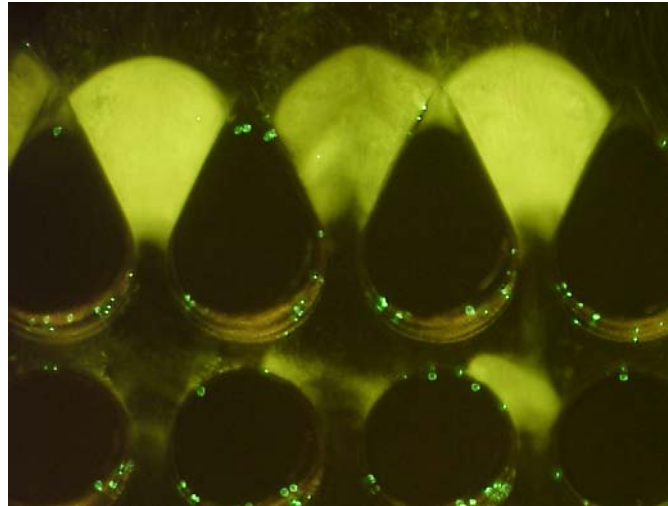




Rapid, On-Chip Differentiation and Detection of Infectious Pathogens Using Insulator-Based Dielectrophoresis



Yusef A. Syed

Mentor: Blake Simmons

**Nanoscale Science and Technology Department
Sandia National Laboratories, Livermore, California**



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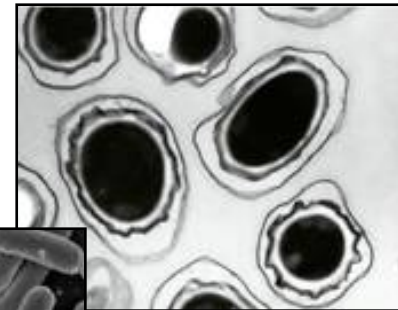


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Outline

- **Goals and Existing Methods**
- **Process Components**
- **iDEP**
- **Results**



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Goals

To Design a System Capable of:

- **Rapid (1-10 min) Pathogen Identification**
- **Environmental Sample Processing**
- **Deployment in Public Spaces**
- **Complete Automation**



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Existing Methods

Immunoassays & PCR:

- Reliable and Sensitive
- Slow
- Require Labs and Training



APDS - LLNL:

- Immunoassay Based (~1 Hour Processing Time)

BAWS - US Military:

- Fluorescence Based
- History of False Positives



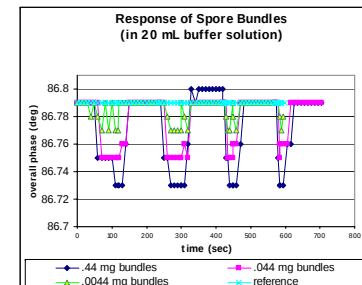
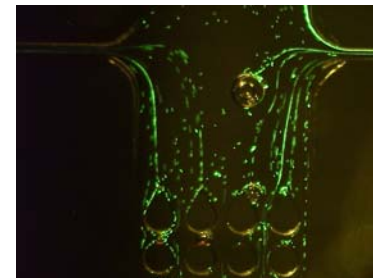
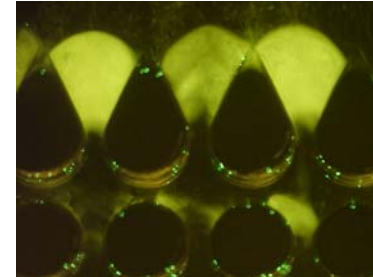
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Process Components

- Separation/Concentration
- Isolation/Deflection
- Detection

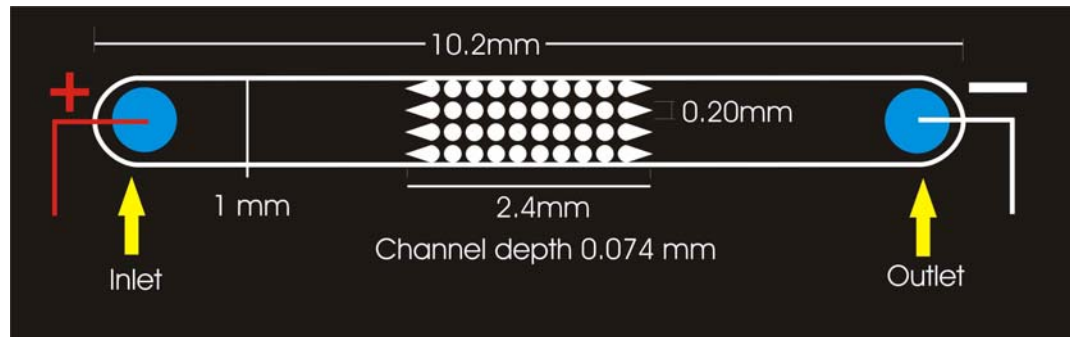


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iDEP Fundamentals



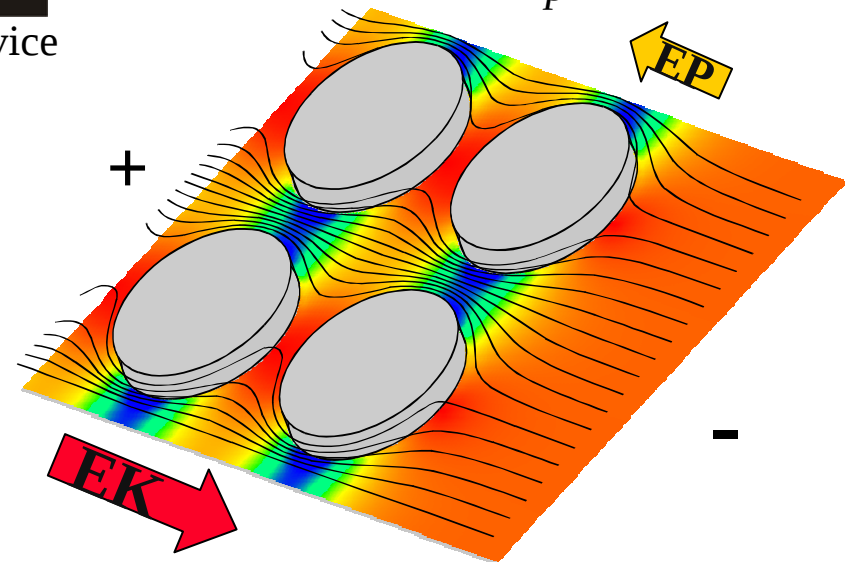
Porosity III Device

Dielectrophoresis: motion of a particle due to polarization induced by nonuniform electric fields

