

Lab on a Chip

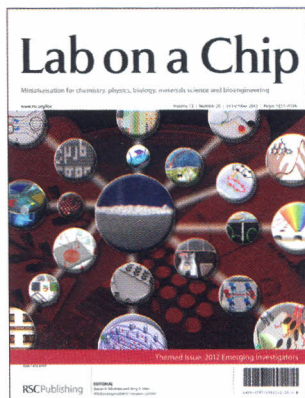
Miniaturisation for chemistry, physics, biology, materials science and bioengineering

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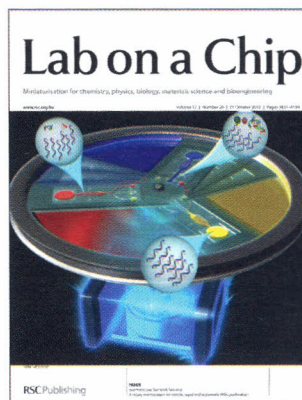
IN THIS ISSUE

ISSN 1473-0197 CODEN LCAHAM 12(20) 3831-4194 (2012)



Cover

See Aaron R. Wheeler and Amy E. Herr, pp. 3851–3852. Image reproduced by permission of Dr Mais Jebrail from *Lab Chip*, 2012, 12, 3851.



Inside cover

See Nae Yoon Lee, Tae Seok Seo *et al.*, pp. 3875–3881. Image reproduced by permission of Tae Seok Seo from *Lab Chip*, 2012, 12, 3875.

THEMED ISSUE ARTICLES

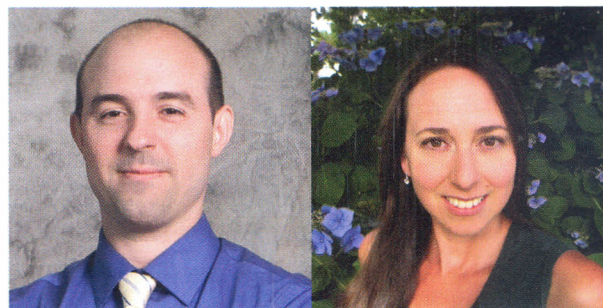
EDITORIAL

3851

Mission impossible to mission control

Aaron R. Wheeler* and Amy E. Herr*

This *Lab on a Chip* themed issue – an issue dedicated to the work of *Emerging Investigators* – sees miniaturisation bringing unprecedented control to chemistry, physics, biology and bioengineering.



PROFILE

3853

Emerging investigators contributors 2012

Contributors to the 2012 Emerging Investigators issue of *Lab on a Chip*.

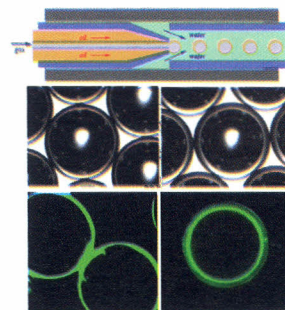


3858

Controllable microfluidic production of gas-in-oil-in-water emulsions for hollow microspheres with thin polymer shells

Ran Chen, Peng-Fei Dong, Jian-Hong Xu,*
Yun-Dong Wang and Guang-Sheng Luo

We developed a simple and novel one-step approach to produce G/O/W emulsions with high gas volume fractions in a capillary microfluidic device. The thickness of the oil layer can be controlled easily by tuning the flow rates. We successfully used the G/O/W emulsions to prepared hollow microspheres with thin polymer shells.

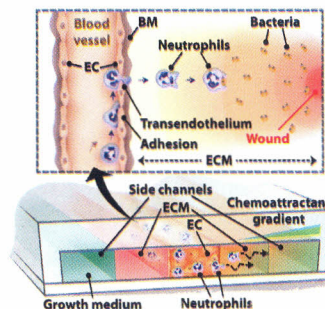


3861

A versatile assay for monitoring *in vivo*-like transendothelial migration of neutrophils

Sewoon Han, Ji-Jing Yan, Yoojin Shin, Jessie S. Jeon,
Jihee Won, Hyo Eun Jeong, Roger D. Kamm,
Young-Joon Kim* and Seok Chung*

Here, we present a novel method for establishing *in vivo*-like inflammatory models in a microfluidic device and quantitatively measuring the three-dimensional transmigration of neutrophils during the inflammatory process.



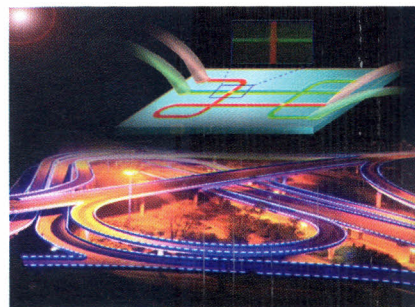
TECHNICAL INNOVATIONS

3866

“Overpass” at the junction of a crossed microchannel: An enabler for 3D microfluidic chips

Yan He, Bai-Ling Huang, Dong-Xiao Lu, Jia Zhao,
Bin-Bin Xu, Ran Zhang, Xiao-Feng Lin, Qi-Dai Chen,
Juan Wang, Yong-Lai Zhang* and Hong-Bo Sun*

We report the design and fabrication of three-dimensional “overpass” microstructures at the junction of crossed microchannels for 3D microchips.

