



Integrated Microfluidics for Biological Detection

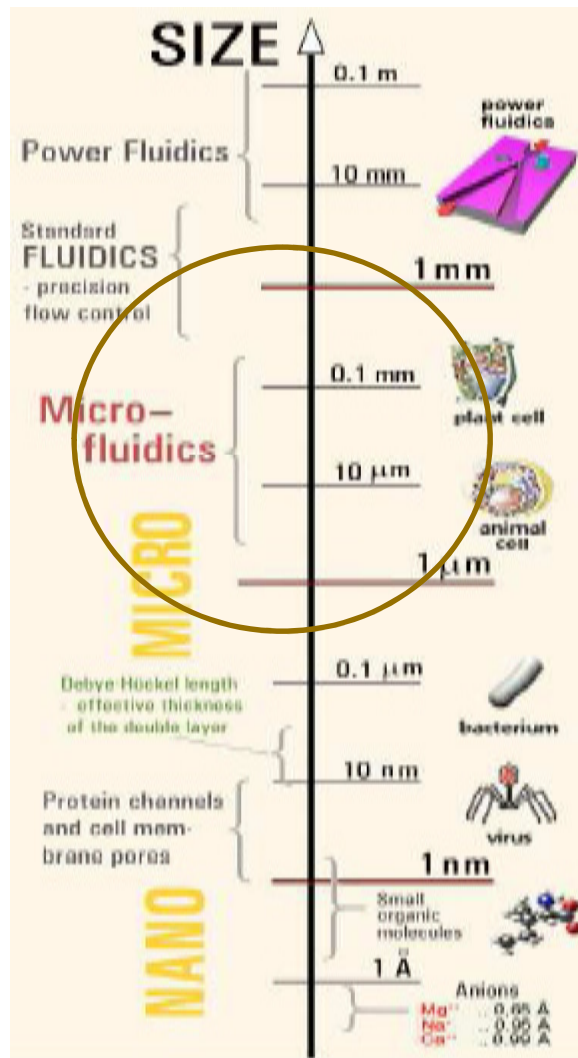
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Background



ANSYS, Inc.

- Microfluidics: devices and methods for controlling fluid flow in less than a millimeter scale
- Lab-on-a-chip: integrate miniaturized chemical reactions and analysis
- Fundamental studies of physical, chemical, and biological analysis
 - Mixing, detection, separation



Technology



Applications

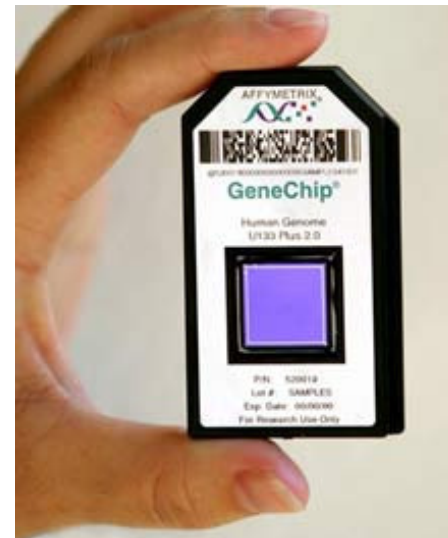
- Medical diagnostics
- DNA Sequencing
- Drug delivery
- Environmental monitoring

Advantages

- Microfabrication
- Small sample volume
- Reduced analysis time
- Automation
- Portable
- Lower cost

Industries

- Medical
- Environmental
- Food
- Pharmaceutical



Affymetrix.com



Research Problem

- To develop microfluidic based immunoassay chip for point-of-care applications
- Problem: detection limit and complex instruments
 - Qualitative measurements
 - Mostly laboratory based and time-consuming
 - Cost ineffective
- Solution: microfluidic integration for active flow control
 - Rapid, simple, low-cost
 - Sensitivity and detection limit
 - Quantitative measurement



