

Tutorial: Digital Microfluidic Biochips: Towards Hardware/Software Co-Design and Cyber-physical System Integration

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Abstract: *This tutorial will first provide an overview of typical bio-molecular applications (market drivers) such as immunoassays, DNA sequencing, clinical chemistry, etc. Next, microarrays and various microfluidic platforms will be discussed. The next part of the tutorial will focus on electro-wetting-based digital micro-fluidic biochips. The key idea here is to manipulate liquids as discrete droplets. A number of case studies based on representative assays and laboratory procedures will be interspersed in appropriate places throughout the tutorial. Basic concepts in micro-fabrication techniques will also be discussed. Attendees will next learn about CAD and reconfiguration aspects of digital microfluidic biochips. Synthesis tools will be described to map assay protocols from the lab bench to a droplet-based microfluidic platform and generate an optimized schedule of bioassay operations, the binding of assay operations to functional units, and the layout and droplet-flow paths for the biochip. The role of the digital microfluidic platform as a “programmable and reconfigurable processor” for biochemical applications will be highlighted. Cyber-physical integration using low-cost sensors and adaptive control, software will be highlighted. Cost-effective testing techniques will be described to detect faults after manufacture and during field operation. On-line and off-line reconfiguration techniques will be presented to easily bypass faults once they are detected. The problem of mapping a small number of chip pins to a large number of array electrodes will also be covered. With the availability of these tools, chip users and chip designers will be able to concentrate on the development and chip-level adaptation of nano-scale bioassays (higher productivity), leaving implementation details to CAD tools.*



Tsung-Yi Ho received his Ph.D. in Electrical Engineering from National Taiwan University, Taipei, Taiwan, ROC, in 2005. Since 2007, he has been with the Department of Computer Science and Information Engineering, National Cheng Kung University, Tainan, Taiwan, ROC, where he is currently an Associate Professor. His research interests include design automation for microfluidic biochips and nanometer integrated circuits. He has published several papers in top journals and conferences such as IEEE TCAD, ACM TODAES, ACM/IEEE DAC, IEEE/ACM ICCAD, ACM ISPD, and etc. He was the recipient of many research awards, such as Dr. Wu Ta-You Memorial Award of National Science Council (NSC) of Taiwan (the most prestigious award from NSC for junior researchers), Distinguished Young Scholar Award of Taiwan IC Design Society, ACM Taipei Chapter Young Researcher Award, IEEE Tainan Chapter Gold Member Award, the Invitational Fellowship of the Japan Society for the Promotion of Science (JSPS), Japan, and the Humboldt Research Fellowship from the Alexander von Humboldt Foundation, Germany. He is a senior member of IEEE. He has presented tutorials and organized special sessions on CAD for digital microfluidic biochips at numerous conferences, e.g., ICCAD 2010, MWSCAS 2011, SOCC2011, ESWeek 2011, and DATE 2013.



Juinn-Dar Huang received his B.S. and Ph.D. degrees in electronics engineering from National Chiao Tung University, Hsinchu, Taiwan, in 1992 and 1998, respectively. He is currently an Associate Professor in the Department of Electronics Engineering and the Institute of Electronics, National Chiao Tung University. His research interests include behavioral and logic synthesis, design automation for biochip, and 3D IC architecture/CAD. He served in the Organizing Committees of IEEE/ACM ASP-DAC 2010. He was the Secretary General of Taiwan IC Design Society (TICD) from 2004 to 2008, and the Technical Program Committee Vice-Chair of VLSI Design/CAD Symposium 2008. He served as a Technical Program Committee member of IEEE/ACM DATE in 2008 and 2010, ASP-DAC from 2012 to 2013, and IEEE VLSI-DAT from 2010 to 2013. Dr. Huang is a member of the IEEE, ACM, IEICE, and Phi Tau Phi.



Paul Pop is an Associate Professor at DTU Compute, Technical University of Denmark (DTU). He has received his Ph.D. degree in computer systems from Linköping University in 2003. His main research interests are in the area of system-level design of embedded systems. He has published extensively in this area, and has received the best paper award at the Design, Automation and Test in Europe Conference (DATE 2005), at the Real-Time in Sweden Conference (RTiS 2007). His research has been highlighted as “The Most Influential Papers of 10 Years DATE” and as “Best papers from DATE” in a special issue of the IEE Computers and Digital Techniques Journal. He has served on the technical program committee of numerous conferences, such as DATE, ICCAD, CODES+ISSS and RTSS. Since 2007 he is the coordinator of a research group focusing on CAD for biochips, composed of two senior researchers, three PhD students and several master students. His work on design techniques for biochips has received the best paper award at the International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES 2010). He has co-organized and participated in tutorials and special sessions on CAD for biochips at conferences such as SOCC 2011 and ESWEK 2011.