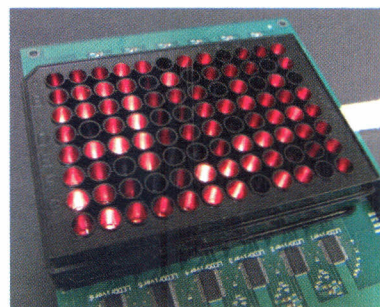


3870

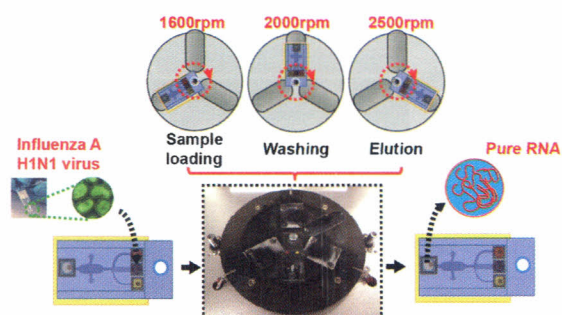
Optical microplates for high-throughput screening of photosynthesis in lipid-producing algae

Meng Chen, Taulant Mertiri, Thomas Holland and
Amar S. Basu*

Optical microplates provide a temporal light stimulus in each well of a standard 96-well plate, enabling high-throughput studies of light-driven bioprocesses, such as photosynthesis.



3875

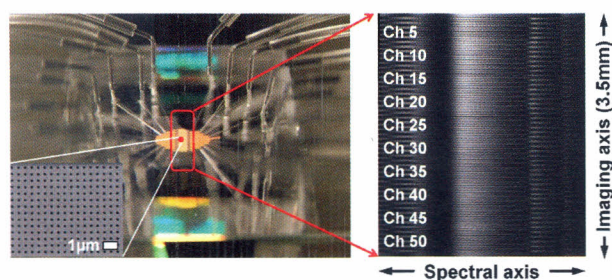


A rotary microsystem for simple, rapid and automatic RNA purification

Byung Hyun Park, Jae Hwan Jung, Hainan Zhang, Nae Yoon Lee* and Tae Seok Seo*

In this paper, we demonstrate a novel rotary microsystem capable of highly simple, rapid and automatic influenza viral RNA purification.

3882

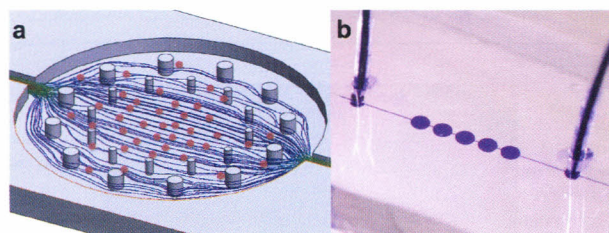


Real-time full-spectral imaging and affinity measurements from 50 microfluidic channels using nanohole surface plasmon resonance

Si Hoon Lee, Nathan C. Lindquist, Nathan J. Wittenberg, Luke R. Jordan and Sang-Hyun Oh*

We demonstrate a nanohole-based surface plasmon resonance imaging spectroscopy instrument capable of simultaneously extracting receptor–ligand binding kinetics and affinities from 50 parallel microfluidic channels in real time.

3891

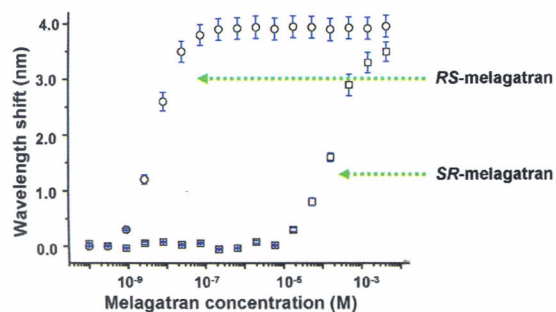


Cytotoxicity analysis of water disinfection byproducts with a micro-pillar microfluidic device

Austin Hsiao, Yukako Komaki, Syed M. Imaad, Benito J. Mariñas, Michael J. Plewa* and G. Logan Liu*

Water disinfection byproducts (DBPs) are a class of chemicals that are produced when chemical disinfectants react with organic materials in untreated water.

3901



Enantioselective analysis of melagatran *via* an LSPR biosensor integrated with a microfluidic chip

Longhua Guo,* Yuechun Yin, Rong Huang, Bin Qiu, Zhenyu Lin, Huang-Hao Yang, Jianrong Li and Guonan Chen*

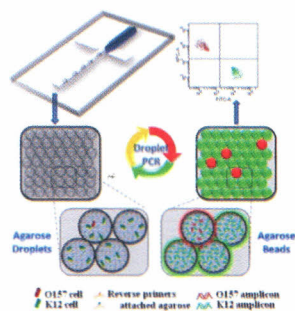
A sensor that was specific for *RS*-melagatran was fabricated, and the presence of 10 000-fold amounts of *SR*-melagatran did not interfere with the detection.

3907

Highly sensitive and quantitative detection of rare pathogens through agarose droplet microfluidic emulsion PCR at the single-cell level

Zhi Zhu, Wenhua Zhang, Xuefei Leng, Mingxia Zhang, Zhichao Guan, Jiangquan Lu and Chaoyong James Yang*

An agarose droplet-based microfluidic single-cell ePCR method has been developed for highly sensitive, specific and quantitative detection of single *E. coli* O157:H7 cells in the high background of 100 000 excess normal K12 cells.

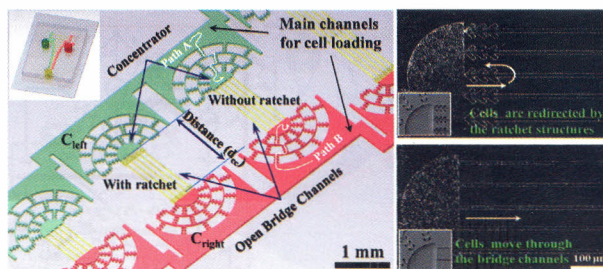


3914

Microfabricated ratchet structure integrated concentrator arrays for synthetic bacterial cell-to-cell communication assays

Seongyong Park, Xiaoqiang Hong, Woon Sun Choi and Taesung Kim*

This work reports a microfluidic concentrator array device confining bacterial cells in a controllable fashion for synthetic cell-to-cell communication assays.

