Preface

This special topic volume ‚Advances in Electronic Materials' covers different fields of materials such as silicon, silicon-germanium hetero-structures, high-k materials, III-V semiconductor alloys and organic materials as well as nano-structures for spintronics and photovoltaics. It starts with a brief summary of the formative years of microelectronics, which is a central area within information technology.

Information technology is still one of the most important global technologies and an extremely complex area. Though electronic materials are primarily connected with computers, internet, or mobile telephones, they are used for many more applications to improve the quality of life for everyone. Progress in classical scientific fields such as physics, biology, chemistry, mechanics and software are often based on new developments within the area of electronic materials.

The performance of electronic materials has made important progress during the last years and further improvements are expected. The second article summarises a few basic requirements and applications of future material systems by taking into account strong links to economics. New hetero-structure device concepts will be the basis for further improvements in micro- and optoelectronics and are described in detail in the subsequent chapter. High-permittivity (k) materials are playing an important role in downscaling both Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) and Dynamic Random Access Memories (DRAMs). Therefore, the next article presents a detailed study of the electrical properties of thin high-k dielectric films by paying particular attention to the strong impact of macroscopic, microscopic and atomic-size defects on leakage currents and reliability concerns in gate stacks. Today Non-Volatile Memories (NVM) represent a large portion of the overall semiconductor market and are considered as one of the most important technologies for the mobile application segment. The main technology line within this field is represented by the Flash Memory. In the following article alternative technologies are discussed which exploit new materials and concepts to go beyond the flash technology.

The development of integrated circuits is based on a long and fascinating history, which is unique in modern time. Yet, the fantastic growth in semiconductor electronics is due to a unique combination of basic conceptional advances, the perfection of new materials and the development of new device principles. The next chapter therefore describes in more detail future material perspectives of nano-electronics and nano-spintronics by considering in particular nano-architecture and scalability issues. This chapter is followed by another article on future material perspectives covering organic materials. Organic materials have recently been developed to operate as the active semiconductor in a wide range of semiconductor devices, including field-effect transistors and photovoltaic diodes. These views on future perspectives are further discussed in the last chapter of the book, which reviews among other things the impact of nano-materials on photovoltaic power generation. Many new ideas have flooded the literature in the last few years most revolving around nanostructures. However, a dominant criterion in this connection is the performance-cost aspect, an essential prerequisite to large-scale adoption of these new perspectives.

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A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass. Its resistance falls as its temperature rises; metals are the opposite. Its conducting properties may be altered in useful ways by introducing impurities ("doping") into the crystal structure. When two differently-doped regions exist in the same crystal, a semiconductor junction is created. The behavior of charge carriers, which include electrons