Pulsatory Mixing of Laminar Flow Using Inertial Micro-Pumps

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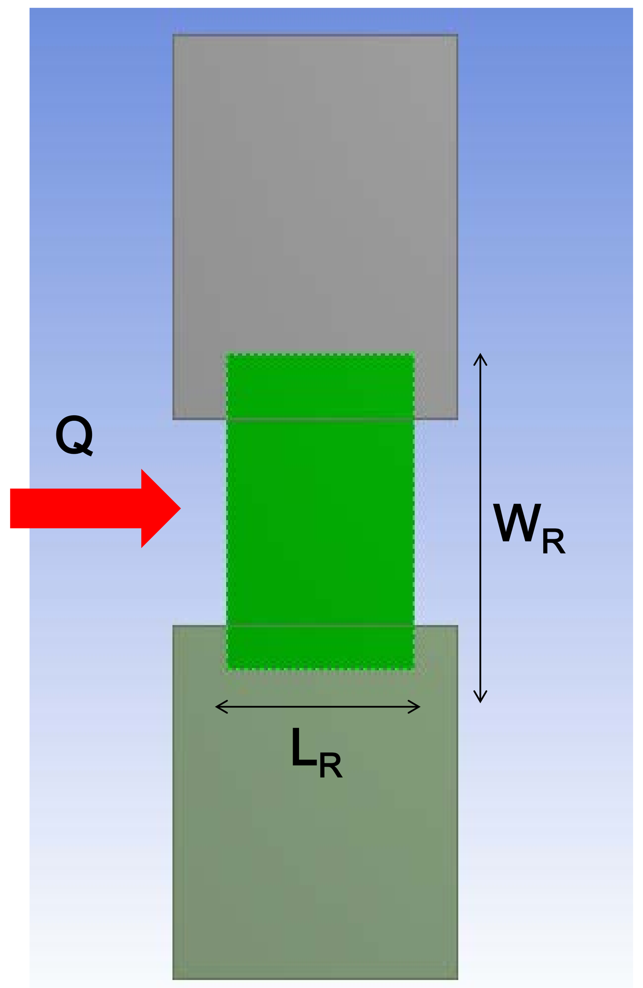
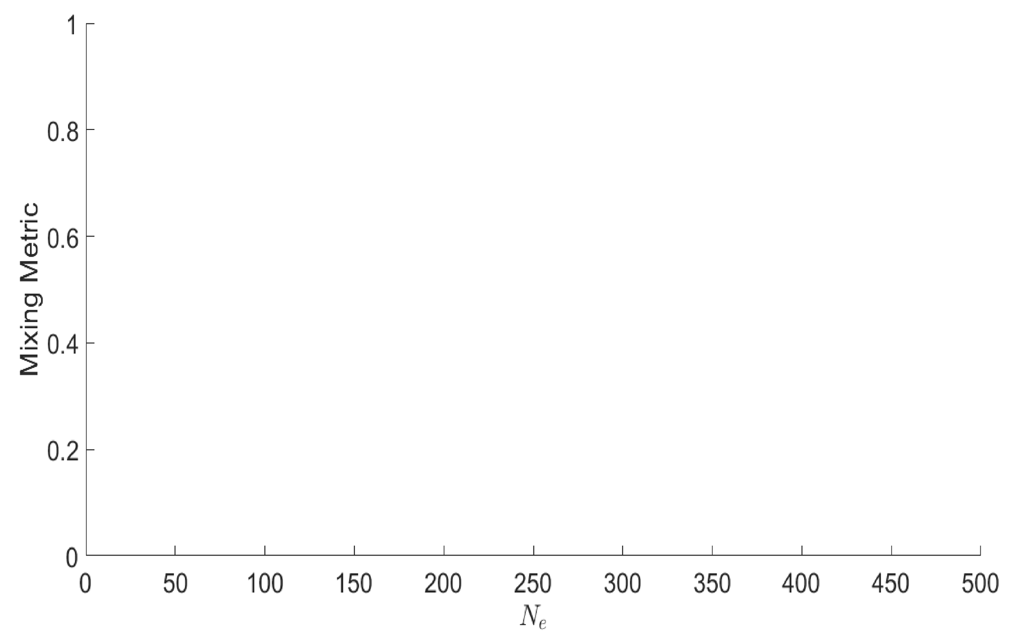
Mixing Metrics