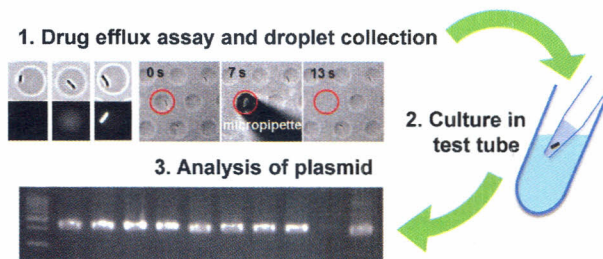


3923

A single-cell drug efflux assay in bacteria by using a directly accessible femtoliter droplet array

Ryota Iino,* Kohei Hayama, Hiromi Amezawa, Shouichi Sakakihara, Soo Hyeon Kim, Yoshimi Matsumono, Kunihiko Nishino, Akihito Yamaguchi and Hiroyuki Noji

Drug efflux activity in single bacterium was assessed in directly accessible femtoliter-droplet, and efflux-active single cell was collected and the harboured plasmid was analyzed.

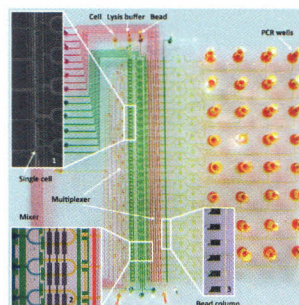


3930

An automated microfluidic device for assessment of mammalian cell genetic stability

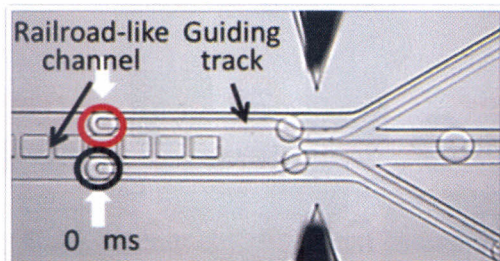
Yan Chen,* Baoyue Zhang, Hongtao Feng, Weiliang Shu, Gina Y. Chen and Jiang F. Zhong

A high-throughput integrated microfluidic device is developed for rapid measurement of gene expression in individual cells for genetic stability assessment.



3936

Fusion and sorting of two trains of droplets

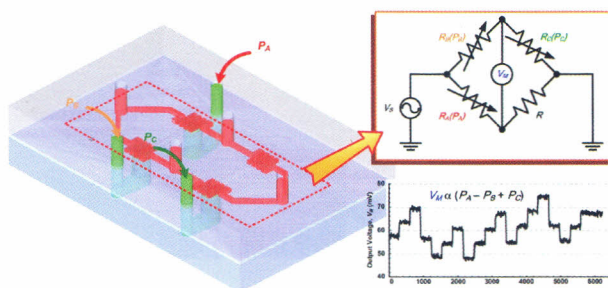


Fusion and sorting of two parallel trains of droplets using a railroad-like channel network and guiding tracks

Linfeng Xu, Hun Lee, Rajagopal Panchapakesan and Kwang W. Oh*

We propose a robust droplet fusion and sorting method for two parallel trains of droplets that is relatively insensitive to frequency and phase mismatch.

3943

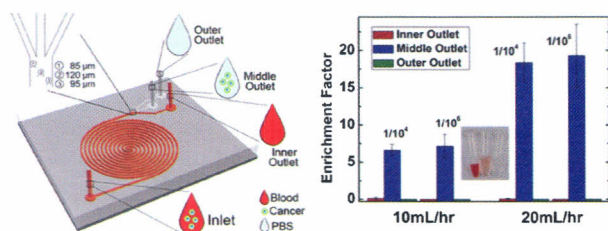


Integrated electrofluidic circuits: pressure sensing with analog and digital operation functionalities for microfluidics

Chueh-Yu Wu, Jau-Ching Lu, Man-Chi Liu and Yi-Chung Tung*

We report the concept of electrofluidic circuits – electrical circuits that are constructed using ionic liquid-filled fluidic channels for pressure sensing with analog and digital operation functionalities.

3952

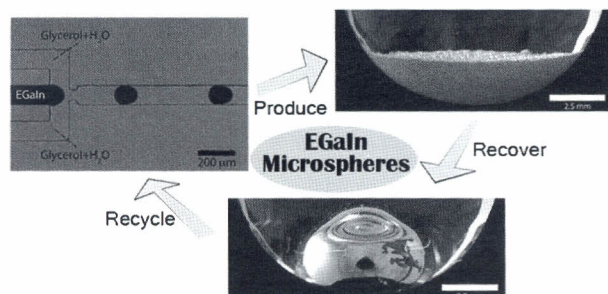


Double spiral microchannel for label-free tumor cell separation and enrichment

Jiashu Sun,* Mengmeng Li, Chao Liu, Yi Zhang, Dingbin Liu, Wenwen Liu, Guoqing Hu* and Xingyu Jiang*

A double spiral microfluidic platform allows for passive, label-free tumor cell enrichment from whole blood with improved throughput and efficiency.

