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Title

Lab-on-a-Chip Aquatic Microorganism Analysis System

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Lab-on-a-Chip Aquatic Microorganism Analysis System

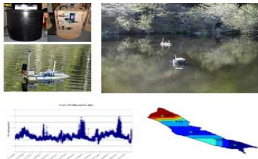
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Introduction: Why Aquatic Monitoring and Lab-on-chip?

Motivation

- Need for monitoring the content of the sea water and assess the concentration of different algae – algal bloom monitoring
- Elucidate the cause of toxin production by algae



• Example of a water monitoring system – “robot duck.” The device can be bulky and miniaturization is desirable.

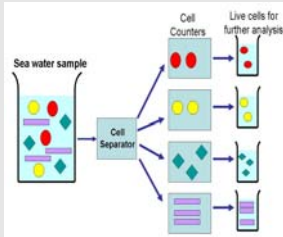
Advantages of lab-on-chip systems

- Batch fabricated, low cost, small sample volume.
- Automation and miniaturization.
- Can be integrated with wireless networks
- Enable multiple parallel experiments.
- Field deployable, disposable, sterile
- High sensitivity detector

Chip for Algal Bloom Monitoring: Cell separation and counting

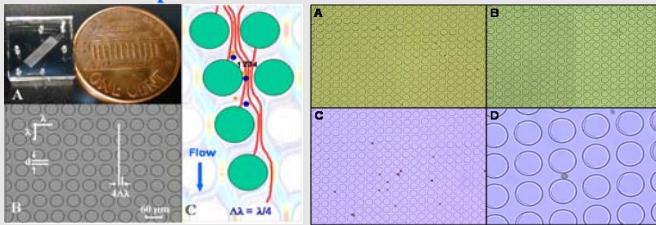
On-chip sea water microorganism monitoring

1. Collect sea water sample
2. Separation of different cells by size
3. Cell counting with impedance sensor
4. Further analysis (ELISA, PCR,..etc.)



A. Cell Separation Based on Particle Size

- Chip has an **array of pillars**
- Small particles can follow a separation lane exactly resulting in a **zigzag flow**
- Large particles, incapable of making sudden turns around pillar, flow in **displacement mode**, and do not remain in one separation lane at all time

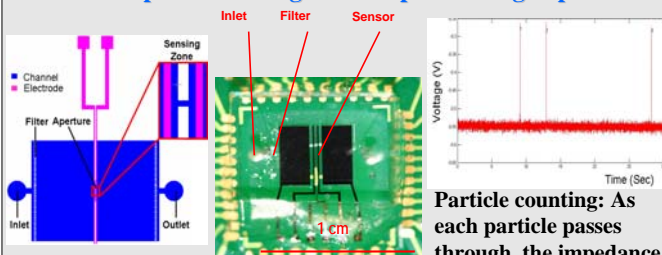


Device for particle separation

Four types of algae tested in device. (A) *Aureococcus anophagefferens* (B) *Chlorella stigmatophora* (C) *Heterosigma akashiwo* (D) *Chlamydomonas sp*

B. Cell Counting with Impedance Sensor

- Detect impedance change as cells pass through aperture



Device design layout

Fabricated device

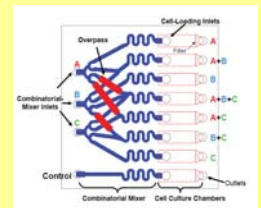
Particle counting: As each particle passes through, the impedance across the aperture changes and this result in the spikes.

Algae Culture on Chip: Screen for factors that induce toxin production

- Culture *Pseudo-nitzschia*, a toxin producing algae, on chip.
- Culture cells under different combinatorial conditions on **one chip** to screen for factors inducing **toxin production**.
- Cell culture arrays with an integrated combinatorial mixer



• Replace several culture experiments with a single chip



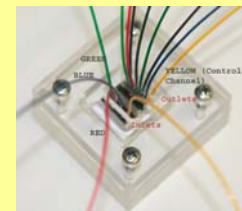
Device design



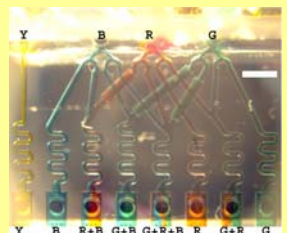
Fabricated 1cm X 1 cm device – Monolithic process with parylene C as the basic structural material



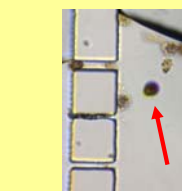
Prorocentrum gracile inside culture chamber



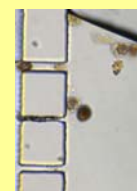
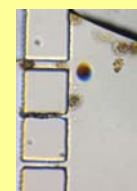
Combinatorial mixer with three inputs – recombines the three inputs food coloring streams



Combinatorial mixing of food coloring streams with Flow rate = 10 μ L/min, scale bar = 1 mm



A. *Sanguinea* inside a 100 μ m high chamber. The algae seems healthy as it swims around near the filter



100 μ m