Overview

Micro-scale sample preparation technology is a critical component next generation biochemical assays. Drastic scale-down of biochemical assays has several advantages over their bench top counterparts that they:

- Can be made into portable systems
- Require smaller sample size
- Have subsequent lower costs
- Provide scalable parallel detection and diagnostic solutions.

We are developing sample preparation technology that can be realized in a handheld device. This technology is capable of manipulating both biological and non-biological materials with micro-scale precision.

System Design

Principle of Operation
- Cascade various micro-scale stages to take an unknown sample and extract, concentrate, and detect properties of its important analytes.

Advantages
- Each stage provides a specific function with minimal footprint
- Can fabricate all components simultaneously

The system requires five core components:
- Sample introduction and pumping – performs pre-filtering and moves sample through system
- DEP-based washing and purification – coarse filtering of non-relevant material
- Vision-based purification – precision sorting of individual cells
- Sample Concentration – concentrate relevant analyte to increase detection probability
- Optical Detection – observe optical properties of sample such as fluorescence, and bioluminescence

Techniques: Microscale Optics

Principle of Operation
- Replace micro-scale optical systems with micro-scale imaging
- particles coupled directly to surface of image sensor
- particles either block light or emit light to produce images on camera

Advantages
- Increase collection efficiency to ~50%
- No need for large, heavy optical components
- Simple on-chip pre-processing facilitates detection algorithms

Techniques: Dielectrophoresis

Principle of Operation
- Direction of force depends on dielectric constant relative to fluid.
- Dielectric constant varies with frequency.

Advantages
- Can apply positive or negative DEP sequentially or simultaneously using multiple control frequencies.
- Parastic traps are actively cancelled using negative DEP.

A system to load cells automatically was designed and modeled carefully. It works for flow speeds of up to 400 mm/s.

Techniques: Electro-Osmotic Flow

Principle of Operation
- Particles suspended in liquid
- Applied electric field induces liquid motion
- Liquid pulls particles

Advantages
- Self-correcting. Any errors at current time fixed at next time.
- Feedback quickly forces system to desired behavior.

Sense current state, compare to desired state, actuate to correct error. Repeat.

Contact imager / cell detector

- 0.18 μm CMOS technology
- Novel 5 x 5 pixel with dark current suppression, high linearity
- 256 x 256 array
- On-chip threshold generation and binarization

Contact images of 48.5 μm diameter polystyrene bead.

Choosing the correct threshold is critical!