3961



A study of the production and reversible stability of EGaln liquid metal microspheres using flow focusing

Jacob Thelen, Michael D. Dickey* and Thomas Ward*

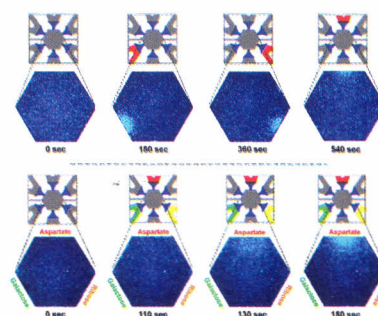
Production of recoverable liquid metal (EGaIn) microspheres through microfluidic flow focusing is demonstrated and compared to a model water-in-oil system.

3968

Concentration gradient generation of multiple chemicals using spatially controlled self-assembly of particles in microchannels

Eunpyo Choi, Hyung-kwan Chang, Chae Young Lim, Taesung Kim and Jungyul Park*

We present a robust microfluidic platform for the stable generation of multiple chemical gradients simultaneously using *in situ* self-assembly of particles in microchannels.

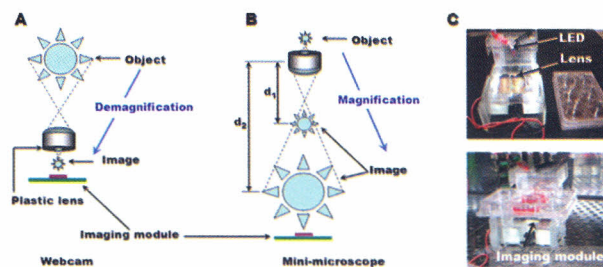


3976

A mini-microscope for *in situ* monitoring of cells

Sang Bok Kim, Kyo-in Koo, Hojae Bae, Mehmet R. Dokmeci, Geraldine A. Hamilton, Anthony Bahinski, Sun Min Kim, Donald E. Ingber and Ali Khademhosseini*

A mini-microscope was developed for *in situ* monitoring of cells by modifying off-the-shelf components of a commercial webcam.

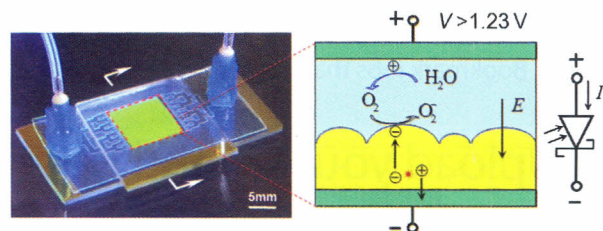


3983

Microfluidic photoelectrocatalytic reactors for water purification with an integrated visible-light source

Ning Wang, Xuming Zhang,* Bolei Chen, Wuzhou Song, Ngai Yui Chan and Helen L. W. Chan

A photoelectrocatalytic microreactor inhibits electron/hole recombination, selectively controls the reaction pathways and brings out the synergistic effect of photocatalysis and electrocatalysis.

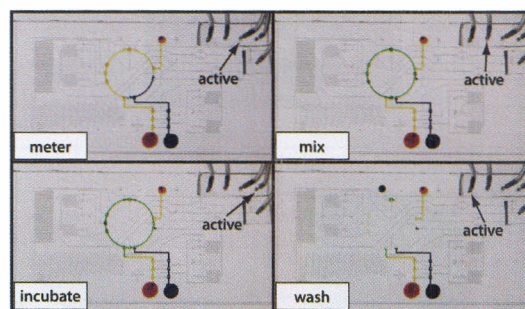


3991

Semi-autonomous liquid handling via on-chip pneumatic digital logic

Transon V. Nguyen, Philip N. Duncan, Siavash Ahrar and Elliot E. Hui*

Digital logic circuits implemented by microfluidic valves and channels are used to control liquid metering, mixing, incubation, and wash procedures with minimal external controls.

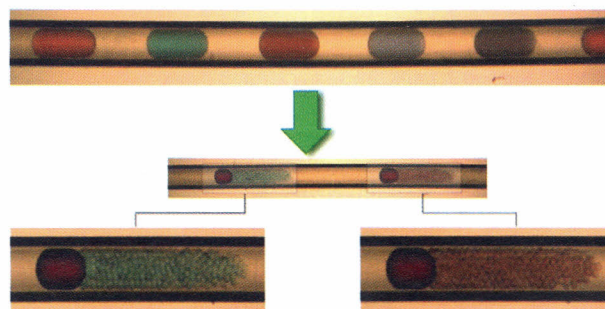


3995

Automated generation of libraries of nL droplets

Tomasz S. Kaminski, Slawomir Jakiela,
Magdalena A. Czekalska, Witold Postek and
Piotr Garstecki*

We demonstrate an integrated system for rapid and automated generation of multiple, chemically distinct populations of $\sim 10^3$ – 10^4 sub-nanoliter droplets.



REGULAR RESEARCH ARTICLES

HIGHLIGHT

4003

Research Highlights

Šeila Selimović, MD Anwarul Hasan, Mehmet R. Dokmeci
and Ali Khademhosseini*

Blood vessels on-chip – Smart implants for diabetes treatment
– Particles in microchannels as active flow elements.



FOCUS

4006

Exploiting mechanical biomarkers in microfluidics

Xiaole Mao and Tony Jun Huang*

In this Focus article, we discuss a few examples of mechanical biomarker-based microfluidic applications. We believe that these examples are just the tip of the iceberg and that the full potential of mechanical biomarkers in microfluidic-based diagnostics and therapeutics has yet to be revealed.