- Integrated arrays of insulators used to create a nonuniform electric field
- DC or AC fields

$$F_{DEP} = 2\pi\epsilon_o\epsilon_m r^3 f \nabla E^2$$

$$f(\sigma_p^*, \sigma_m^*) = \frac{\sigma_p^* - \sigma_m^*}{\sigma_p^* + 2\sigma_m^*}$$

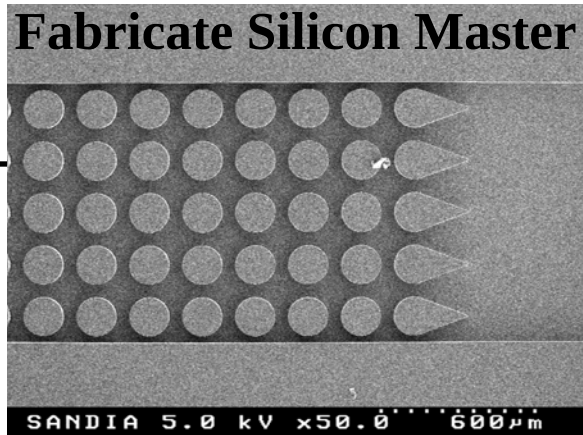


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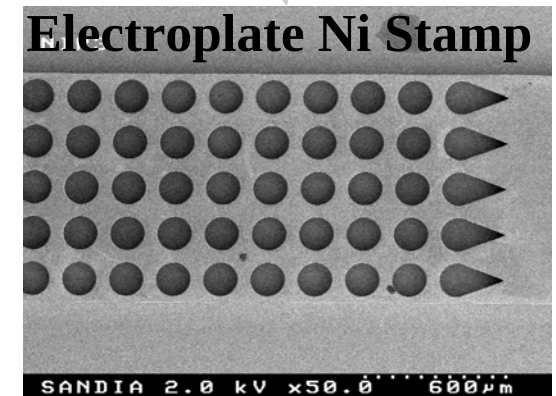




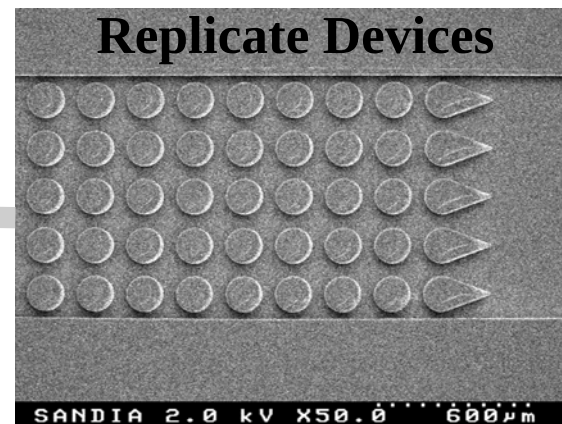
Fabrication



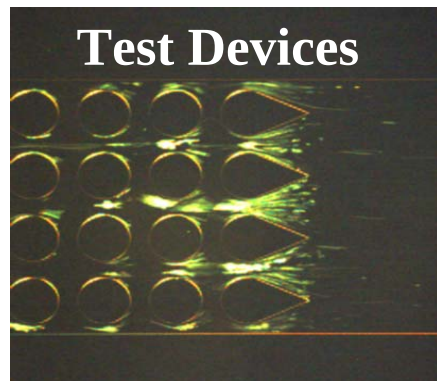
QC: SEM, metrology



QC: SEM, metrology



Sample testing



QC: SEM, metrology

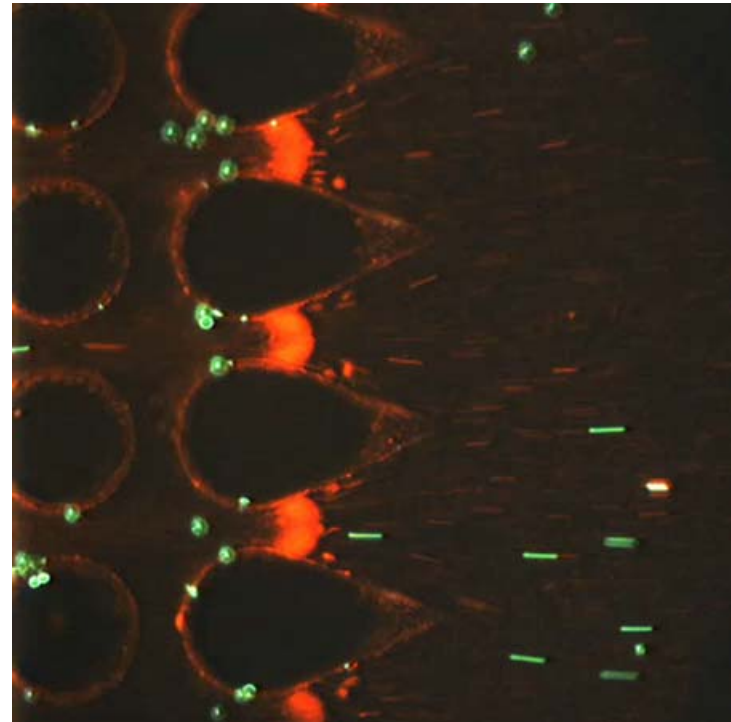
Zeonor fabrication techniques
were developed at Sandia





iDEP is ideal for spore detection

- Spores trap in high field gradient regions
- Varying trapping threshold E fields allow for species-specific identification



