

DIGITAL MICROFLUIDIC BIOCHIPS

Design Automation and Optimization



**Krishnendu Chakrabarty
Tao Xu**



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Digital Microfluidic Biochips Design Automation And Optimization

Michael Rajnik



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Digital Microfluidic Biochips Krishnendu Chakrabarty, Tao Xu, 2010-05-03 Microfluidics based biochips combine electronics with biochemistry providing access to new application areas in a wide variety of fields Continued technological innovations are essential to assuring the future role of these chips in functional diversification in biotech pharmaceuticals and other industries Revolutionary guidance on design opti

Digital Microfluidic Biochips Krishnendu Chakrabarty, Tao Xu, 2010 Microfluidics based biochips combine electronics with biochemistry providing access to new application areas in a wide variety of fields Continued technological innovations are essential to assuring the future role of these chips in functional diversification in biotech pharmaceuticals and other industries Microfluidic Biochips Design Automation and Optimization comprehensively covers the appropriate design tools and in system automation methods that will help users adapt to new technology and progress in chip design and manufacturing Based on results from several Duke University research projects on design automation for biochips this book uses real life bioassays as examples to lay out an outomated design flow for creating microfluidic biochips It also develops solutions to the unique problems associated with the process In addition to covering automated design the authors provide a detailed methodology for the testing use and optimization of robust cost efficient manufacturable digital microfluidic systems used in protein crystallization and other areas The authors present specialized pin constrained design techniques for making biochips with a focus on cost and disposability They also discuss chip testing to ensure dependability which is key to optimizing safety critical applications such as point of care medical diagnostics on chip DNA analysis automated drug discovery air quality monitoring and food safety testing This book is an optimal reference for academic and industrial researchers in the areas of digital microfluidic biochips and electronic design automation

BOOK JACKET *Micro-Electrode-Dot-Array Digital Microfluidic Biochips* Zipeng Li, Krishnendu Chakrabarty, Tsung-Yi Ho, Chen-Yi Lee, 2018-12-14 This book provides an insightful guide to the design testing and optimization of micro electrode dot array MEDA digital microfluidic biochips The authors focus on the characteristics specific for MEDA biochips e g real time sensing and advanced microfluidic operations like lamination mixing and droplet shape morphing Readers will be enabled to enhance the automated design and use of MEDA and to develop a set of solutions to facilitate the full exploitation of design complexities that are possible with standard CMOS fabrication techniques The book provides the first set of design automation and test techniques for MEDA biochips The methods described in this book have been validated using fabricated MEDA biochips in the laboratory Readers will benefit from an in depth look at the MEDA platform and how to combine microfluidics with software e g applying biomolecular protocols to software controlled and cyberphysical microfluidic biochips

Design Automation Methods and Tools for Microfluidics-Based Biochips Jun Zeng, 2006-11-08 Design Automation Methods and Tools for Microfluidics Based Biochips deals with all aspects of design automation for microfluidics based biochips Experts have contributed chapters on many aspects of biochip design automation

Topics covered include device modeling adaptation of bioassays for on chip implementations numerical methods and simulation tools architectural synthesis scheduling and binding of assay operations physical design and module placement fault modeling and testing and reconfiguration methods

Digital Microfluidic Biochips Krishnendu Chakrabarty, Fei Su, 2018-10-03 Digital Microfluidic Biochips focuses on the automated design and production of microfluidic based biochips for large scale bioassays and safety critical applications Bridging areas of electronic design automation with microfluidic biochip research the authors present a system level design automation framework that addresses key issues in the design analysis and testing of digital microfluidic biochips The book describes a new generation of microfluidic biochips with more complex designs that offer dynamic reconfigurability system scalability system integration and defect tolerance Part I describes a unified design methodology that targets design optimization under resource constraints Part II investigates cost effective testing techniques for digital microfluidic biochips that include test resource optimization and fault detection while running normal bioassays Part III focuses on different reconfiguration based defect tolerance techniques designed to increase the yield and dependability of digital microfluidic biochips Expanding upon results from ongoing research on CAD for biochips at Duke University this book presents new design methodologies that address some of the limitations in current full custom design techniques Digital Microfluidic Biochips is an essential resource for achieving the integration of microfluidic components in the next generation of system on chip and system in package designs