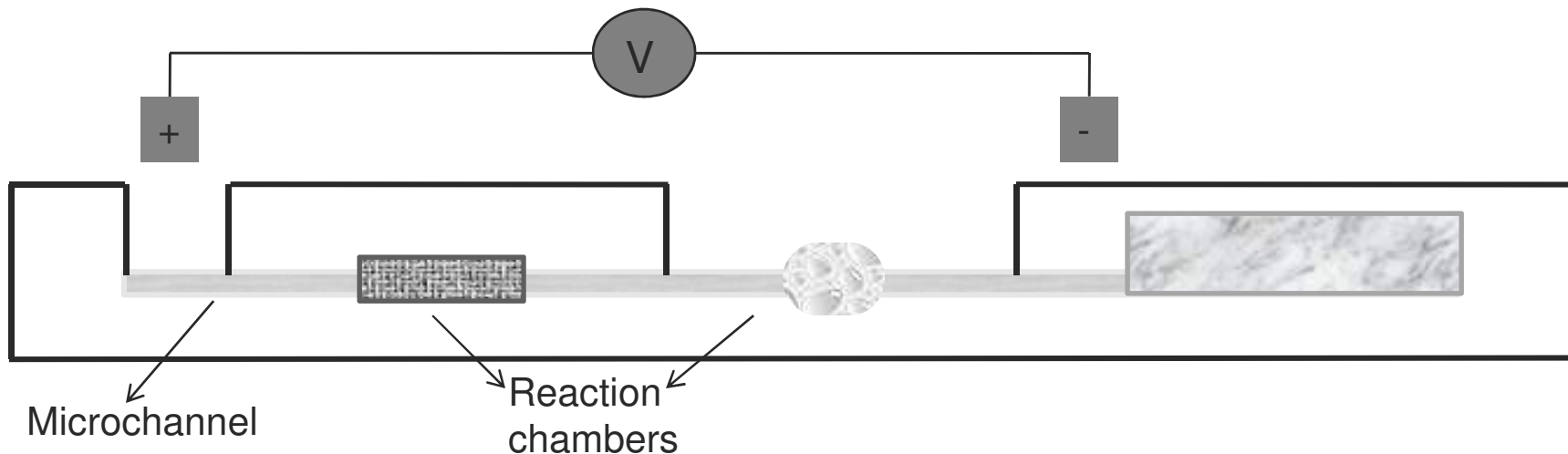
Approach

- Transport phenomena
 - Capillary driven and electrically driven flows
- Bio-molecule manipulation
 - Fluidic, electrical, chemical
- Sensing
 - Electrical and optical detection
- Design based on numerical simulation
 - Multi-scale/physics CFD aided by visualization
- Microfabrication and integration



Proposed Chip System

- Components
 - Microchannel for fluid manipulation
 - Reaction chamber for immobilizing biological materials
 - Sample inlets and outlets
 - Pair of electrodes for applying electrical potential
- Channel dimensions within few hundred micrometers





Transport Mechanism

- Fluid motion and associated transport processes
 - Autonomous fluid delivery
 - Optimize species delivery
 - Enhance mixing reaction and speed
 - Higher detection capability
- Numerical simulation
 - Predict and optimize processes and system behavior
 - Couple design requirements with physical realization
- Obtain electroosmosis and electrophoresis flow for one dimensional channel
- Multiple channels and dimensions, cyclic flow

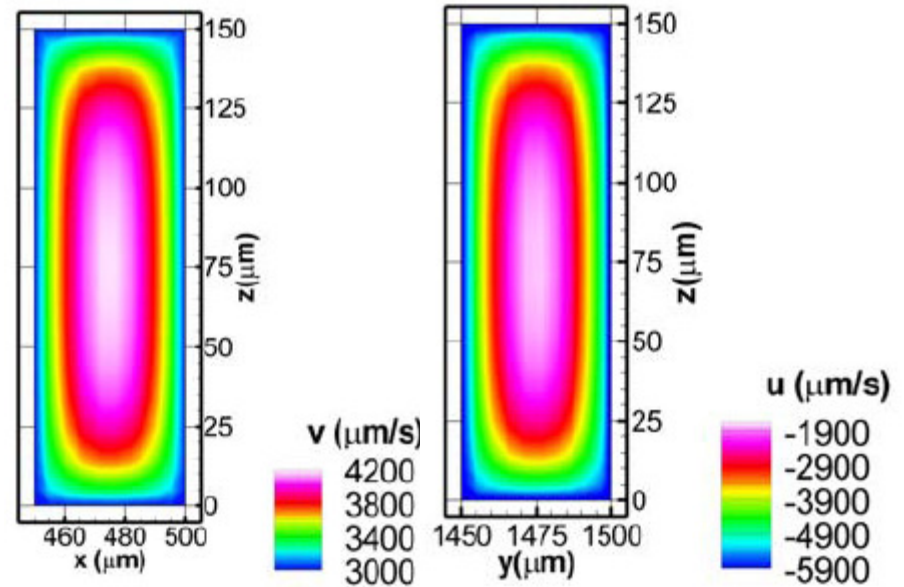


Microscale Flow

- Buffer and species transport
 - Capillary flow
 - Electroosmotic flow
 - Electrophoresis flow
- Combine surface characteristics with driving forces



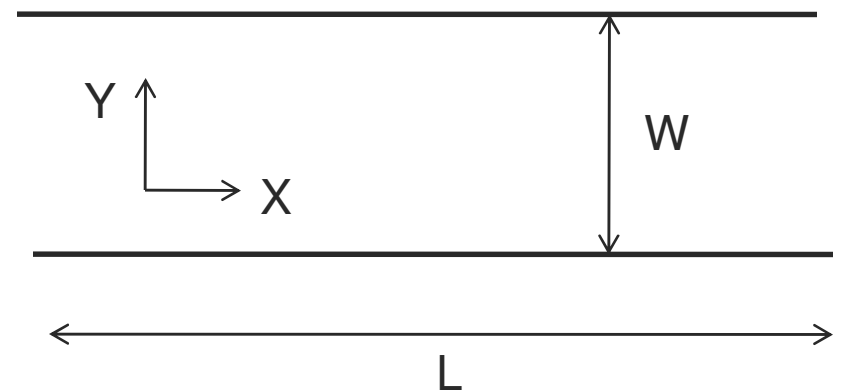
Elmajdoub, LSU thesis (2006)





Model Equations

- Continuity: $\nabla \cdot \mathbf{v} = 0$
- Momentum: $\rho \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = -\nabla P + \mu \nabla^2 \mathbf{v} + \rho_e \nabla E$
- Laplace: $\nabla^2 \phi = 0$
- Poisson: $\nabla^2 \Psi = \frac{-\rho_e}{\epsilon \epsilon_0}$
- Poisson-Boltzmann: $\nabla^2 \psi = k^2 \psi$





Research Update

- Focused on experimental work
 - Studying biochemical reactions and materials
 - Designing chip without the fluidic component
- Numerical simulation
 - CoventorWare 2008
 - Identifying parameters particular to flow and species transport
 - Applicable system or subsystem
- Validation and optimization
- Optical microscope for visualization
- Microfabrication and integration



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