B. thuringiensis (red) separated from 1- μ m green beads at 720 V



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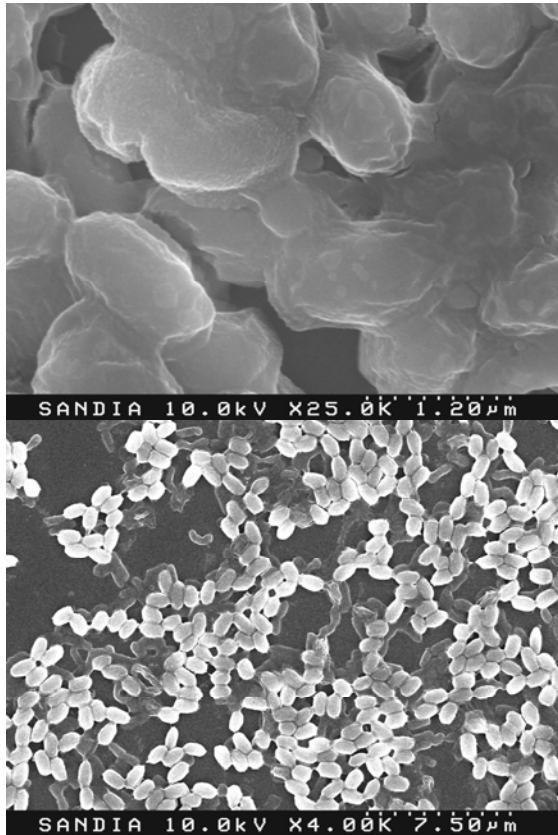


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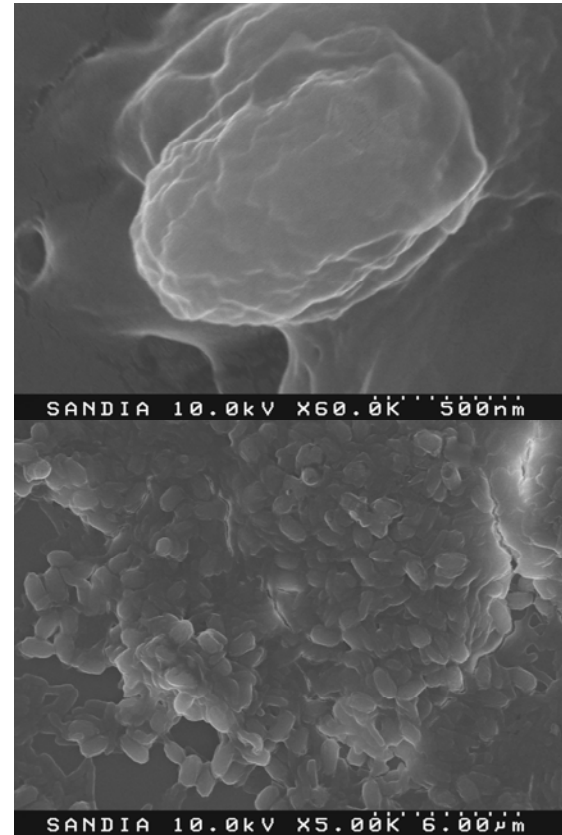


Spores Vary in Size

B. anthracis (delta stern) – 1.3 μm



B. subtilis – 1.5 μm



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iDEP Effectively Traps Representative Particles



2 μm polystyrene microspheres
Gen 1B Chip (90 μm depth)



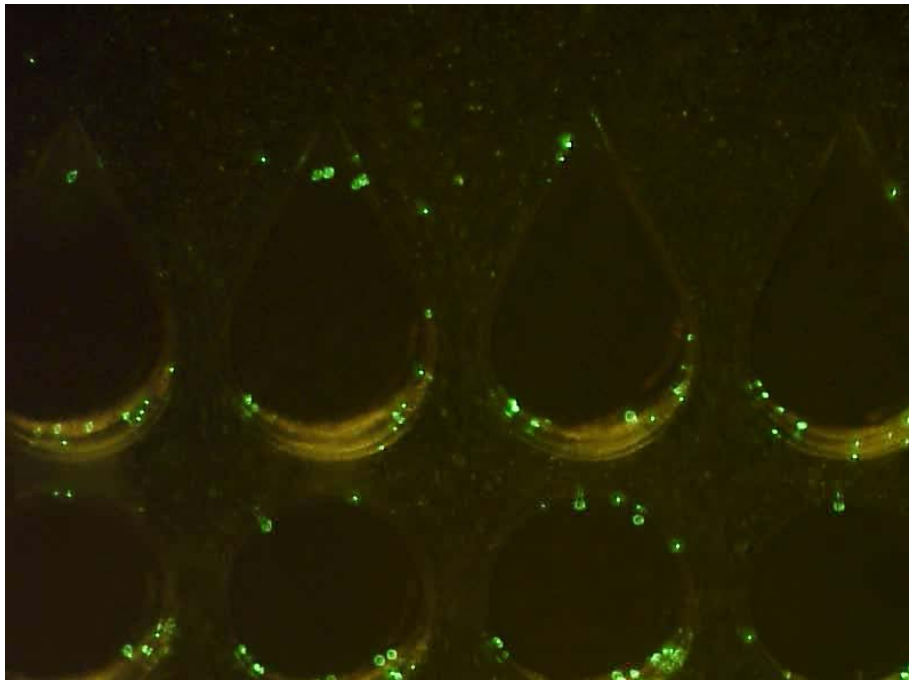
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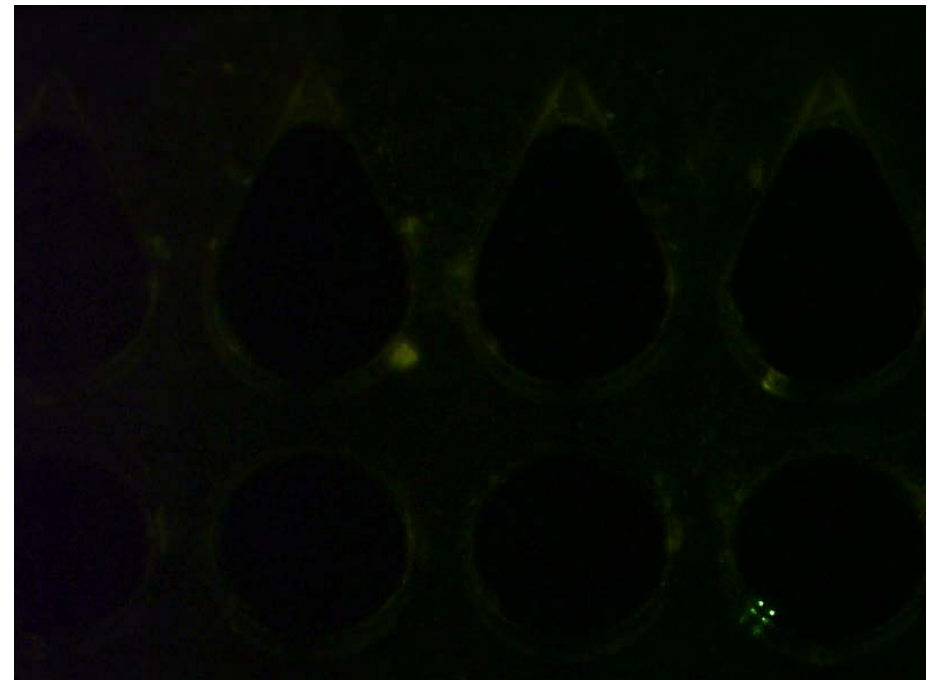
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Effective Species-Specific Spore Trapping by iDEP