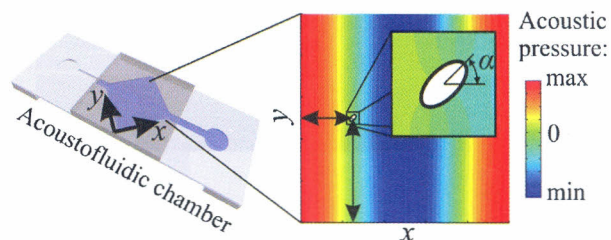


4010

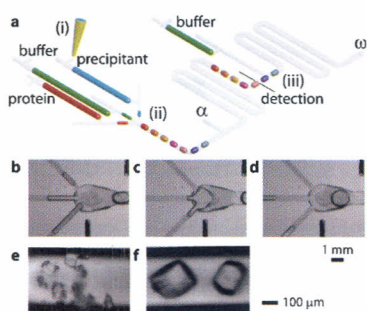
Acoustofluidics 19: Ultrasonic microrobotics in cavities: devices and numerical simulation

Jürg Dual,* Philipp Hahn, Ivo Leibacher, Dirk Möller,
Thomas Schwarz and Jingtao Wang

Arrangement, transport and rotation of particles in chambers are presented with according numerical tools (FVM, COSMOL).



4022

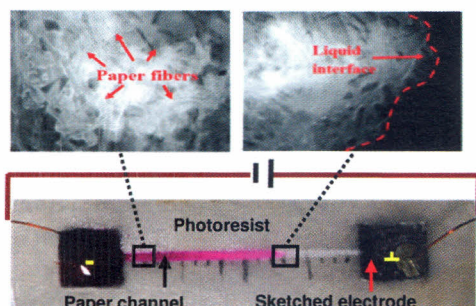


Iterative operations on microdroplets and continuous monitoring of processes within them; determination of solubility diagrams of proteins

Monika E. Dolega, Slawomir Jakiela, Michal Razew, Agata Rakszewska, Olgierd Cybulski and Piotr Garstecki*

We demonstrate a technique for controlling the content of multiple microdroplets in time.

4026

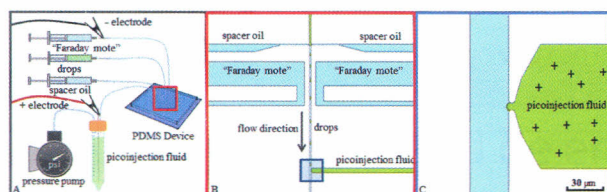


Electrokinetics with “paper-and-pencil” devices

Pratiti Mandal, Ranabir Dey and Suman Chakraborty*

A “paper-and-pencil”-based inexpensive microdevice results in appreciable augmentation in the rate of microcapillary filling, by using electrokinetic phenomenon.

4029

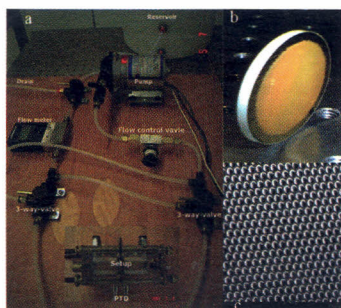


Electrode-free picoinjection of microfluidic drops

Brian O'Donovan, Dennis J. Eastburn and Adam R. Abate*

A novel technique for reagent injection into microfluidic drops that obviates the need for on-chip electrode fabrication.

4033



High-power electrokinetic energy conversion in a glass microchannel array

Abraham Mansouri,* Subir Bhattacharjee and Larry Kostiuk

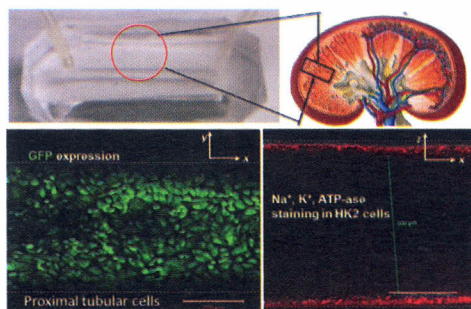
The electrokinetic conversion of flow work to electricity using a glass microchannel array coated with nano-layers of gold that serve as electrodes on both its ends was studied and a maximum power output of 1 mW at an efficiency of 1.3% is reported.

4037

Engineering of polarized tubular structures in a microfluidic device to study calcium phosphate stone formation

Zengjiang Wei, Prince K. Amponsah, Mariyam Al-Shatti, Zhihong Nie* and Bidhan C. Bandyopadhyay*

This communication describes the generation of a functional biological tubular structures with a circular cross-section by growing epithelial cells in a microfluidic device for studying kidney stone formation.



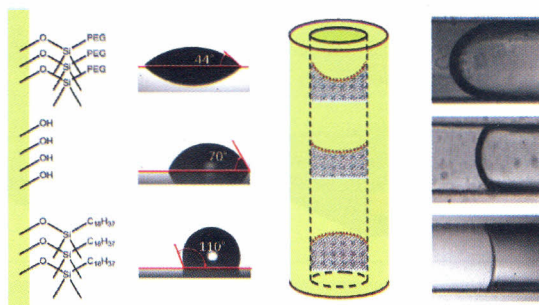
TECHNICAL INNOVATIONS

4041

Tailoring the wetting properties of thiolene microfluidic materials

Simone Silvestrini, Davide Ferraro, Tamara Tóth, Matteo Pierno, Tommaso Carofiglio, Giampaolo Mistura* and Michele Maggini*

Chlorosilane chemistry has been used to tailor the wettability of thiolene surfaces in open or closed chip geometries in a wide range of contact angles.

