Enhanced capture of magnetic microbeads in a microfluidic channel for water treatment

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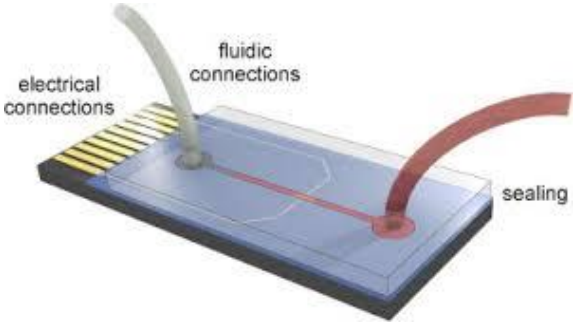
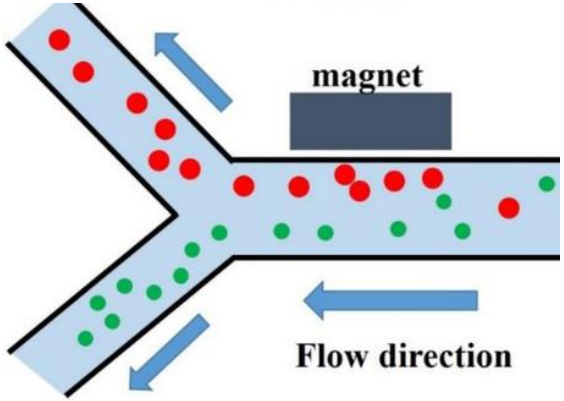
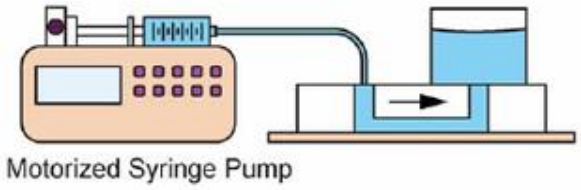
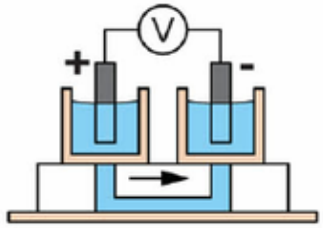
Introduction

- μTAS: micro total analysis systems or lab-on-chip devices[1,2]
  - Small, fast response, reliable
- Magnetophoretic separation[3]
  - Adaptable, reliable









[1]Temiz et al (2015) [2]Byun et al (2014) [3]Jiang et al (2014)

Objective & Hypothesis

- *Objective*

  To develop an efficient lab-on-chip device by increasing capture efficiency of magnetic microbeads

