7. Highlights

Science Highlights

- Tuning the synthesis of ECM proteins by mechanical and topographical cues
- Shear-induced chiral migration of particles with anisotropic rigidity
- Electrokinetic transport in the nanofactory, and fundamental insight into the electrical double layer
- Mobile Magnetic Traps for Particle and Cell Manipulation

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- CANPBD Participates in COSI Nanodays: April 2, 2008

Shared Facilities Highlights

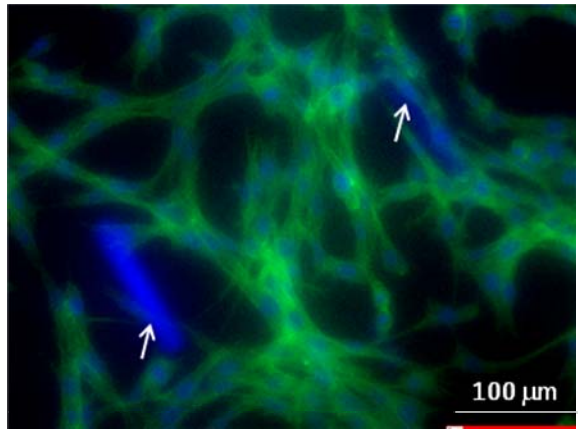
- Massively Parallel Positioning of Dip-Pen Lithography Arrays

Tuning the synthesis of ECM proteins by mechanical and topographical cues

Perla Ayala, Tejal A. Desai
University of California San Francisco

Physical signals and mechanical stresses can be converted into intracellular responses that regulate cell behavior and fate. Microfabricated systems provide a platform to study how discrete microscale topographical cues affect cell behavior. In this work, the role of stiffness and topography on ECM synthesis is investigated. In a 3D system with biocompatible (PEGDMA) microrods of varying stiffness, it was observed that rod stiffness had a differential response on fibroblast proliferation and contractility as analyzed by MTT assay and by the expression of alpha smooth muscle actin respectively. Results from this work will provide new tools to create more tunable tissue engineered constructs.

This material is supported by funds from the National Science Foundation (Grant No. EEC-0425626)



Fibroblasts interact with PEGDMA microrods in the 3D Matrigel (Day 3).

Shear-induced chiral migration of particles with anisotropic rigidity

Nobuhiko Watari, Ronald G. Larson
University of Michigan

We report that an achiral particle with anisotropic rigidity can migrate in the vorticity direction in shear flow. A minimal model of such a particle is constructed from four beads and six springs to make a tetrahedral structure, whicl we call ``tetrumbbell''. Using combination of two different spring constants corresponding to ``hard'' and ``soft'' springs, ten distinguishable tetrumbbells with anisotropic rigidity are constructed, and subjected to shear flow by computer simulation with hydrodynamic interactions between beads but no Brownian motion at zero Reynolds number. Five different types of behavior occur, depending on the structure, and seven out of ten tetrumbbell structures migrate in the vorticity direction under shear. Some of the structures migrate in the same direction along the vorticity direction even when the shear flow is reversed, which is impossible for permanently chiral objects.

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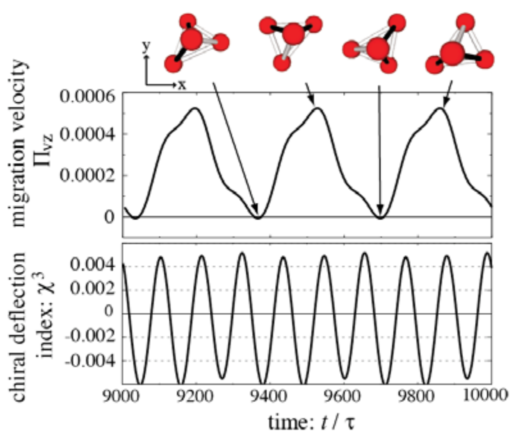


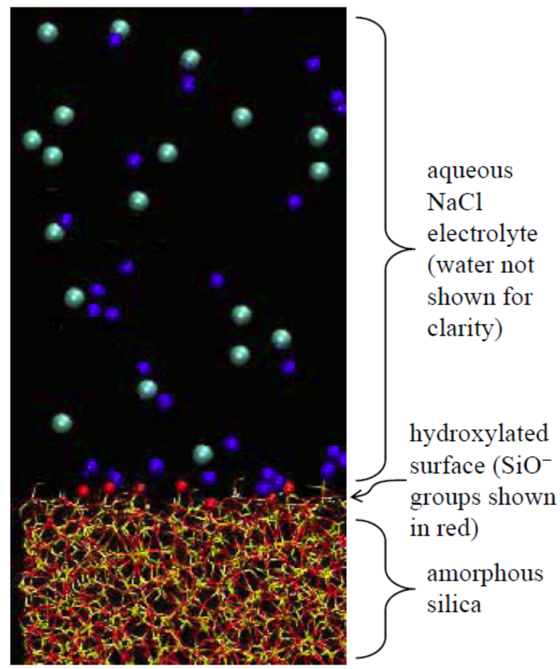
Figure: History of a migration of a tetrumbbell in a shear flow. The conformation change, the migration velocity in the vorticity direction, and the chiral deflection index, which is a measure of chirality of the tetrumbbell, are shown.

Electrokinetic transport in the nanofactory, and fundamental insight into the electrical double layer

Hui Zhang, Yun Kyung Shin, Ali A. Hassanali, Chris Knight, Sherwin J. Singer
The Ohio State University

We have constructed realistic models of the water/amorphous silica interface that allow us to study electrolytes near the walls of a nanofluidic device. Besides predicting characteristics of biomolecule delivery devices, these studies advance aqueous our understanding of long-standing scientific NaCl problems, the structure of the electrical double layer electrolyte and the precise nature of the Stern layer.

