

Preface

Microdroplet technology has recently been exploited to provide new and diverse applications via microfluidic functionality, especially in the arenas of biology and chemistry. This book gives a timely overview on state of the art of droplet-based microfluidics. The disciplines related to microfluidics and microdroplet technology are diverse and where interdisciplinary cooperation is pivotal for the development of new and innovative technological platforms. The chapters are contributed by internationally leading researchers from physics, engineering, biology and chemistry to address: fundamental flow physics; methodology and components for flow control; and applications in biology and chemistry. They are followed by a chapter giving a perspective on the field. Therefore, this book is a key point of reference for academics and students wishing to better their understanding and facilitate optimal design and operation of new droplet-based microfluidic devices for more comprehensive analyte assessments.

The first part of this book (Chaps. 1, 2, 3, 4 and 5) focuses on fundamental flow physics, device design and operation, while the rest of the chapters (Chaps. 6, 7, 8, 9 and 10) deal with the wide range of applications of droplet-based microfluidics. It starts with the discussion of flow physics of microdroplets confined in lab-on-a-chip devices in Chap. 1, where Zhang and Liu emphasize the important dimensionless parameters relating to droplet dynamics. Meanwhile, droplet generation process is used as an example to illustrate the unique flow physics in comparison with conventional droplet dynamics in unconfined environments.

Chapter 2 deals with microfluidics droplet manipulations and applications, including droplet fusion, droplet fission, mixing in droplets and droplet sorting. By combining these operations, Simon and Lee demonstrate how to execute chemical reactions and biological assays at the microscale. Using the flow rates, applied pressures and flow rate ratios in a closed feedback system, the active control of droplet size during formation process in microfluidics is addressed in Chap. 3 by Nguyen and Tan.

In Chap. 4, Barber and Emerson discuss the fundamental droplet handling operations and the recent advances in electrowetting microdroplet technologies and their applications in biological and chemical processes. Kaminski, Churski

and Garstecki review the recent advances in building modules for automation of handling of droplets in microfluidic channels, in Chap. 5, including the modules for generation of droplets on demand, aspiration of samples onto chips, splitting and merging of droplets, incubation of the content of the drops and sorting.

From Chap. 6, the book shifts its focus on the applications of microdroplet technology. In Chap. 6, Philip Day and Ehsan Karimiani discuss dropletisation of bio-reactions. The use of large-scale microdroplet production is described for profiling single cells from complex tissues and assists with the production of quantitative data for input into systems modelling of disease.

Droplet-based microfluidics as a biomimetic principle in diagnostic and biomolecular information handling are highlighted in Chap. 7 by Köhler. This chapter also addresses the potential of applying segmented fluid technique to answer to the challenges of information extraction from cellular and biomolecular systems. In Chap. 8, Carroll et al. focus on droplet microreactors for materials synthesis, with a brief description of microfluidics for droplet generation as well as fabrication technology. In addition, a detailed study of transport in microchannels and droplet microfluidics for mesoporous particle synthesis is included.

In Chap. 9, Zagnoni and Cooper demonstrate the use of on-chip biocompatible microdroplets both as a carrier to transport encapsulated particles and cells, and as microreactors to perform parallel single-cell analysis in tens of milliseconds. Finally, trends and perspectives are provided by Neužil, Xu and Manz to discuss challenges in fundamental research and technological development of droplet-based microfluidics.

This book is intended for established academics, researchers and postgraduate students at the frontier of fundamental microfluidic research, system design and applications (particularly bio/chemical applications) of microfluidic droplet technology. It can mainly be used as a reference book for the basic principles, components and applications of microdroplet-based microfluidic systems. Those postgraduates and researchers whose study is related to microfluidics will benefit from closely engaging the emerging droplet-based microfluidics comprehensively covered in this book. Furthermore, the publication will serve as a text or reference book for academic courses teaching advanced analytical technologies, medical devices, fluid engineering, etc. Potential markets for researchers include in sectors related to medical devices, fluid dynamics, engineering, analytical chemistry and biotechnology.

Manchester, UK
Saarbrücken, Germany
Glasgow, UK

Philip Day
Andreas Manz
Yonghao Zhang