$$\tau_r = \frac{L_r}{v_f} = \frac{L_R}{Q/A_c} = \frac{L_R A_c}{Q} \quad [s]$$

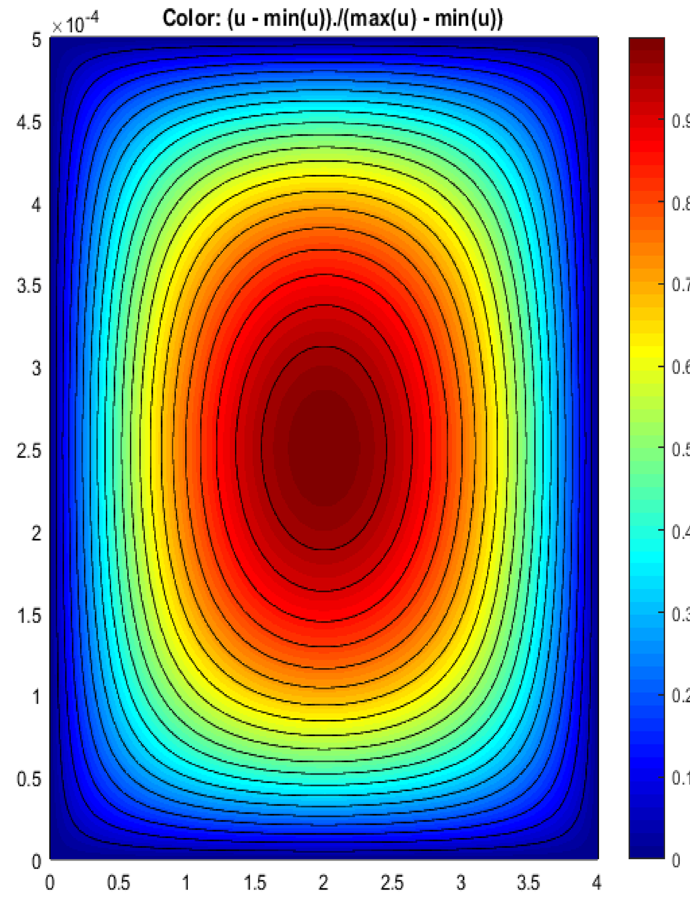
$$N_e = f\tau_r$$

A_c $[m^2]$ – cross-sectional area
τ_r [s] – residency time
v_f $[\frac{m}{s}]$ – fluid velocity
Q $[\frac{m^3}{s}]$ – flow rate
f [Hz] – electrical resistor firing frequency
N_e – number of pump events per unit fluid element over the resistor

Theoretical Flow Profile

$$\frac{\partial^2 V_x}{\partial y^2} + \frac{\partial^2 V_x}{\partial z^2} = -\frac{\Delta P}{\mu L}$$

