Preface

Over the past five decades, the microelectronics industry has sustained tremendous growth and has become what is arguably the most dominant industrial sector for our society. The electronics industry has spawned annual growth of more than 30% over this extended time period and has touched almost every aspect of our modern lives through the development of personal computers, portable communication devices, various consumer electronics, navigation tools, and imaging devices. The availability of a powerful microfabrication tool set that can be used to process these devices in a highly parallel manner has led to this explosive growth. Recently, it has become clear that the electronics industry will face new and significant challenges as component device feature sizes shrink into the nanometer size regime. However, with the challenge here has come the opportunity to develop a number of fascinating new sensors and devices using nanometer-sized building blocks. Challenges with spiraling health care costs, the global HIV crisis, environmental, and homeland defense areas all provide strong motivation for the creation of a bridge between microelectronics, nanoscience engineering, and the health sciences. The ultimate applications to be derived from such interdisciplinary efforts are likely to occur for the sectors of environmental, life sciences, and health industries.

Indeed, remarkable advances have been made recently in the development of miniaturized sensing and analytical components for use in a variety of chemical, biological, biomedical, and clinical applications. These efforts have led to the development of microcomponents, such as microchambers, microfilters, microchannels, microarrays, micropumps, and microvalves, whose presence in analytical systems earns them the denomination of "microchip." However, the ability to assemble and interface individual components in order to achieve a high level of functionality in complete working devices continues to pose a daunting challenge for the scientific community as a whole. Lessons learned from the microelectronics and computer software industries provide inspiration for what may be gained from the marriage of microelectronics and sensing areas, through the development of micro-total analysis systems (μ-TAS), and integrated lab-on-a-chip (LOC) approaches. Although chemical and medical tests have traditionally been completed in central laboratories that are filled with specialized equipment and trained technicians, there is currently a trend to complete more tests using portable instrumentation.

Tremendous advances have been made recently in the area of LOC devices exploiting the advantages of miniaturization mediated by the small reagent and sample volumes required. Smaller sample and reagent volumes translate to rapid analysis times and less waste volumes, and result in more cost-effective assays that can be operated with less technological constraints making them amenable to point-of-care or field testing. Most importantly, these characteristics when fully developed into a functional system have the potential to lead to a significant reduction in the time that is needed for an accurate diagnosis or analysis, and subsequent treatment or action (i.e., "turn-around time"). Although there are still only a few commercially available microchips for use as environmental, chemical, military, or medical sensor devices, the area has attracted significant attention as research teams strive to develop new miniaturized sensor devices.

We wish to express our immense gratitude to all the authors for their dedication and expert contributions. Most of the exciting work presented here has greatly benefited from ground-breaking research in the fields of sensing, nanotechnology, and microfluidics, across multidisciplinary collaborative work in chemistry, biology, immunology, physics, and engineering. Therefore, we would also like to extend our appreciation to such pioneers who were not able to contribute to this book but kindly responded with helpful suggestions. Although the presentation of a specific technique alone would require at least an entire volume for appropriate coverage, presented here are examples of DNA-, cellular-, chemical-, protein-based assays conducted on microchips utilizing various aspects of microchip fabrication for application in specific disease diagnostic, and chemical or biological sensing. The overall purpose of this volume is to provide a "taste" of what can be envisioned and realized with microchip approaches. Moreover, the protocols here detailed will help foster interest in microchip-based assays by providing readers with all the tools necessary to create their own microchip-based assays targeted to new applications. It is hoped that this compilation of methods and protocols will help to expand the scope and accelerate the transition of microchip-based assays from academic and industrial research and development centers to real-world use.

I would like to join Satie Siewah and her colleagues in remembrance of Dr. Kenneth Anil Deisingh who tragically passed away during the editing phase of this book.

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