B. Subtilis trapping at 1000 V



B. Anthracis delta stern trapping at 1000 V

Posts are 250 μm in diameter and on 250 μm centers, 30 μm depth



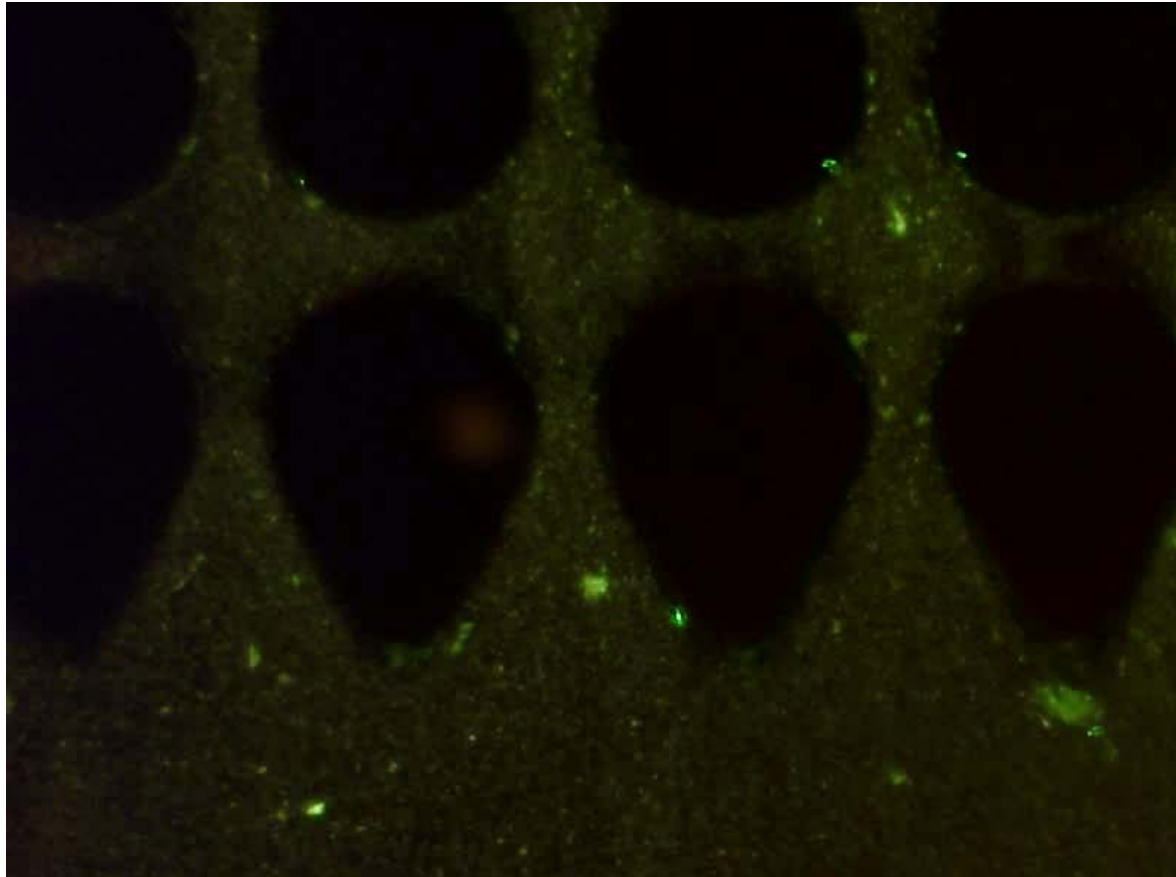
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Spore Differentiation by iDEP



B. anthracis
(delta stern)

B. subtilis



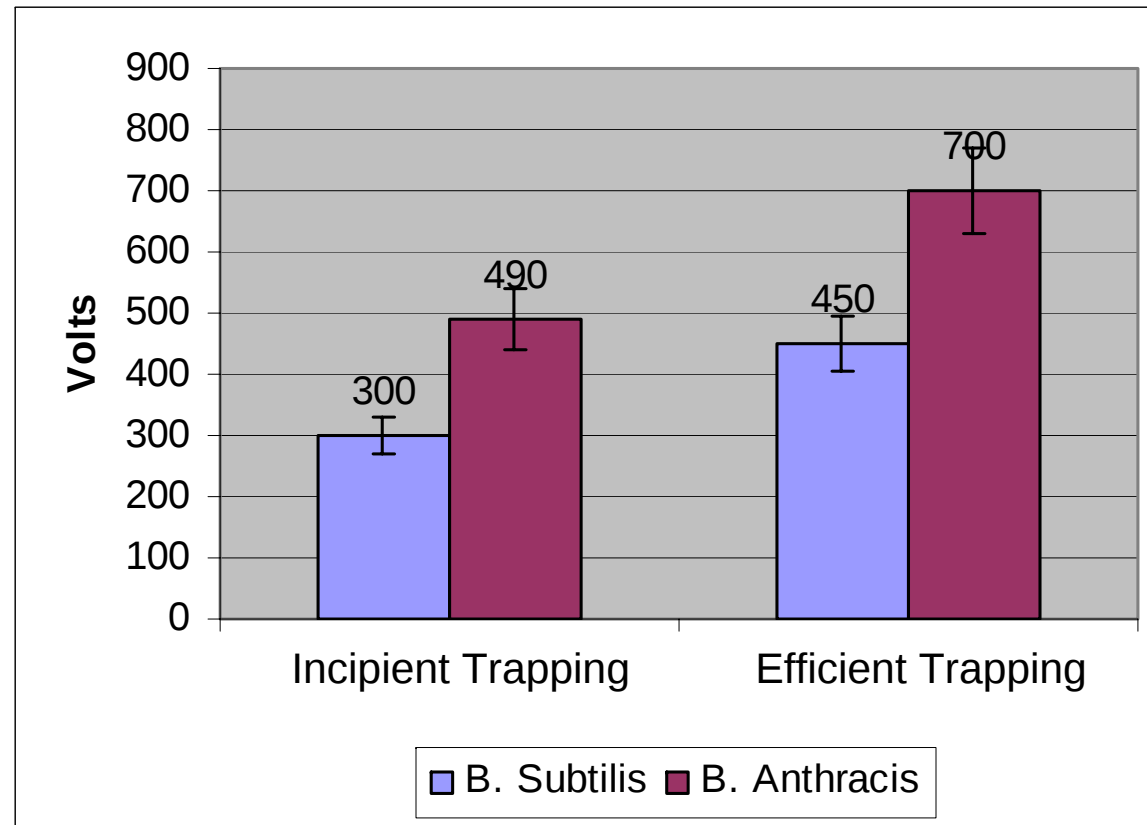
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Unique Thresholds Allow for Differential Trapping for Low Spore Concentrations