$V_x(0,z)=0$
$V_x(a,z)=0$
$V_x(y,0)=0$
$V_x(y,b)=0$



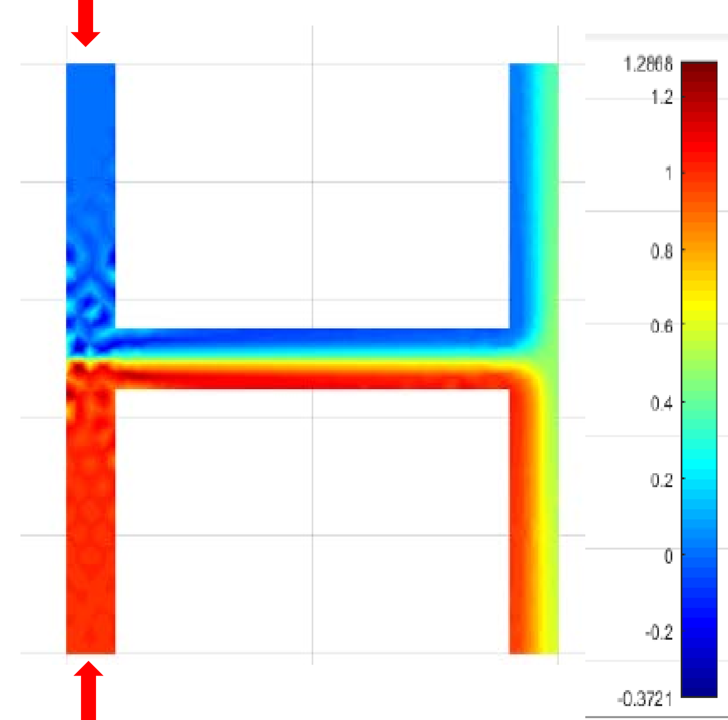
Convective-Diffusion

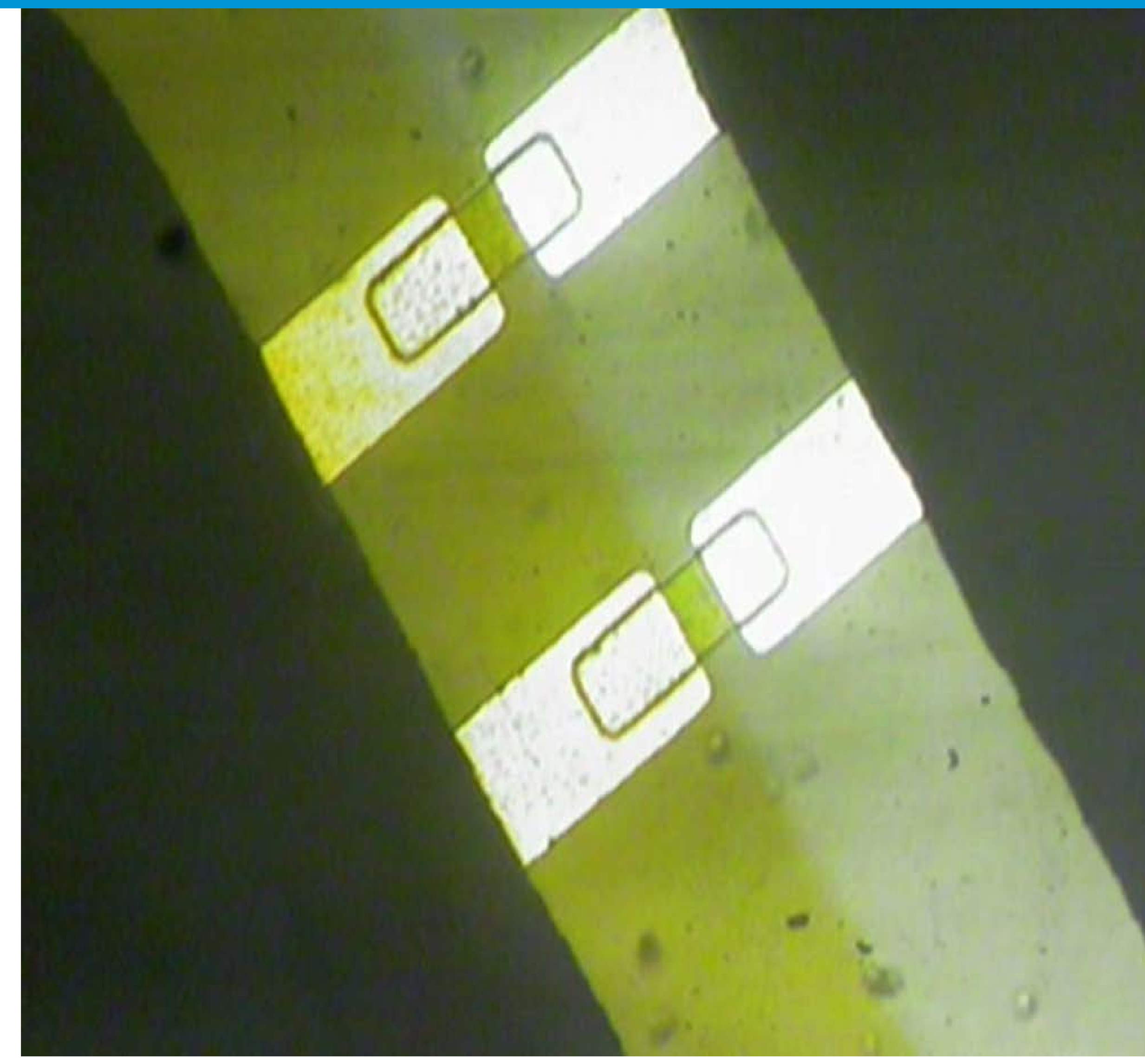
$$\rho\vec{v}\cdot\nabla\vec{v} = -\nabla p + \mu\nabla^2\vec{v}$$

$$\nabla\cdot\vec{v} = 0$$

$$\vec{v}\cdot\nabla c = D_{12}\nabla^2 c$$

$\vec{v}(walls) = 0$
$D_{12}\frac{\partial c}{\partial x}(walls) = 0$
$D_{12}\frac{\partial c}{\partial y}(walls) = 0$
$Q(inlet\ 1) = Q_1$
$Q(inlet\ 2) = Q_2$
$c(inlet\ 1) = C_o$
$c(inlet\ 2) = 0$