- *Hypothesis*

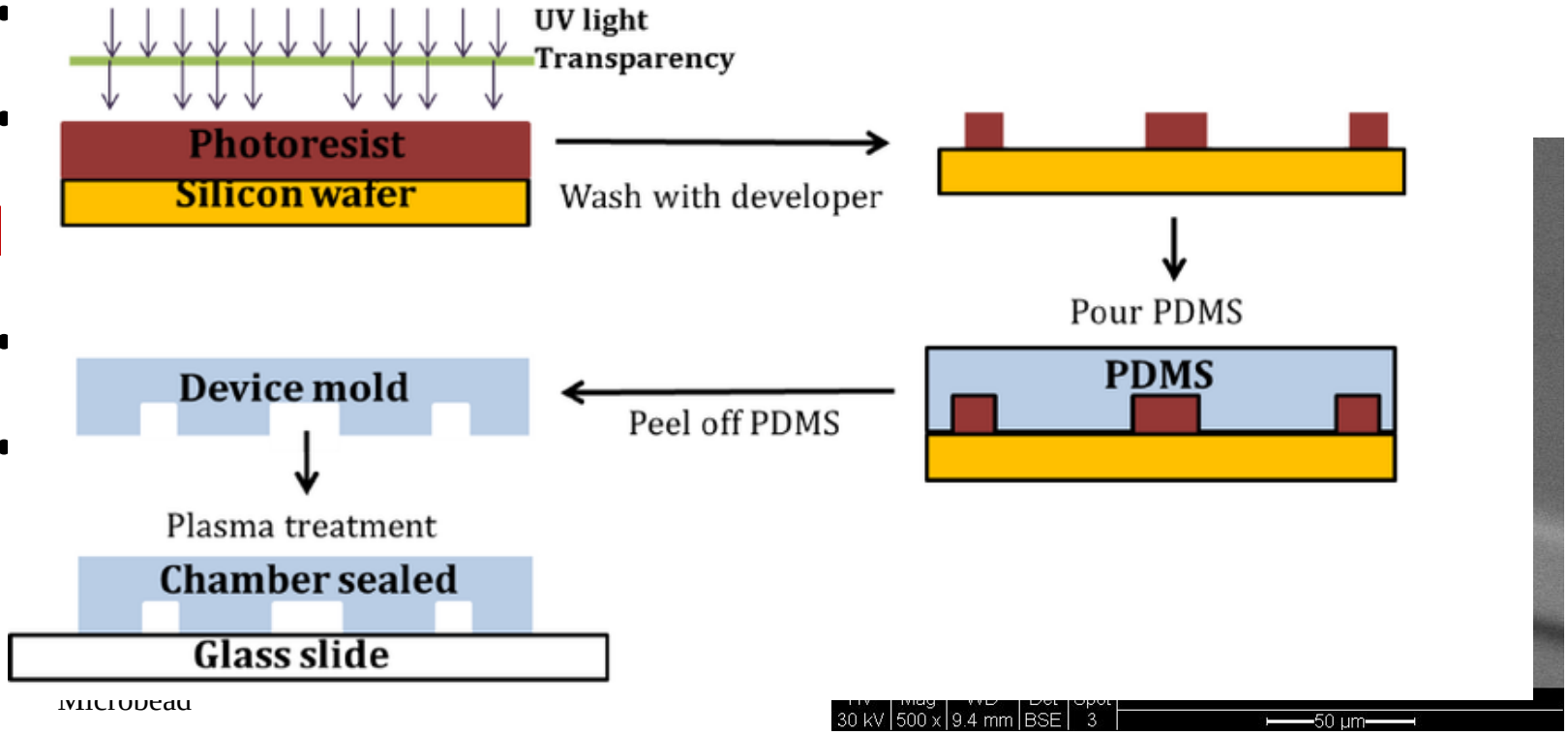
  The flow switching protocol will significantly increase the capture efficiency of microbeads, greatly increasing the reliability and accuracy of the device

Specific Aims

- *Specific Aim 1*
  - Examine the effect of electroosmotic flow switching on capture efficiency in microfluidic channels
- *Specific Aim 2*
  - Evaluate bacteria binding and create a calibration curve for bacteria capture in the device