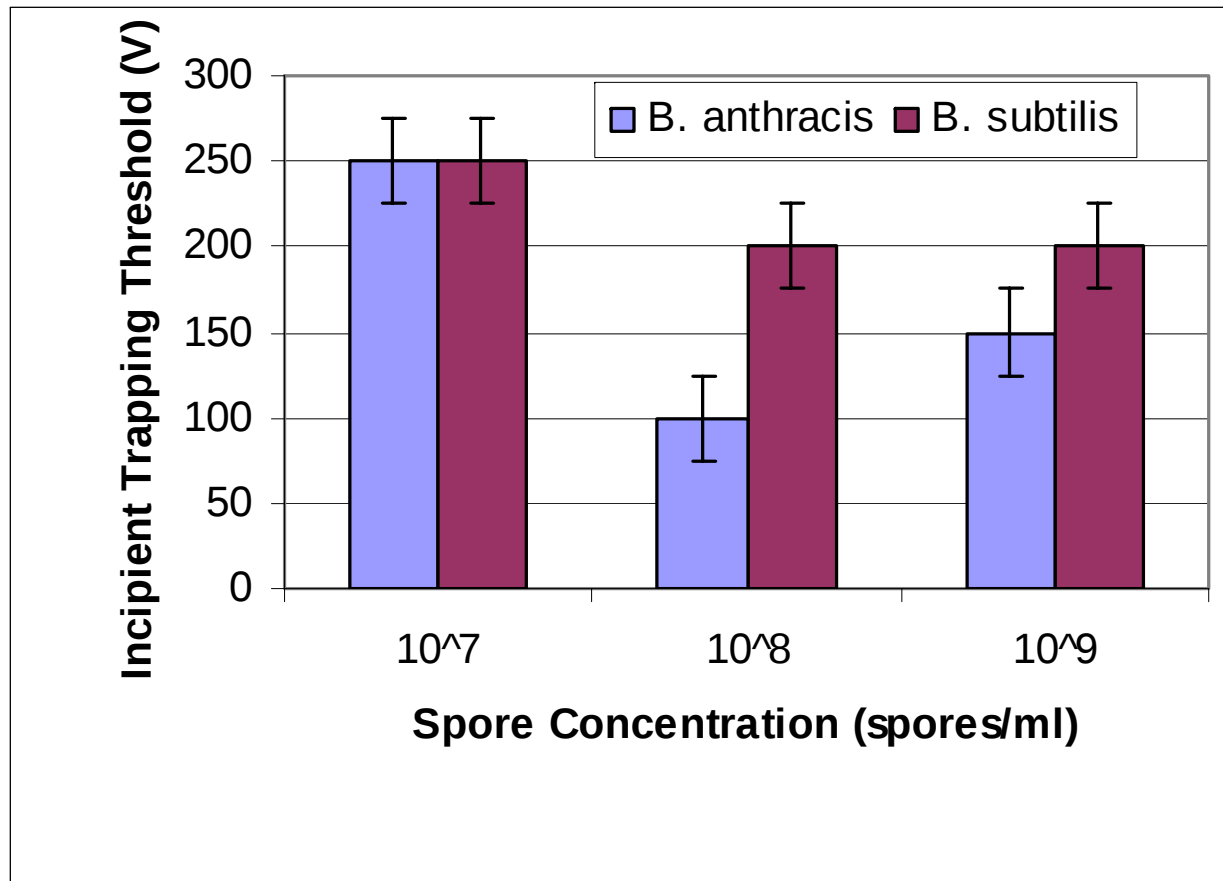
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Observed Trapping Properties Vary with Concentration