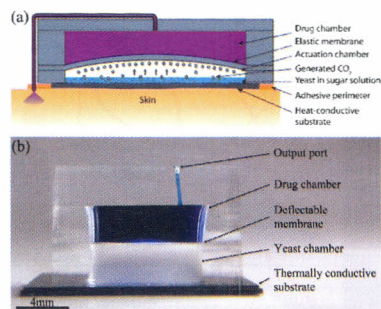


4044

A fermentation-powered thermopneumatic pump for biomedical applications

Manuel Ochoa and Babak Ziaie*

We present a microorganism-powered thermopneumatic pump that utilizes temperature-dependent slow-kinetics gas (carbon dioxide) generating fermentation of yeast as a pressure source.

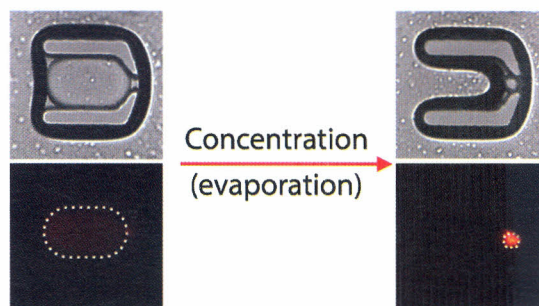


4049

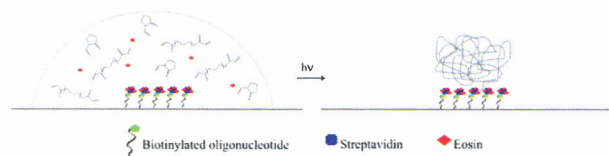
Microfluidic evaporator for on-chip sample concentration

Xavier Casadevall i Solvas,* Vladimir Turek, Themistoklis Prodromakis and Joshua B. Edel

Simple method for evaporative sample concentration of general applicability for single or multiphase microfluidic configurations.



4055

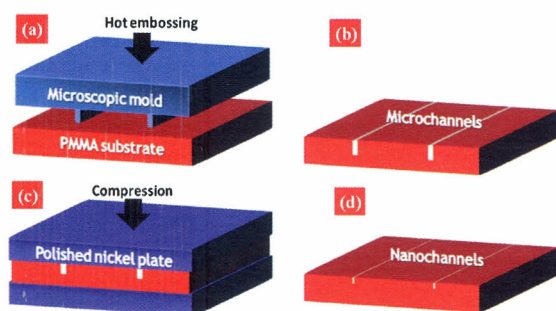


Polymerization-based signal amplification under ambient conditions with thirty-five second reaction times

Kaja Kaastrup and Hadley D. Sikes*

We demonstrate an improvement to a low cost detection technology for use in point-of-care medical diagnostic devices.

4059



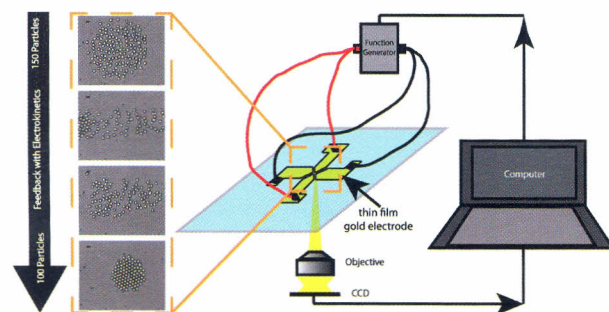
Microchannel refill: a new method for fabricating 2D nanochannels in polymer substrates

Jing-min Li, Chong Liu,* Xue Ke, Zheng Xu, Ya-jie Duan, Yan Fan, Meng Li, Kai-ping Zhang and Li-ding Wang

In this paper, we present a new approach that is capable of fabricating nanochannels in a poly(methyl methacrylate) (PMMA) substrate.

PAPERS

4063

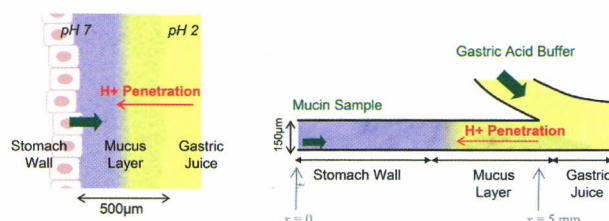


Multiple electrokinetic actuators for feedback control of colloidal crystal size

Jaime J. Juárez, Pramod P. Mathai, J. Alexander Liddle* and Michael A. Bevan*

We illustrate a conceptually new technique for controlling the size of 2D colloidal crystals in real-time with multiple electrokinetic actuators.

4071



A microfluidic *in vitro* system for the quantitative study of the stomach mucus barrier function

Leon Li, Oliver Lieleg, Sae Jang, Katharina Ribbeck* and Jongyoon Han*

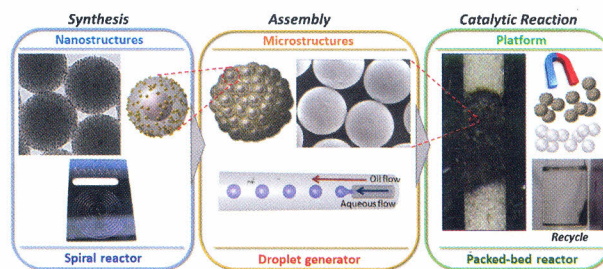
A microfluidic model to mimic mucus secretion into the stomach. We probe the mechanism of acid barrier function provided by gastric mucins.

4080

Synthesis, assembly and reaction of a nanocatalyst in microfluidic systems: a general platform

Seung-Kon Lee, Xiaoying Liu, Víctor Sebastián Cabeza and Klavs F. Jensen*

We present a successive microfluidic approach to create and characterize hierarchical catalyst structures consisting of metal-decorated nanoparticles that are assembled into porous microparticles (“supraball” catalysts).