Methods

- Microchannel
  - SU-8 micro lithography[4]
- M



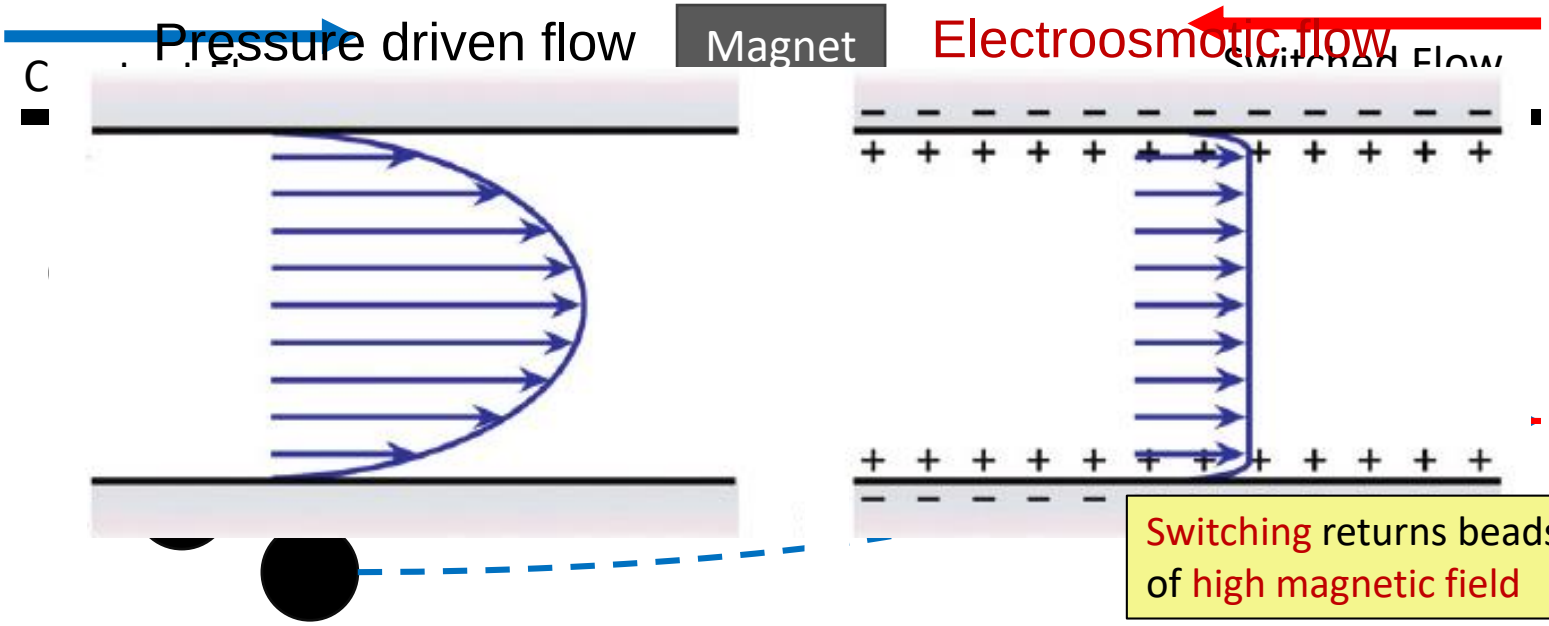
[4]Feng et al (2015)

Methods

- Electroosmotic Flow (EOF): plug flow profile[5], easy flow manipulation
  - $U_{ep} = -\frac{E_z \varepsilon_r \varepsilon_o \zeta_p}{\mu}$

U_{ep}: fluid velocity (cm/s)
E_z: applied electric field (V/cm)
ε_r: dielectric constant of medium
ε_o: vacuum permittivity (F/m)
ζ_p: zeta potential (V)
μ: dynamic viscosity (Pa·s)