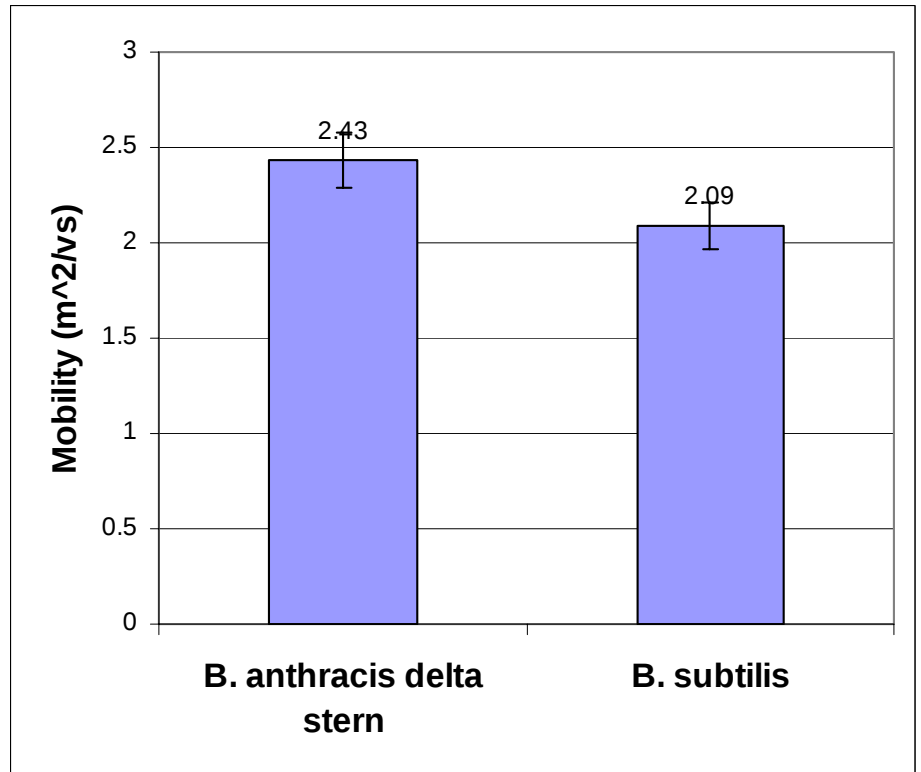
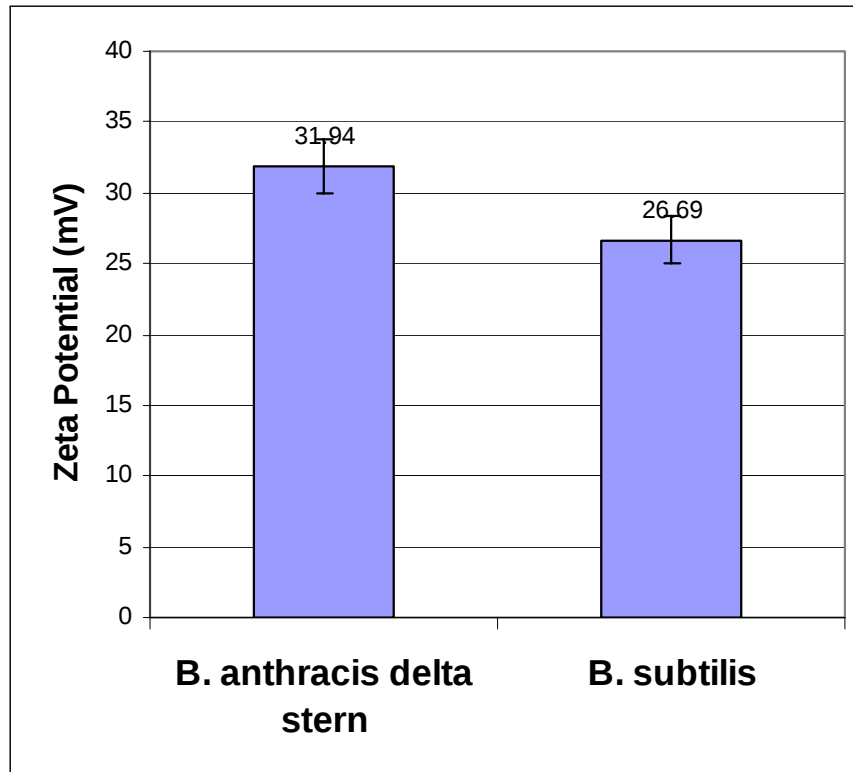
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Spores Vary in Zeta Potential



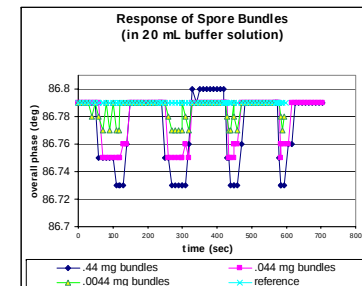
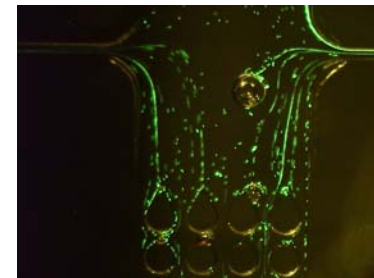
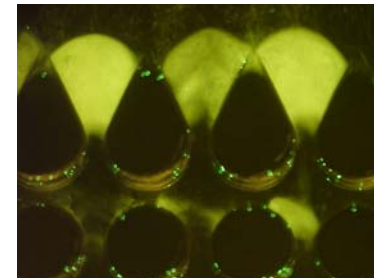
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Process Components

- Separation/Concentration
- Isolation/Deflection
- Detection

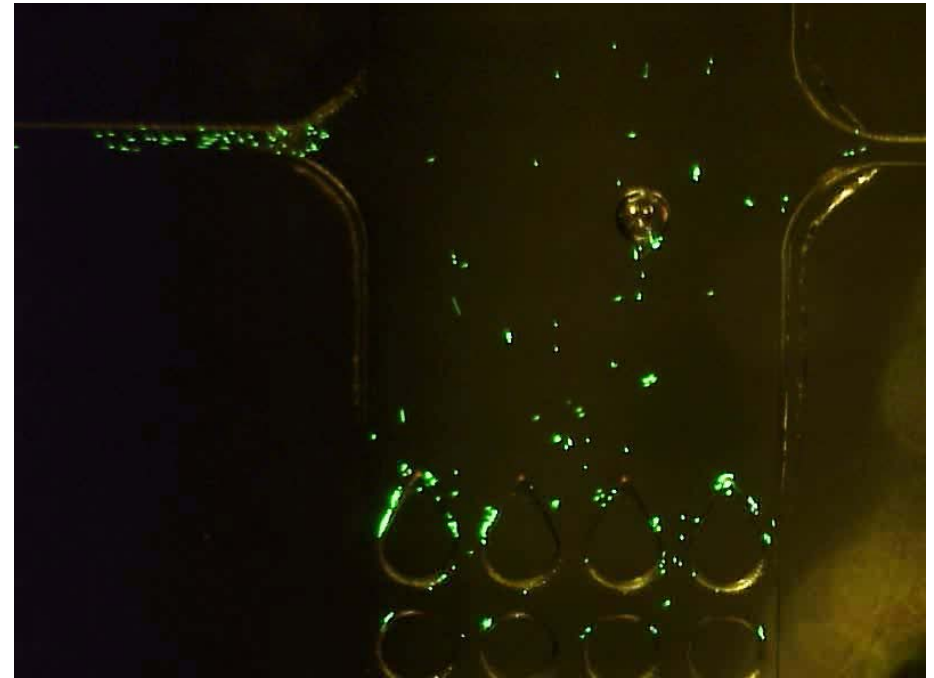
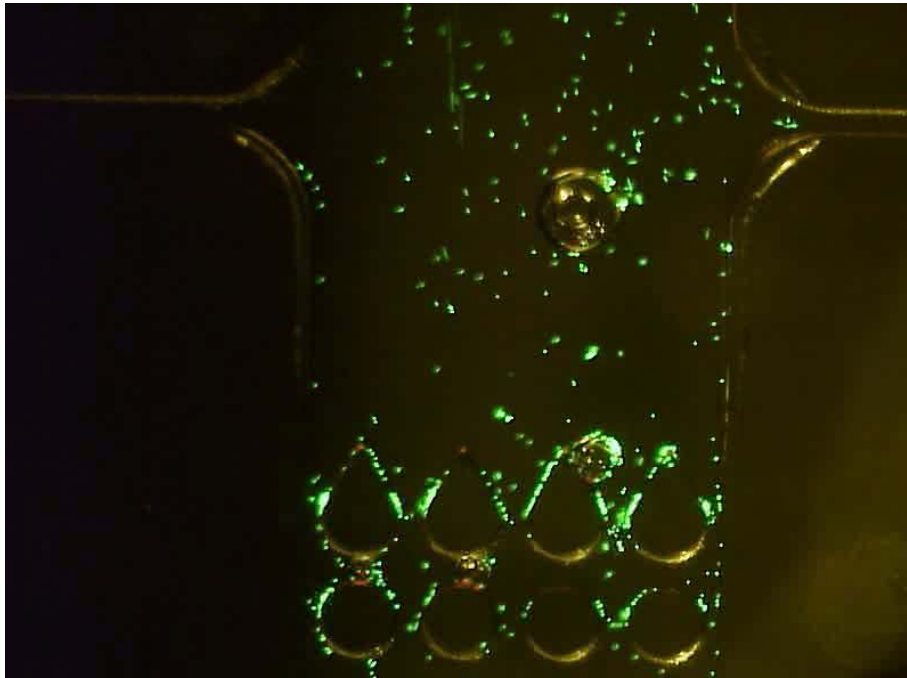


