BOOK REVIEW

Microfluidic devices in nanotechnology: Fundamental concepts

C. S. Kumar, 350 pages, ISBN 978-0-470-47227-9, John Wiley & Sons, Inc., Hoboken, New Jersey, USA (2010), US $145.00, hardcover.

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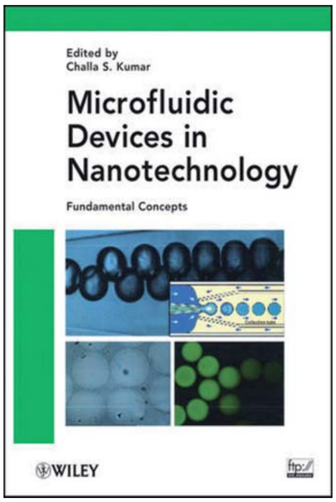

Microfluidics and nanotechnology. Both are thought-provoking fields which promise us revolutions in biomedicine. The book edited by Kumar is the first in a two-volume set. The goal is to educate the reader about the physical phenomena related to where microfluidics and nanotechnology overlap and the importance of applications generated thereby.

The reader is introduced to the world of microfluidics by Addae-Mensah et al. in the first chapter. The major vocabulary terms, dimensionless numbers, and equations are explained. The ever-important fabrication schemes described in this chapter are put into context as important fundamental microfluidics devices (i.e., mixers, pumps, etc.) are introduced. In Chap. 2, Genualdi and Gracias explain how microfluidics has allowed extensive control over the temporal and spatial properties of fluid interactions. Intrinsic laminar flows allow interfaces between fluids to be shifted, electrode arrays help place cells where they are needed, chemicals are captured in microbeakers and later released at new locations, and even RNA is "told" when it will be allowed to interact. The concepts, theory, and applications involved in microfluidic kinetic experiments are introduced by Wilson in Chap. 3. Rapid transfers of mass and thermal energy are identified as the main benefit microfluidics provides for kinetic studies. This chapter is a fantastic reference for methods and equations necessary for understanding processes such as enzyme kinetics and protein folding.

In Chap. 4, Drikakis et al. enlighten the reader on the importance of computational techniques in the study of microfluidics, especially as the dimensions of the channel approach the nanoscale. The inaccuracies of the continuum model and the inefficiencies of the molecular model have led to hybrid models combining the two. Dilute solutions of large molecules are modeled as chains of constrained beads in metamodels.

Abgrall et al. navigate through nanostructures, and the fabrication and applications of nanofluidic devices in Chap. 5. Electrokinetic effects such as the electric double layer, electroneutrality, and semi-permeability help the reader distinguish nanochannels from microchannels and lead to interesting new devices such as nanofluidic transistors. Nanoscale fluidics is further explored by discussing hydrodynamic effects (capillarity, solid-liquid friction, zeta-potential alterations) and the methods for separating and analyzing single DNA molecules.

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The last four chapters focus on nanoparticles. Magnetism is introduced into the reader's fluidic world by Furlani as he describes magnetic nanoparticles and how they behave in both fluids and magnetic fields in Chap. 6. An extensive description of magnetic theory and how it applies to nanoparticles is given, generating a comprehensive reference. Minerick supplies the reader with an overview of nanoparticles in Chap. 7. Inorganic, organic, and magnetic nanoparticles are discussed with regard to type, fabrication process, transportation techniques, and important applications such as reaction kinetics. Wu describes methods such as electrophoresis, dielectrophoresis, electro-osmosis, and electrothermal transport to concentrate nanoparticles and enhance the detection and separation of samples. In the final chapter, the reader is left with a description from Groß and Köhler about an important effect which affects the formation of nanoparticles: the residence-time distribution effect. They describe the relevance of this effect, introduce its characterization in microfluidic devices, and discuss relevant experimental data.

Anyone interested in microfluidics or nanoparticles would find this book useful, but the book should be especially useful for those interested in where these fields overlap. A book of this nature is quite necessary, as both microfluidics and nanotechnology are multidisciplinary fields. This book helps to bring together the aspects most vital for researchers in these fields. Concepts which have already been extensively covered in another book or review paper are briefly discussed, and the reader is directed toward the appropriate references. Newer topics are covered in great detail, and all relevant equations are introduced and discussed. Although the intended audience for the book is not explicitly clear, the book's structure leads one to believe that it is intended as a handbook or reference book for active researchers in these fields. This book could also be used as a textbook for a course, but the lack of homework problems would be detrimental.

Although the book is well written and easy to navigate, it suffers from issues related to its multi-author configuration. Several chapters repeatedly introduce core concepts and ideals in microfluidics, such as Reynolds number and laminar flow. Likewise, there is significant overlap in the last four chapters on nanoparticles. For example, while Chap. 6 is an extensive review of magnetic nanoparticles, Sec. 7.3 is a short review of the same topic. This book is essentially a combination of nine extremely well-written and relevant review articles. Some of the overlapping elements could have been removed by careful editing, which could have allowed the two volumes to be combined into one.

Your reviewer, a young microfluidics researcher, became very engaged by the contents of the book. It helped to pull together in a concise volume all of the important aspects relating to microfluidics and nanotechnology. Both microfluidics and nanoparticle researchers will learn some new techniques and theories from this book. This book can be easily navigated for a first-time read or even for extensive referencing and is recommended to interested researchers.