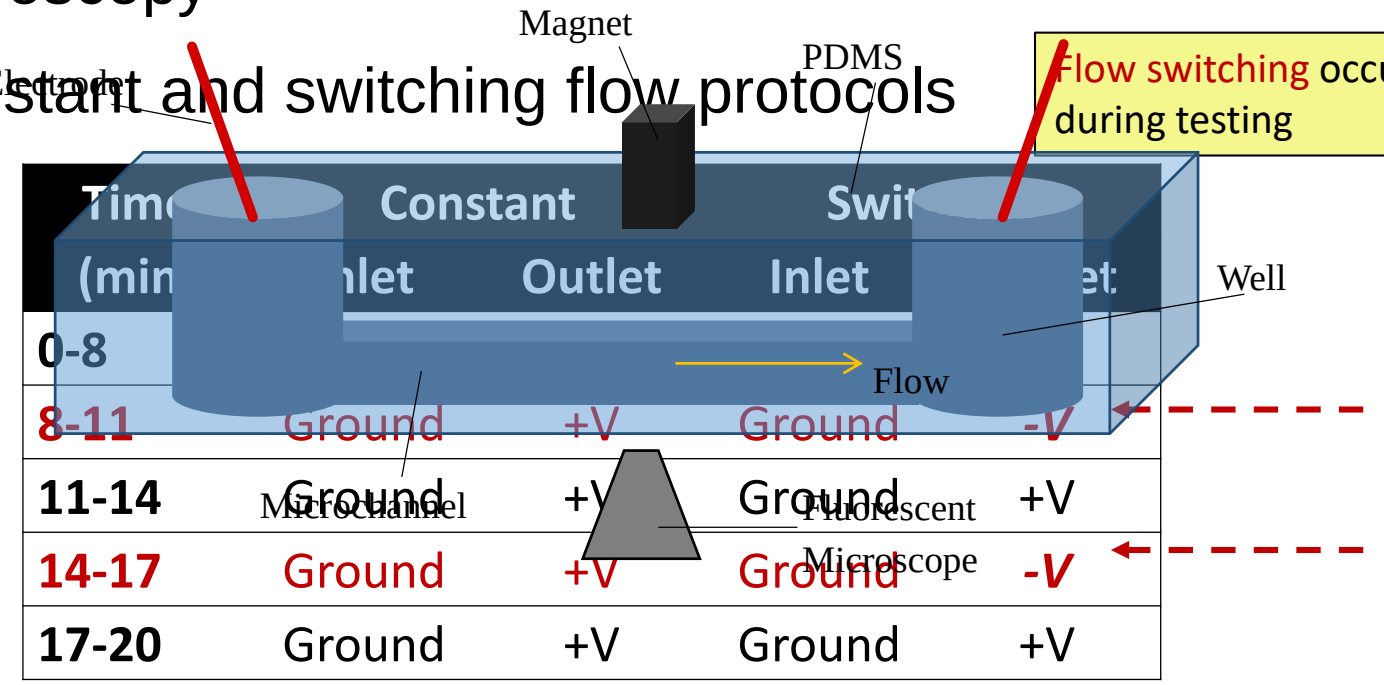
- Constant flow vs. switching flow



[5]*Microfluidics* 2013

Methods

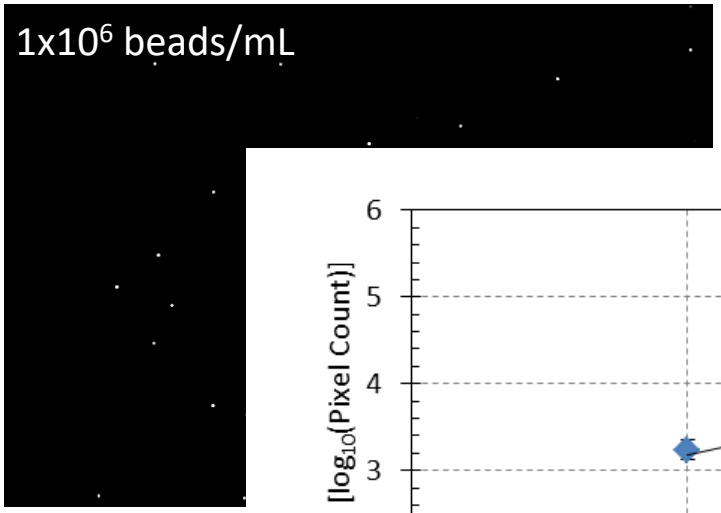
- Testing Procedure
  - PDMS microchannel bound to glass slide
  - Analysis performed using inverted fluorescent microscopy
  - Constant and switching flow protocols