Efficient transport within nanoscale fluidic channels can be achieved by applying an electrical field to an electrolyte solution. The electric field induces motion of ions (electrophoresis) which, in turn, can generate overall motion of the fluid (electroosmosis). We focus on the ion distribution and dynamics of the electrolyte very near the channel walls because this crucial region controls the flow characteristics throughout the channel.



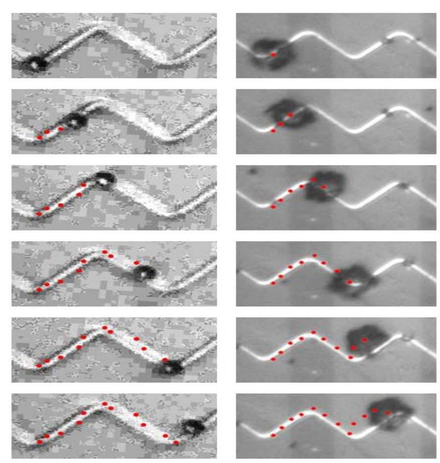
This material is supported by funds from the National Science Foundation (Grant No. EEC-0425626)

Mobile Magnetic Traps for Particle and Cell Manipulation

Gregory Vieira, Thomas Henighan, Aaron Chen, R. Sooryakumar
The Ohio State University

We have developed techniques to remotely apply directed forces on individual or multiple biological cells and magnetic micro-/nano-particles. Narrow magnetic wires or disks imprinted on a surface underlie the manipulation scheme. Dynamic control of the pico-Newton scale forces is being advanced to integrate ultra-small components into various emerging biomedical and solid state devices. The platform provides convenience optical microscope observation, suppression of randomizing thermal fluctuations of fluid-borne entities and more accurate cell analysis than ensemble-averaging over a population.

This material is supported by funds from the National Science Foundation (Grant No. EEC-0425626).



Transport (*a la* joystick) of a micro sphere (left) and T-lymphocyte cell (right) on a Si platform along a zigzag wire. Trajectories indicated by red dots.

CANPBD Participates in COSI Nanodays: April 2, 2008

As part of its external outreach activities, CANPBD sponsored a "Nanoday" on Wednesday, April 2, 2008. This event was co-sponsored by the Center of Science and Industry (COSI), the Columbus area science museum, which was recently voted best science museum in the US by Parent's magazine [1], and was part of a nationwide program directed by the Nanoscale Informal Science Education (NISE) network [2]. The OSU CANPBD-COSI Nanoday consisted of material provided by the NISE network and experiments derived from NSEC research. In particular, the following concepts were demonstrated by 25 CANPBD affiliated graduate and undergraduate students:

- Scanning Electron Microscopy- Demonstration of a portable SEM which could be operated by children as young as elementary school.
- CD-ELISA- Demonstration of enzyme linked immunosorbant assay technology developed by the NSEC on a CD platform.
- Nanofabric- Demonstration of commercially available stain-resistant fabric developed using nanotechnology (superhydrophobicity).
- Electrospinning- Full-scale demonstration of a portable electrospinning apparatus designed by the NSEC for educational use.

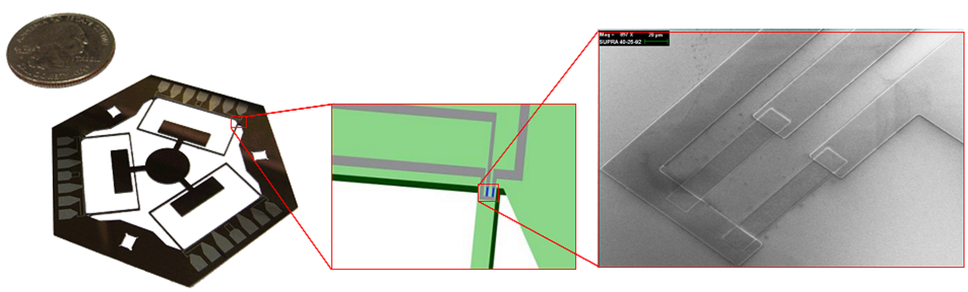
[1] Cicero, K. The 10 Best Science Centers. Parents Magazine [cited 09/03/2008]; Available from: http://www.parents.com/family-life/travel/us-destinations/best-science-centers/.
[2] Nanodays [cited 03/23/2009]; Available from: http://www.nisenet.org/nanodays.

CANPBD-COSI Nanoday activities; April 2, 2009

Massively Parallel Positioning of Dip-Pen Lithography Arrays

Martin Culpepper
Massachusetts Institute of Technology

In dip pen nanolithography (DPN), a micro-scale probe tip is used to deposit nm-scale features onto a substrate. Members of the OSU NSEC have found a need for high-rate, high-quality, low-cost nanopositioning technology for use in massively parallel DPN and other nanomanufacturing processes. The MIT team has been conducting research on nanopositioners that possess desired cost, rate, quality, and stability characteristics. A case study on the alignment and positioning of a two-dimensional 55,000 tip DPN array is driving the development of the general technology. Two dimensional arrays of tips, e.g. surface tools, must be controlled in six degrees-of-freedom (DOF) with respect to the surface they interact with. Researchers at MIT have designed and fabricated a low-cost (~$500), microfabricated nanopositioner that is equipped for closed-loop operation throughout a 50x50x50 μm^3 work volume and capable of nm-level resolution. The figure at the right shows a completed microfabricated positioner as well as a close-up of the integrated piezoresistive strain sensors that are used to determine the displacement of the central positioning stage. This research has led to the first practical MEMS six-axis nanopositioner with closed-loop control capability.



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