4085

Microcapillary-assisted dielectrophoresis for single-particle positioning

Yuan Luo, Xu Cao, Pingbo Huang and Levent Yobas*

Here, we demonstrate microcapillary-assisted dielectrophoresis, a new capability for precise positioning of particles or biological cells in applications such as dynamic assays.

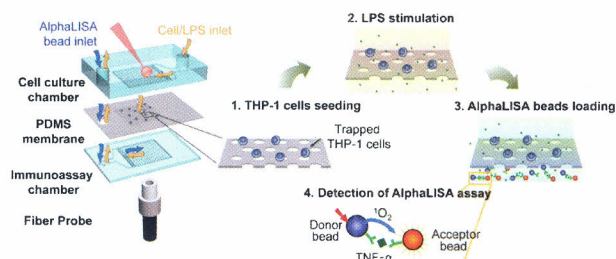


4093

An integrated microfluidic platform for *in situ* cellular cytokine secretion immunophenotyping

Nien-Tsu Huang, Weiqiang Chen, Bo-Ram Oh, Timothy T. Cornell, Thomas P. Shanley, Jianping Fu* and Katsuo Kurabayashi*

We have developed a microfluidic cellular immunophenotyping assay device incorporating a surface-micromachined PDMS microfiltration membrane, capable of cell seeding, endotoxin stimulation of cells and detection of cell-secreted cytokines.

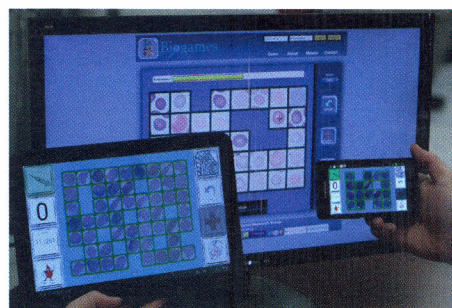


4102

Crowd-sourced BioGames: managing the big data problem for next-generation lab-on-a-chip platforms

Sam Mavandadi, Stoyan Dimitrov, Steve Feng, Frank Yu, Richard Yu, Uzair Sikora and Aydogan Ozcan*

We describe a crowd-sourcing based solution (*i.e.*, BioGames) to manage large quantities of data that are created by emerging digital imaging, sensing and lab-on-a-chip devices.

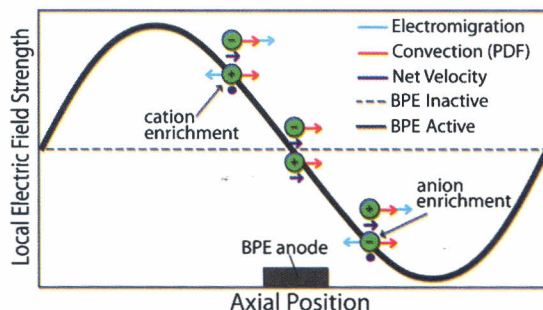


4107

Dual-channel bipolar electrode focusing: simultaneous separation and enrichment of both anions and cations

Kyle N. Knust, Eoin Sheridan, Robbyn K. Anand and Richard M. Crooks*

We demonstrate simultaneous separation and enrichment of anions and cations in a microelectrochemical cell comprising parallel microchannels spanned by a bipolar electrode.

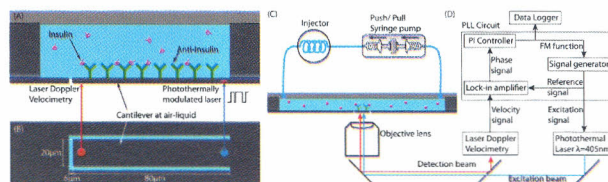


4115

Application of a new microcantilever biosensor resonating at the air–liquid interface for direct insulin detection and continuous monitoring of enzymatic reactions

Jungwook Park,* Stanislav L. Karsten, Shuhei Nishida, Hideki Kawakatsu and Hiroyuki Fujita

We describe the application of a recently developed high-resolution microcantilever biosensor resonating at the air–liquid interface for the continuous detection of antigen–antibody and enzyme–substrate interactions.

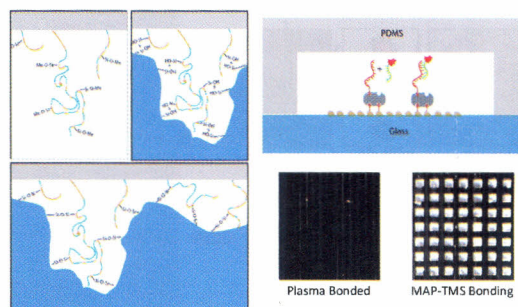


4120

PDMS–glass bonding using grafted polymeric adhesive – alternative process flow for compatibility with patterned biological molecules

Cyrus Weijie Beh, Weizhuang Zhou and Tza-Huei Wang*

We report a novel modification of polydimethylsiloxane with a polymer graft that allows interfacial bonding between an elastomer and glass substrate to be performed without exposure of the substrate to harsh treatment conditions, such as oxygen plasma.