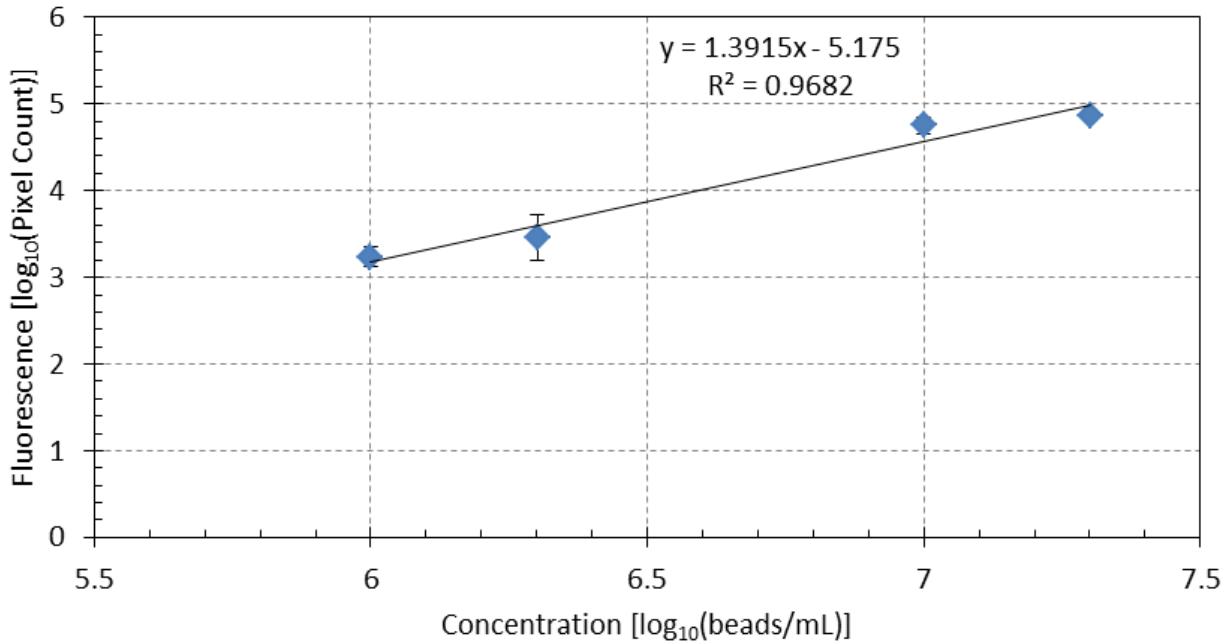


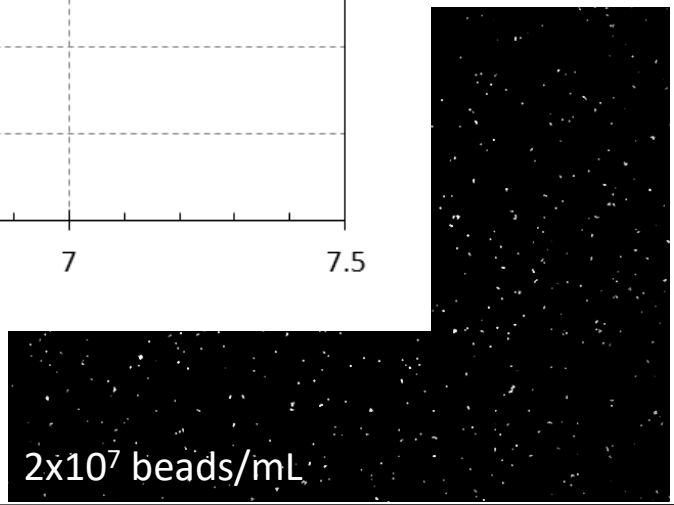
Time (min)	Constant Inlet	Outlet	Switching Inlet	Outlet
0-8				
8-11	Ground	+V	Ground	-V
11-14	Ground	+V	Ground	+V
14-17	Ground	+V	Ground	-V
17-20	Ground	+V	Ground	+V

