

Preface

Electronics is more and more dominating our daily life. Computers provide our entry to internet and, hence, the world's largest storage of knowledge, cell phones connect us to relatives, friends and business partners, electronics is more and more controlling every function of our automobiles, and electronic automation technology supports efficient production of goods and is a reliable "partner" in health care. This process of evolution of electronics started in the twentieth century but has been radically accelerated with the occurrence of microelectronics after the transistor was invented in 1947 and the first integrated semiconductor circuit was built in 1958. The world-renowned Moore's law describes this long-term trend in the development of microelectronics that the number of transistors that can be placed on an integrated circuit doubles approximately every eighteen months. Now, this trend has continued for more than half a century and is expected to continue at least until 2020. In conjunction with this technological development, electronics has turned almost completely into semiconductor electronics. Semiconductor technology and microelectronic manufacturing methods, respectively, make it possible to simultaneously produce large numbers of similar devices and components with dimensions that are much too small for conventional technologies like precision mechanics.

Semiconductors entered the nano-technology era when structure dimensions went below 100 nm in the 2002–2003 timeframe, after the most leading semiconductor companies, like Intel, AMD, Infineon, Texas Instruments, IBM, and TSMC had introduced the 90 nm technology node. Here, technology node refers to the level of CMOS process technology defined by the International Technology Roadmap for Semiconductors (ITRS). In 2011, wafers with 22 nm technology came into production; its technology successor, the 16 nm technology, is expected to follow likely in 2013.

However, packaging in microelectronics cannot keep pace with this impressive development. Packaging is the final manufacturing process transforming semiconductor devices into functional products for the end user. It has to fulfill a wide variety of tasks regarding system functions, e.g. power supply, signal distribution, protection, and compatibility with regard to the system's application. Hence,

packaging is a key enabling technology achieving the requirements for the reliable operation of electronic systems and for reducing the size and the cost at the system and product level. However, packaging is not only the enabling force but today also the limiting factor in the further development of electronics system integration.

Nano- and biotechniques promise to offer new approaches and solutions to close the growing gap between the development of CMOS technology and the improvements in packaging technology. The application of nanotechnology, i.e. the manipulation and control of matter on the nano-scale, in packaging makes use of size- and structure-dependent properties and phenomena distinct from those of bulk materials. Nano-materials exhibit a much larger specific surface or interface area than coarser materials which leads to a totally different surface-volume ratio. Furthermore, the confinement of atoms and electrons within boundaries of a few nanometers lead to particular nano-scale properties. By this, nano-techniques enable novel approaches and solutions for example regarding nano-sized interconnects, sensor and information processing functionalities, nano-power sources, heat removal, and the protection and functionalization of surfaces matching the system to the environment.

Bio-objects like DNAs or proteins with their corresponding dimensions on the nm- to μm -scale and their particular properties for bio-sensing can be applied in packaging very similar to nano-technology. Bio-techniques offer very particular functionalities like self-organisation, self-assembly, programmability and biocompatibility so far not utilized in packaging. Further into the future, such bottom-up approaches are expected to open many unique solutions for nano-electronics that would not be possible with top-down methods based on photolithography. Nanomaterials with their superior properties and bio-techniques with their opportunity for self-assembly and self-repair had fired up the imagination of engineers and scientists alike. This was the reason that in 2003 colleagues from our Electrical and Computer Engineering Department, the Mechanical Engineering Department, the Sciences Department (Physics, Chemistry and Biology) and the Medical Department came to the idea to establish a Research Training Group “Nano- and Biotechniques for Electronic Device Packaging” at our Technische Universität Dresden, Germany. This idea came finally to life in the fall of 1995 when the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) agreed to provide funding for 20 PhD and 2 postdoc positions over a period of nine years. Since then professors, PhD students and many other scientists of TU Dresden have been contributing in an astonishing way to this most recent field in packaging.

Nano- and bio-techniques are still in the early stages of research and development. Nevertheless, some of the results, like biosensors on silicon nanowires, are tempting to being transferred to industrial applications of packaging. Therefore, the intentions of this book are to provide an overview about what is possible in packaging with these new technologies and where are the limitations. The book is composed as a compendium of in-depth reviews. It covers the broad aspects of the field from the present and future of packaging (Part I) via modeling and

simulation of three-dimensional electronic systems (Part II) and packaging-related material and technology issues (Parts III and IV) up to the point of functionalized surfaces (Parts V and VI). Each of these six parts of the book will be introduced by a chapter providing a more comprehensive overview. Most of the other chapters include more a focus on the authors' own research in each respective field. Nevertheless, each chapter presents an outlook about what can be expected in the future and provides an extensive reference listing. We hope that this will give the reader a resource for keeping pace with the fast development in this emerging field. It is hoped that he can find stimulating new ideas and some food for thought.

The book is the result of the commitment of the many co-authors most of them associated with our Research Training Group. It was impressing to observe their verve and enthusiasm to make this book a reality. The editors would like to express their thankfulness to Martin Waegner who provided the necessary support to bring the chapters into the right shape and to manage the electronic files. We would also like to express our appreciation to Springer Verlag for the opportunity to publish this book and, in particular, to Thomas Lehnert and Ulrike Butz for their excellent cooperation, but also for their patience when repeatedly faced with delays due to the authors' workload.

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