

Preface

BioMEMS and its extensions into biomedical nanotechnology have tremendous potential both from a research and applications point of view. Exciting strides are being made at intersection of disciplines and BioMEMS and biomedical nanotechnology is certainly one of these very interdisciplinary fields, providing many opportunities of contribution from researchers from many disciplines. In the specific areas of biomolecular sensing, processing and analysis, BioMEMS can play a critical role to provide the various technology platforms for detection of cells, microorganisms, viruses, proteins, DNA, small molecules, etc. and the means to interface the macroscale realm to the nanoscale realm.

We are very pleased to present volume 4 in the Handbook of BioMEMS and Biomedical Nanotechnology, published by Kluwer Academic Press. This volume contains 18 chapters focused on 'Biomolecular Sensing, Processing and Analysis', written by experts in the field of BioMEMS and biomedical nanotechnology. The chapters are grouped into three broad categories of Sensors and Materials, Processing and Integrated Systems, and Microfluidics.

Prof. Taun Vo-Dinh from Oakridge National Labs begins the Sensors and Materials section by providing a review of biosensors and biochips. This review is followed by an example of mechanical cantilever sensor work described by Prof. Arun Majumdar's group at UC Berkeley and Prof. Tom Thundat at Oakridge National Laboratory. An example of a nano-scale sensor electrical sensor, an artificial pore, integrated in a microscale device is presented next by Prof. Lydia Sohn's group at UC Berkeley. Cell based sensors are an important class of electrical sensors and Profs. Cengiz Ozkan and Mihri Ozkan at UC Riverside present a review of their work in this area. These chapters on sensors are followed by a review chapter on silicon and glass BioMEMS processing by Prof. Nam Trung Nguyen at Nanyang Technological University. Polymers and hydrogels are an important class of bioMEMS materials and Profs. Nicholas Peppas at UT Austin and Zach Hilt at University of Kentucky provide a review chapter in this area to close off this section.

The Processing and Integrated Systems section is focused on means to manipulate biological and fluidic samples in BioMEMS device and examples of integrated BioMEMS systems. Prof. Abe Lee from UC Irvine presents a review of magnetohydrodynamic methods and their utility in BioMEMS and micro-total-analysis (μ TAS) systems. Dielectrophoresis (DEP) is being increasingly used at the microscale and in BioMEMS applications and Prof. Joel Voldman from MIT provides a review of DEP and applications, especially for cellular analysis and manipulation. Prof. Rashid Bashir and his group from Purdue present an overview of BioMEMS sensors and devices for cellular sensing, detection and manipulation. Microsystems and BioMEMS integrated with wireless and RF devices for in-vivo applications is a growing field and Prof. Babak Ziaie, previously of University of Minnesota,

and now at Purdue, presents an overview of this area. As reviewed in the first section, polymers and hydrogels are a very important class of BioMEMS materials and Prof. David Beebe from University of Wisconsin presents an overview of the work in his group on polymer based self-sensing and actuating microfluidic systems. Lastly, mixing and stirring of fluids is an important problem to be addressed at the microscale due to the fact that Reynold's numbers are small, flows are laminar, and it is challenge to create mixing. Prof. Meinhart and colleagues at UC Santa Barbara present the use of AC electrokinetic methods, including DEP, for mixing of fluids in BioMEMS devices.

The Microfluidics section describes work in a very important supporting field for BioMEMS—microfluidics. Since nearly all life processes occur in or with the help of water, microfluidics is a key technology necessary in miniaturizing biological sensing and processing applications. This section starts off with a contribution by Prof. Steve Wereley's group at Purdue University quantitatively exploring how DEP influences particle motion and proposing a new experimental technique for measuring this influence. Prof. David Erickson from Cornell University and Prof. Dongqing Li from Vanderbilt University have contributed an article reviewing emerging computational methods for simulating flows in microdevices. Prof. Terry Conlisk and Prof. Sherwin Singer's (both of Ohio State University) contribution focused exclusively on modeling electroosmotic flow in nanochannels—a challenging domain where Debye length is comparable to channel dimension. This is followed by a contribution from Prof. Minami Yoda at Georgia Tech describing a new version of the versatile micro-Particle Image Velocimetry technique demonstrating spatial resolutions smaller than 1 micron, a requirement for making measurements in nanochannels. Viosense Corporation, led by Dominique Fourquette, has contributed an article on the development of optical MEMS-based sensors, an area of distinct important to BioMEMS. The last contribution to this section is certainly the most biological. Jennifer McCann together with Profs Thomas Webster and Karen Haberstroh (all of Purdue) have contributed a study of how flow stresses influence vascular cell behavior.

Our sincere thanks to the authors for providing the very informative chapters and to Prof. Mauro Ferrari and Kluwer Academic Press for initiating this project. We hope the text will serve as an excellent reference for a wide ranging audience, from higher level undergraduates and beginning graduate students, to industrial researchers, and faculty members.

With best regards

Rashid Bashir (bashir@purdue.edu)

Steve Wereley (wereley@purdue.edu)

Purdue University, West Lafayette, IN

Mauro Ferrari

Professor, Brown Institute of Molecular Medicine Chairman

Department of Biomedical Engineering

University of Texas Health Science Center, Houston, TX

Professor of Experimental Therapeutics

University of Texas M.D. Anderson Cancer Center, Houston, TX

Professor of Bioengineering, Rice University, Houston, TX

Professor of Biochemistry and Molecular Biology

University of Texas Medical Branch, Galveston, TX

President, the Texas Alliance for NanoHealth, Houston, TX