Results

- Calibration Curve



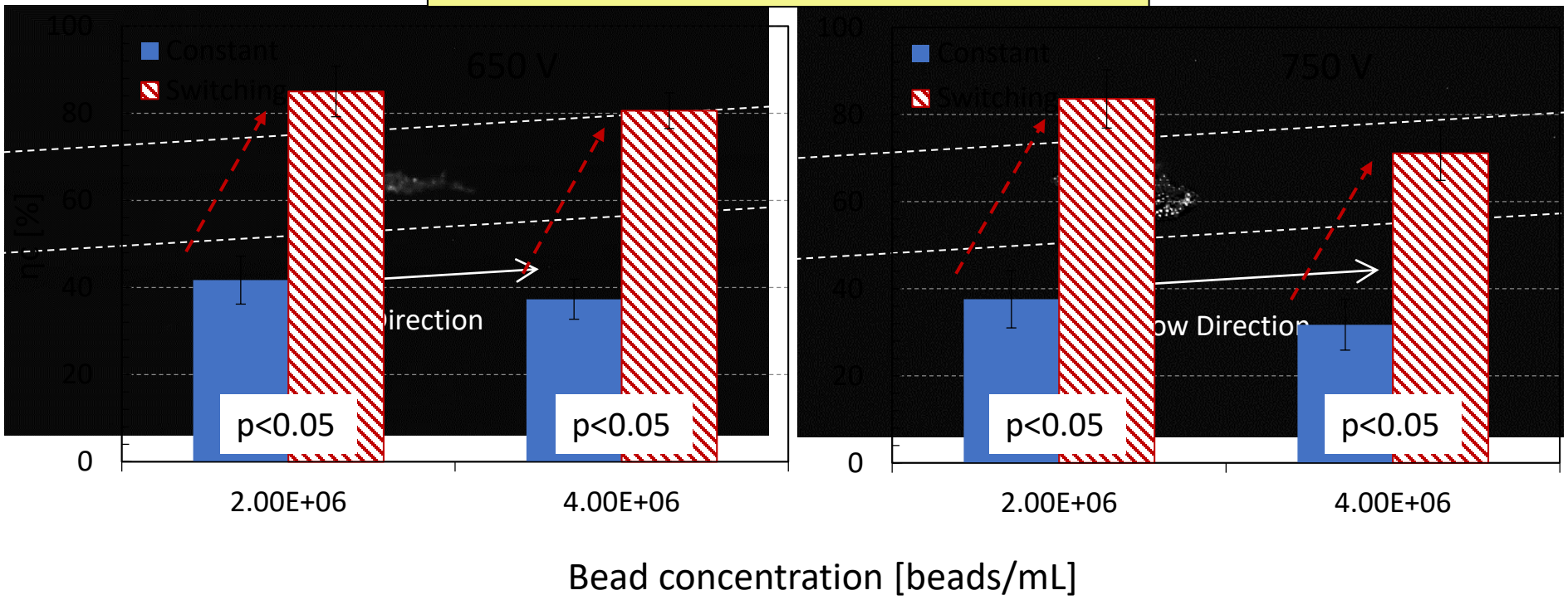




Results

- Capture Efficiency
  - $\eta_c = \frac{pixel\ count\ captured}{pixel\ count\ captured + pixel\ count\ uncaptured}$

Capture efficiency increased up to 2 times using the flow switching protocol.



Bead concentration [beads/mL]

Specific Aims

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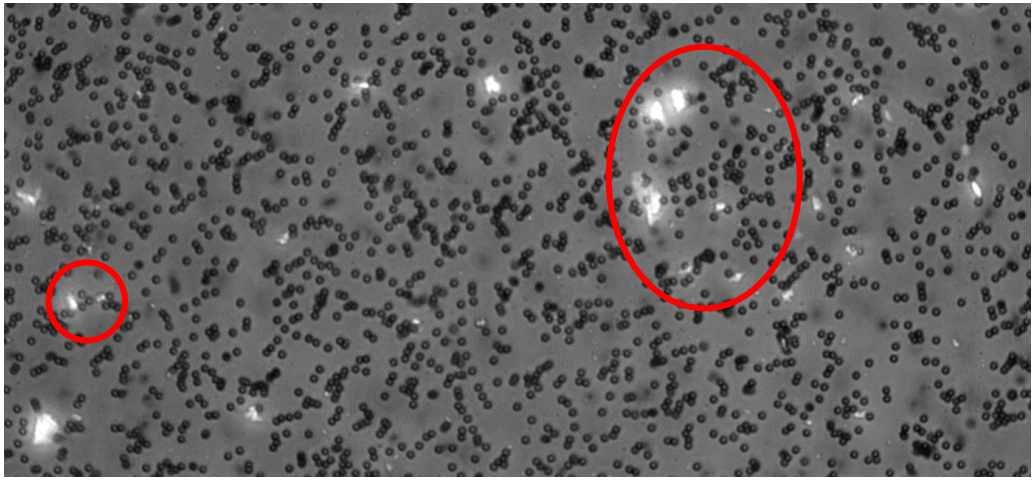
Results

- Bacteria binding
  - Separate antibodies to prevent bead-tag complexes
  - Excess beads to bind efficiently



- Future
  - Completion of calibration curve for bacteria capture

Conclusion

- Fluorescent analysis
  - Differences in fluorescent intensity shown among varying microbead concentrations
- Flow switching
  - Significantly increased capture efficiency compared to constant flow
- Bacteria binding
  - Shows promise with binding of microbeads and fluorescent tag

Future Direction

- Completion of bacteria study and calibration curve
- Analysis of different bacteria to increase device versatility
- Development of device into a closed system with analysis sensors included

Acknowledgement

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Thanks & Questions