Hardware/Software Co-Design and Optimization for Cyberphysical Integration in Digital Microfluidic Biochips Yan Luo, Krishnendu Chakrabarty, Tsung-Yi Ho, 2014-08-06 This book describes a comprehensive framework for hardware software co design optimization and use of robust low cost and cyberphysical digital microfluidic systems Readers with a background in electronic design automation will find this book to be a valuable reference for leveraging conventional VLSI CAD techniques for emerging technologies e g biochips or bioMEMS Readers from the circuit system design community will benefit from methods presented to extend design and testing techniques from microelectronics to mixed technology microsystems For readers from the microfluidics domain this book presents a new design and development strategy for cyberphysical microfluidics based biochips suitable for large scale bioassay applications Takes a transformative cyberphysical approach towards achieving closed loop and sensor feedback driven biochip operation under program control Presents a physically aware system reconfiguration technique that uses sensor data at intermediate checkpoints to dynamically reconfigure biochips Enables readers to simplify the structure of biochips while facilitating the general purpose use of digital microfluidic biochips for a wider range of applications

Exact Design of Digital Microfluidic Biochips Oliver Keszocze, Robert Wille, Rolf Drechsler, 2018-06-11 This book presents exact that is minimal solutions to individual steps in the design process for Digital Microfluidic Biochips DMFBs as well as a one pass approach that combines all these steps in a single process All of the approaches discussed are based on a formal model that can easily be extended to cope with further design problems In

addition to the exact methods heuristic approaches are provided and the complexity classes of various design problems are determined Presents exact methods to tackle a variety of design problems for Digital Microfluidic Biochips DMFBs Describes an holistic one pass approach solving different design steps all at once Based on a formal model of DMFBs that is easily adaptable to deal with further design tasks Proceedings of the International Conference on Computing and Communication Systems Arnab Kumar Maji,Goutam Saha,Sufal Das,Subhadip Basu,João Manuel R. S. Tavares,2021-04-11

This book contains the latest research work presented at the International Conference on Computing and Communication Systems I3CS 2020 held at North Eastern Hill University NEHU Shillong India The book presents original research results new ideas and practical development experiences which concentrate on both theory and practices It includes papers from all areas of information technology computer science electronics and communication engineering written by researchers scientists engineers and scholar students and experts from India and abroad **Design and Testing of Digital**

Microfluidic Biochips Yang Zhao,Krishnendu Chakrabarty,2012-07-25 This book provides a comprehensive methodology for automated design test and diagnosis and use of robust low cost and manufacturable digital microfluidic systems It focuses on the development of a comprehensive CAD optimization framework for digital microfluidic biochips that unifies different design problems With the increase in system complexity and integration levels biochip designers can utilize the design methods described in this book to evaluate different design alternatives and carry out design space exploration to obtain the best design point *Microfluidic Very Large Scale Integration (VLSI)* Paul Pop,Wajid Hassan Minhas,Jan

Madsen,2016-02-08 This book presents the state of the art techniques for the modeling simulation testing compilation and physical synthesis of mVLSI biochips The authors describe a top down modeling and synthesis methodology for the mVLSI biochips inspired by microelectronics VLSI methodologies They introduce a modeling framework for the components and the biochip architecture and a high level microfluidic protocol language Coverage includes a topology graph based model for the biochip architecture and a sequencing graph to model for biochemical application showing how the application model can be obtained from the protocol language The techniques described facilitate programmability and automation enabling developers in the emerging large biochip market Proceedings of International Conference on Data, Electronics and Computing Nibaran Das,Ajoy Kumar Khan,Swagata Mandal,Ondrej Krejcar,Debotosh Bhattacharjee,2024-10-07