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Complete Sample Isolation by Flow Diversion



2 μm polystyrene microspheres
Gen 1C Chip (30 μm depth)



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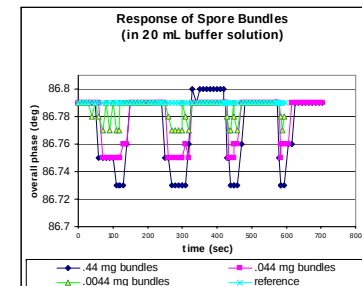
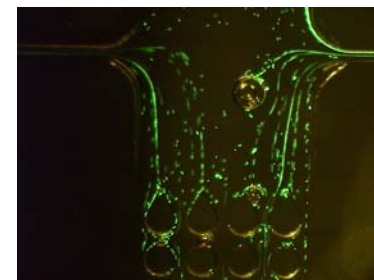
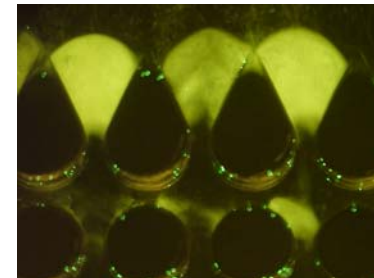


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Process Components

- Separation/Concentration
- Isolation/Deflection
- **Detection**

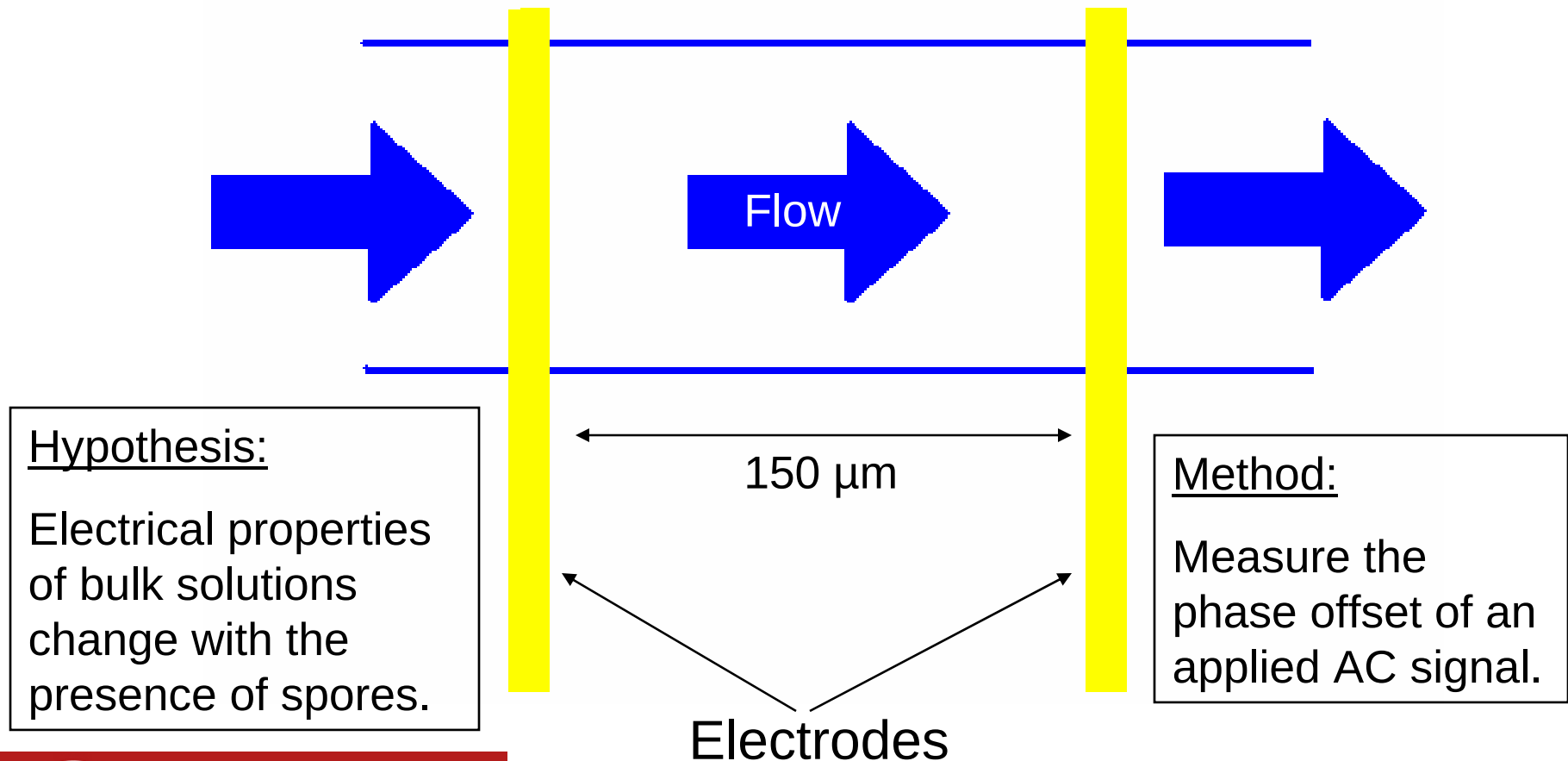


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Impedance Detection Scheme



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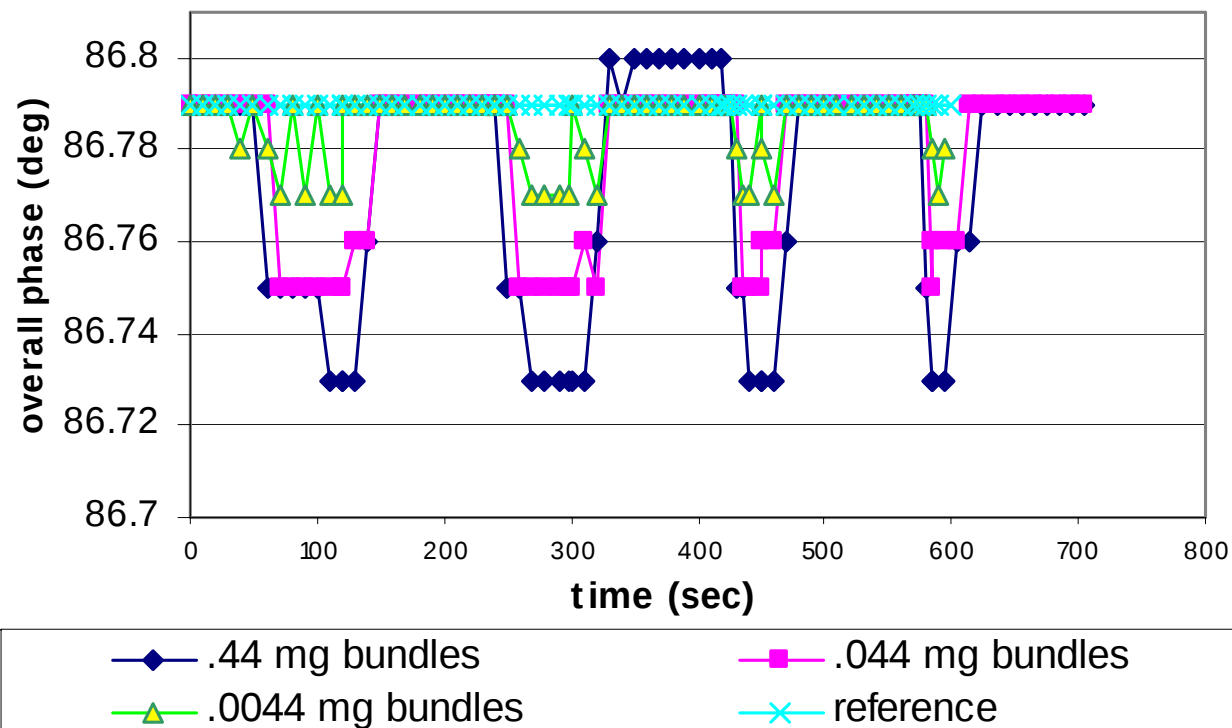


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Impedance Detection Results

