhou, Qiwang Zhang, and Xing Yu from Central South University. Without their support and guidance, this book could not have been written. In addition, we would like to extend our appreciation to Ganesh Hariharan and Michael Shaw from Torrey Hills Technologies, LLC, and Adam Ding from the University of Southern California. They rendered valuable assistance in providing materials for several chapters.

Changsha, Hunan, China
Springfield, MO, USA
San Diego, CA, USA

Guosheng Jiang
Liyong “Alex” Diao
Ken Kuang

Advanced Thermal Management Materials

Jiang, G.; Diao, L.; Kuang, K.

2013, XII, 156 p.,

ISBN: 978-1-4614-1963-1