Special issue on fundamental principles and techniques in microfluidics

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About a year ago we were charged, by the *Lab on a Chip* Editorial Board, to edit a themed issue on fundamental principles and techniques in microfluidics. The outcome is this set of non-traditional reviews, each written as a primer for those in the *Lab on a Chip* audience unfamiliar with the specific topic and/or as a critical review of recent developments for more advanced researchers. Since microfluidics has expanded rapidly in the past two decades to a field with a variety of dedicated journals, we have made no attempt to be exhaustive in covering all topic areas. Instead, we chose to cover a few topics which are fundamental to implementing microfluidic functionalities required for lab on a chip devices and systems.

Understanding transport phenomena is essential to the successful development of microfluidic systems thus Tabeling (*Lab Chip*, 2009, **9**, DOI: 10.1039/b904937c) introduces some basic flow physics of microfluidics. Much of the fundamental discussions on slippage, capillarity and mixing are echoed in the discussions of engineering implementation of microfluidic systems. Persat *et al.* present two companion articles (*Lab Chip*, 2009, **9**, DOI: 10.1039/b906465f and *Lab Chip*, 2009, **9**, DOI: 10.1039/b906468k) on the basic principles of electrolyte chemistry. The first of these focuses on theoretical and applied aspects of acid–base equilibria in aqueous buffers which should be of general interest. The second deals with ion mobility theory and the effects of electrolysis on electrolyte chemistry which is ubiquitous in DC electrokinetic microfluidics. The discussion on the important topic of electrokinetics is complemented by a critical review by Squires (*Lab Chip*, 2009, **9**, DOI: 10.1039/b906909g) on the advances and challenges in induced-charge electrokinetics, in which the physical modeling is cast in light of practical lab-on-a-chip applications.

An open challenge in the field is the problem of robust and efficient sample preparation and its integration with other on-chip steps such as reaction, separation, and detection. Price *et al.* (*Lab Chip*, 2009, **9**, DOI:10.1039/b907652m) review the historical development of strategies to purify nucleic acids and the research trends in miniaturizing DNA purification using solid phase extraction. The problem of on-chip chemical processing is

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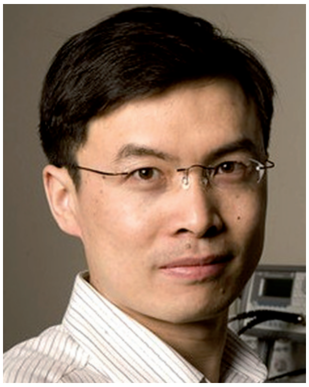
Prof. Juan G. Santiago is an Associate Professor in the Mechanical Engineering Department at Stanford, and specializes in microscale transport phenomena and electrokinetics. He received his MS and PhD in Mechanical Engineering from the University of Illinois at Urbana-Champaign (UIUC). His research includes the development of microsystems for on-chip electrophoresis, drug delivery, sample concentration methods, and miniature fuel cells. He has received a Frederick Emmons Terman Faculty Fellowship ('98–'01); won the National Inventor's Hall of Fame Collegiate Inventors Competition ('01); was awarded the Outstanding Achievement in Academia Award by the GEM Foundation ('06); and was awarded a National Science Foundation Presidential Early Career Award for Scientists and Engineers (PECASE) ('03–'08). Santiago has given 13 keynote and named lectures and more than 100 additional invited lectures. He and his students have been awarded nine best paper and best poster awards. Since 1998, he has graduated 15 PhD students and advised 10 postdoctoral researchers. He has authored and co-authored 95 archival publications, authored and co-authored 190 conference papers, and been awarded 25 patents.



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reviewed by Aota *et al.* (*Lab Chip*, 2009, **9**, DOI: 10.1039/b904430m) with an emphasis on the physics, stabilization, and applications of parallel multiphase flows. In a related review, Hartman and Jensen (*Lab Chip*, 2009, **9**, DOI: 10.1039/b906343a) cover microchemical synthesis which requires controlled mixing of reagents on-chip as well as separation and isolation of reaction products.

Separation is a central task for many micro total analysis systems. Salieb-Beugelaar *et al.* (*Lab Chip*, 2009, **9**, DOI: 10.1039/b905448k) review electrophoresis of DNA in gels and nanostructures, where the long-chained DNA polymer interacts with the background matrix. Tia and Herr (*Lab Chip*, 2009, **9**, DOI: 10.1039/b900683b) review on-chip multidimensional electrophoresis for protein analysis, with an extensive discussion of existing coupling modes and future trends. The unavoidable topic of sample dispersion during microfluidic separation is taken up by Datta and Ghosal (*Lab Chip*, 2009, **9**, DOI: 10.1039/b822948c) who discuss dispersions due to hydrodynamic inhomogeneities and wall interactions.

Two optical techniques for detection and characterization are reviewed. Lindken *et al.* (*Lab Chip*, 2009, **9**, DOI: 10.1039/b906558j) review micron-resolution particle image velocimetry (μPIV) as a diagnostic tool for microfluidic flows. The guidelines for practical implementations may be particularly useful for beginners. Yao *et al.* (*Lab Chip*, 2009, **9**, DOI: 10.1039/b907992k) review the fundamental principles and recent developments in micro-rheology measurement with optical tweezers. This non-intrusive diagnostic tool is useful in measuring cellular materials.

As with everything in *Lab on a Chip*, this issue is unique in that these reviews are all critical assessments of the literature and not just summaries of what has been published to date. They have each been rigorously reviewed and revised. The principles and techniques reviewed in this issue have wide-ranging applications both in the study of fundamental transport phenomena (*e.g.*, ion mobility) and practical microsystems (*e.g.*, biochemical analysis and synthesis). We hope you will find them useful in your microfluidic adventures.

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