This book features high quality peer reviewed research papers presented at the International Conference on Data Electronics and Computing ICDEC 2023 organized by Department of Computer Science cloud computing IoT and smart city AI ML big data and data mining VLSI design antenna and microwave and control *Optimization of Trustworthy Biomolecular Quantitative Analysis Using Cyber-Physical Microfluidic Platforms* Mohamed Ibrahim,Krishnendu Chakrabarty,2020-05-31 A microfluidic biochip is an engineered fluidic device that controls the flow of analytes thereby enabling a variety of useful applications According to recent studies the fields that are best set to benefit from the microfluidics technology also known as lab on chip

technology include forensic identification clinical chemistry point of care PoC diagnostics and drug discovery The growth in such fields has significantly amplified the impact of microfluidics technology whose market value is forecast to grow from 4 billion in 2017 to 13.2 billion by 2023 The rapid evolution of lab on chip technologies opens up opportunities for new biological or chemical science areas that can be directly facilitated by sensor based microfluidics control For example the digital microfluidics based ePlex system from GenMarkDx enables automated disease diagnosis and can bring syndromic testing near patients everywhere However as the applications of molecular biology grow the adoption of microfluidics in many applications has not grown at the same pace despite the concerted effort of microfluidic systems engineers Recent studies suggest that state of the art design techniques for microfluidics have two major drawbacks that need to be addressed appropriately 1 current lab on chip systems were only optimized as auxiliary components and are only suitable for sample limited analyses therefore their capabilities may not cope with the requirements of contemporary molecular biology applications 2 the integrity of these automated lab on chip systems and their biochemical operations are still an open question since no protection schemes were developed against adversarial contamination or result manipulation attacks Optimization of Trustworthy Biomolecular Quantitative Analysis Using Cyber Physical Microfluidic Platforms provides solutions to these challenges by introducing a new design flow based on the realistic modeling of contemporary molecular biology protocols It also presents a microfluidic security flow that provides a high level of confidence in the integrity of such protocols In summary this book creates a new research field as it bridges the technical skills gap between microfluidic systems and molecular biology protocols but it is viewed from the perspective of an electronic systems engineer VLSI 2010 Annual Symposium Nikolaos Voros, Amar Mukherjee, Nicolas Sklavos, Konstantinos Masselos, Michael Huebner, 2011-09-08 VLSI 2010 Annual Symposium will present extended versions of the best papers presented in ISVLSI 2010 conference The areas covered by the papers will include among others Emerging Trends in VLSI Nanoelectronics Molecular Biological and Quantum Computing MEMS VLSI Circuits and Systems Field programmable and Reconfigurable Systems System Level Design System on a Chip Design Application Specific Low Power VLSI System Design System Issues in Complexity Low Power Heat Dissipation Power Awareness in VLSI Design Test and Verification Mixed Signal Design and Analysis Electrical Packaging Co Design Physical Design Intellectual property creating and sharing Algorithms and Complexity Pinar Heggernes, 2019-05-20 This book constitutes the refereed conference proceedings of the 11th International Conference on Algorithms and Complexity CIAC 2019 held in Rome Italy in May 2019 The 30 full papers were carefully reviewed and selected from 95 submissions The International Conference on Algorithms and Complexity is intended to provide a forum for researchers working in all aspects of computational complexity and the use design analysis and experimentation of efficient algorithms and data structures The papers present original research in the theory and applications of algorithms and computational complexity *Proceedings of the International Conference on Computational*

Intelligence and Sustainable Technologies Kedar Nath Das, Debasish Das, Anjan Kumar Ray, Ponnuthurai Nagaratnam Suganthan, 2022-02-12 This book presents the collection of the accepted research papers presented in the 1st International Conference on Computational Intelligence and Sustainable Technologies ICoCIST 2021 This edited book contains the articles related to the themes on artificial intelligence in machine learning big data analysis soft computing techniques pattern recognitions sustainable infrastructural development sustainable grid computing and innovative technology for societal development renewable energy and innovations in Internet of Things IoT

Handbook of Nanoscience, Engineering, and Technology William A. Goddard III, Donald Brenner, Sergey Edward Lyshevski, Gerald J Iafrate, 2018-09-03 In his 1959 address There is Plenty of Room at the Bottom Richard P Feynman speculated about manipulating materials atom by atom and challenged the technical community to find ways of manipulating and controlling things on a small scale This visionary challenge has now become a reality with recent advances enabling atomistic level tailoring and control of materials Exemplifying Feynman s vision Handbook of Nanoscience Engineering and Technology Third Edition continues to explore innovative nanoscience engineering and technology areas Along with updating all chapters this third edition extends the coverage of emerging nano areas even further Two entirely new sections on energy and biology cover nanomaterials for energy storage devices photovoltaics DNA devices and assembly digital microfluidic lab on a chip and much more This edition also includes new chapters on nanomagnet logic quantum transport at the nanoscale terahertz emission from Bloch oscillator systems molecular logic electronic optics in graphene and electromagnetic metamaterials With contributions from top scientists and researchers from around the globe this color handbook presents a unified up to date account of the most promising technologies and developments in the nano field It sets the stage for the next revolution of nanoscale manufacturing where scalable technologies are used to manufacture large numbers of devices with complex functionalities