**Response of Spore Bundles
(in 20 mL buffer solution)**



Injection Times:

1. 2 minutes
2. 1 minute
3. 30 seconds
4. 15 seconds



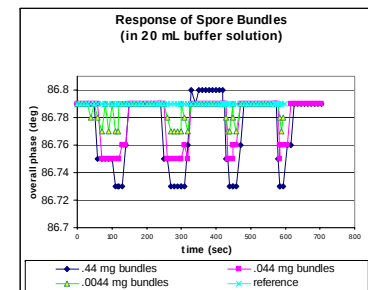
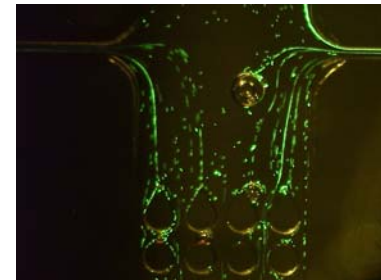
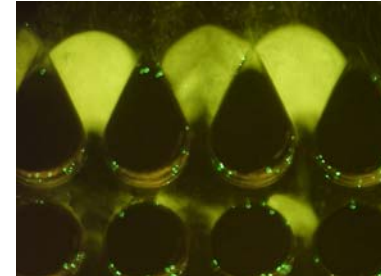
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Summary

- Species-specific spore trapping has been demonstrated.
- Sample isolation has been demonstrated.
- Impedance measurements allow for repeatable spore detection.
- Remaining tasks: System integration and final testing



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Acknowledgements

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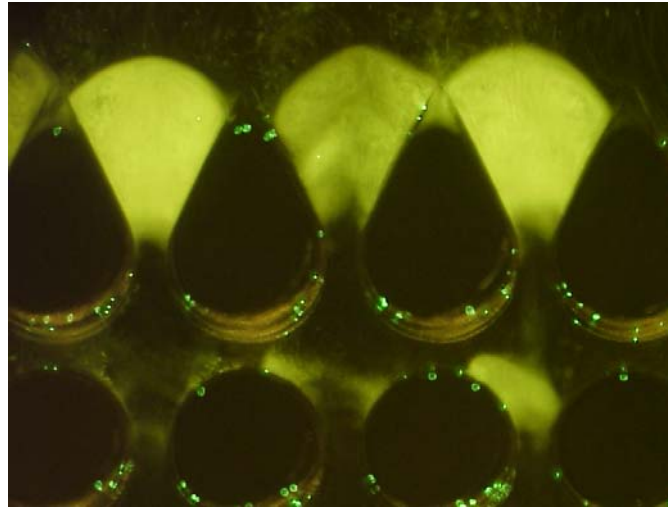
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