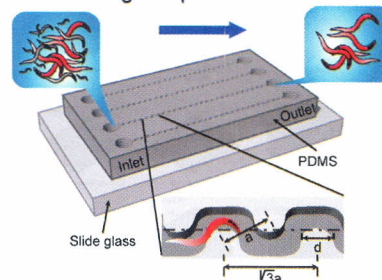
4128

A sorting strategy for *C. elegans* based on size-dependent motility and electotaxis in a micro-structured channel

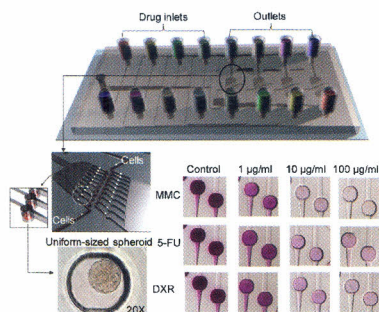
Bicheng Han, Daeyeon Kim, Ung Hyun Ko and Jennifer H. Shin*

A novel sorting strategy for separating a mixed population of different sized worms into specific sized worms in a cost-effective and simple manner.

Self-sorting of specific sized worms



4135

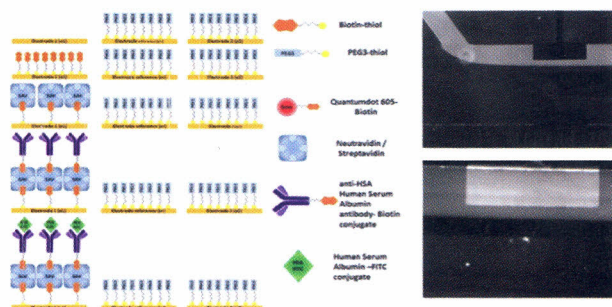


On-chip anticancer drug test of regular tumor spheroids formed in microwells by a distributive microchannel network

Choong Kim, Jae Hoon Bang, Young Eun Kim, Soo Hyun Lee and Ji Yoon Kang*

This paper proposes a new cytotoxicity assay in a microfluidic device with microwells and a distributive microfluidic channel network for the formation of cancer cell spheroids. The assay can generate rapid and uniform cell clusters in microwells and test *in situ* cytotoxicity of anticancer drugs.

4143

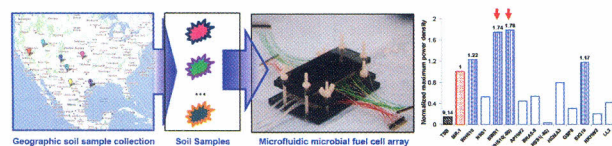


Selective *in situ* functionalization of biosensors on LOC devices using laminar co-flow

C. Parra-Cabrera,* C. Sporer, I. Rodriguez-Villareal, R. Rodriguez-Trujillo, A. Homs-Corbera and J. Samitier

A selective *in situ* functionalization was performed using a laminar co-flow, and real time differential measurements were obtained for the detection of human serum albumin.

4151

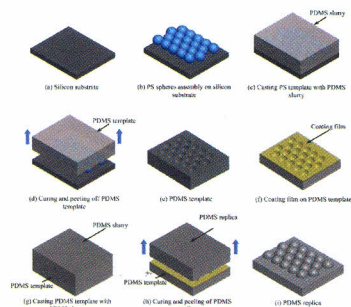


A microfluidic microbial fuel cell array that supports long-term multiplexed analyses of electricigens

Huijie Hou, Lei Li, Cemile Ümran Ceylan, Abria Haynes, Julia Cope, Heather H. Wilkinson, Celal Erbay, Paul de Figueiredo and Arum Han*

We developed a high throughput microfluidic microbial fuel cell array capable of catholyte and anolyte replenishments, enabling long-term characterization of electricigens and parallel comparison of various factors that influence microbial fuel cell performance on a miniature MFC platform.

4160



Fabrication of hybrid nanostructured arrays using a PDMS/PDMS replication process

H. Hassanin, A. Mohammadkhani and K. Jiang

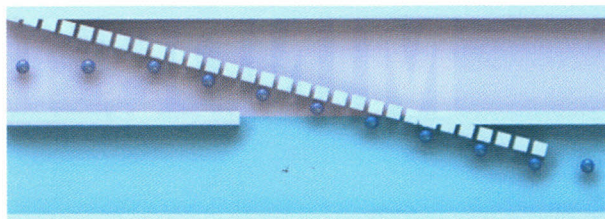
In the study, a novel and low cost nanofabrication process is proposed for producing hybrid polydimethylsiloxane (PDMS) nanostructured arrays.

4168

Continuous flow multi-stage microfluidic reactors *via* hydrodynamic microparticle railing

Ryan D. Sochol,* Song Li, Luke P. Lee and Liwei Lin

We present a micropost array railing (μ PAR) system for passively guiding suspended microbeads and cells into distinct, adjacent flow streams using continuous input flow sources.

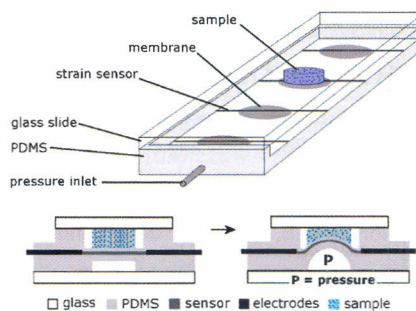


4178

Miniaturized platform with on-chip strain sensors for compression testing of arrayed materials

Luke MacQueen, Oleg Chebotarev, Craig A. Simmons* and Yu Sun*

Elastomeric strain sensors embedded in bulging membranes provide continuous strain readout for sample compression measurements.



4185

A simple method to evaluate the biochemical compatibility of oil/surfactant mixtures for experiments in microdroplets

Miriam Kaltenbach, Sean R. A. Devenish and Florian Hollfelder*

We report a method for evaluating the biochemical compatibility of microdroplet systems by measuring droplet fluorescence *vs.* droplet diameter and comparing concentrations *via* the slope of such curves.