Secure and Trustworthy Cyberphysical Microfluidic Biochips Jack Tang, Mohamed Ibrahim, Krishnendu Chakrabarty, Ramesh Karri, 2019-05-28 This book describes novel hardware security and microfluidic biochip design methodologies to protect against tampering attacks in cyberphysical microfluidic biochips CPMBs It also provides a general overview of this nascent area of research which will prove to be a vital resource for practitioners in the field This book shows how hardware based countermeasures and design innovations can be a simple and effective last line of defense demonstrating that it is no longer justifiable to ignore security and trust in the design phase of biochips

Fault-Tolerant Digital Microfluidic Biochips Paul Pop, Mirela Alistar, Elena Stuart, Jan Madsen, 2015-09-07 This book describes for researchers in the fields of compiler technology design and test and electronic design automation the new area of digital microfluidic biochips DMBs and thus offers a new application area for their methods The authors present a routing based model of operation execution along with several associated compilation approaches which progressively relax the assumption that operations execute inside fixed rectangular modules Since operations can experience transient faults during the

execution of a bioassay the authors show how to use both offline design time and online runtime recovery strategies The book also presents methods for the synthesis of fault tolerant application specific DMB architectures Presents the current models used for the research on compilation and synthesis techniques of DMBs in a tutorial fashion Includes a set of benchmarks which are presented in great detail and includes the source code of most of the techniques presented including solutions to the basic compilation and synthesis problems Discusses several new research problems in detail using numerous examples

Languages, Design Methods, and Tools for Electronic System Design Tom J. Kazmierski, Sebastian Steinhorst, Daniel Große, 2019-12-20 This book brings together a selection of the best papers from the twenty first edition of the Forum on specification and Design Languages Conference FDL which took place on September 10 12 2018 in Munich Germany FDL is a well established international forum devoted to dissemination of research results practical experiences and new ideas in the application of specification design and verification languages to the design modeling and verification of integrated circuits complex hardware software embedded systems and mixed technology systems Covers Assertion Based Design Verification Includes language based modeling and design techniques for embedded systems Covers design modeling and verification of mixed physical domain and mixed signal systems that include significant analog parts in electrical and non electrical domains Includes formal and semi formal system level design methods for complex embedded systems based on the Unified Modelling Language UML and Model Driven Engineering MDE

Error-Tolerant Biochemical Sample Preparation with Microfluidic Lab-on-Chip Sudip Poddar, Bhargab B. Bhattacharya, 2022-07-27 Microfluidic biochips have gained prominence due to their versatile applications to biochemistry and health care domains such as point of care clinical diagnosis of tropical and cardiovascular diseases cancer diabetes toxicity analysis and for the mitigation of the global HIV crisis among others Microfluidic Lab on Chips LoCs offer a convenient platform for emulating various fluidic operations in an automated fashion However because of the inherent uncertainty of fluidic operations the outcome of biochemical experiments performed on chip can be erroneous even if the chip is tested a priori and deemed to be defect free This book focuses on the issues encountered in reliable sample preparation with digital microfluidic biochips DMFBs particularly in an error prone environment It presents state of the art error management techniques and underlying algorithmic challenges along with their comparative discussions Describes a comprehensive framework for designing a robust and error tolerant biomedical system which will help in migrating from cumbersome medical laboratory tasks to small sized LOC based systems Presents a comparative study on current error tolerant strategies for robust sample preparation using DMFBs and reports on efficient algorithms for error tolerant sample dilution using these devices Illustrates how algorithmic engineering cyber physical tools and software techniques are helpful in implementing fault tolerance Covers the challenges associated with design automation for biochemical sample preparation Teaches how to implement biochemical protocols using software controlled microfluidic biochips Interdisciplinary in its coverage this reference is written for practitioners and researchers in

biochemical biomedical electrical computer and mechanical engineering especially those involved in LOC or bio MEMS design

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