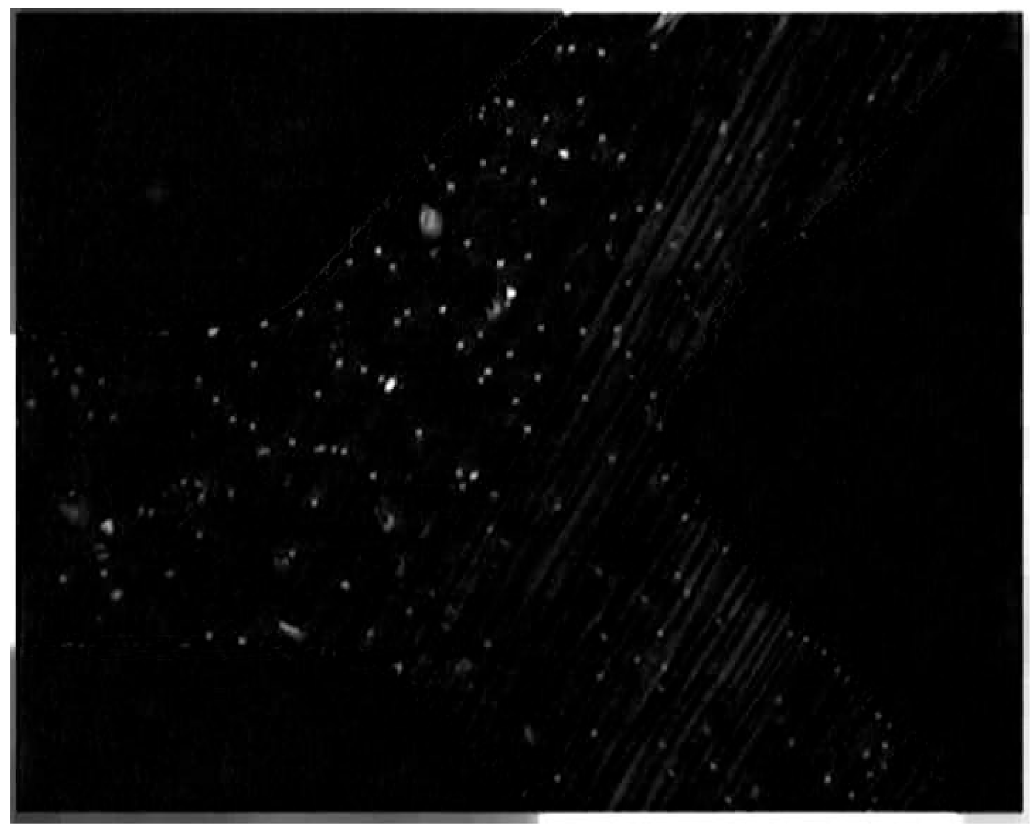




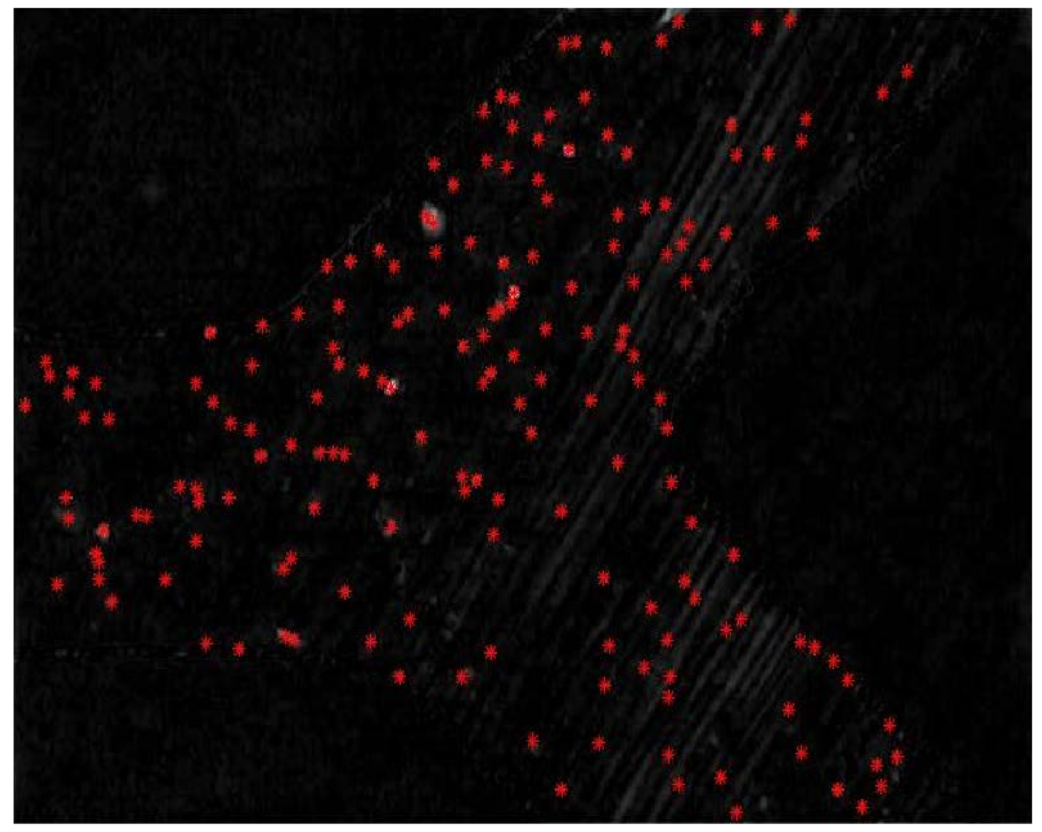
Particle Tracking

7 µm particles

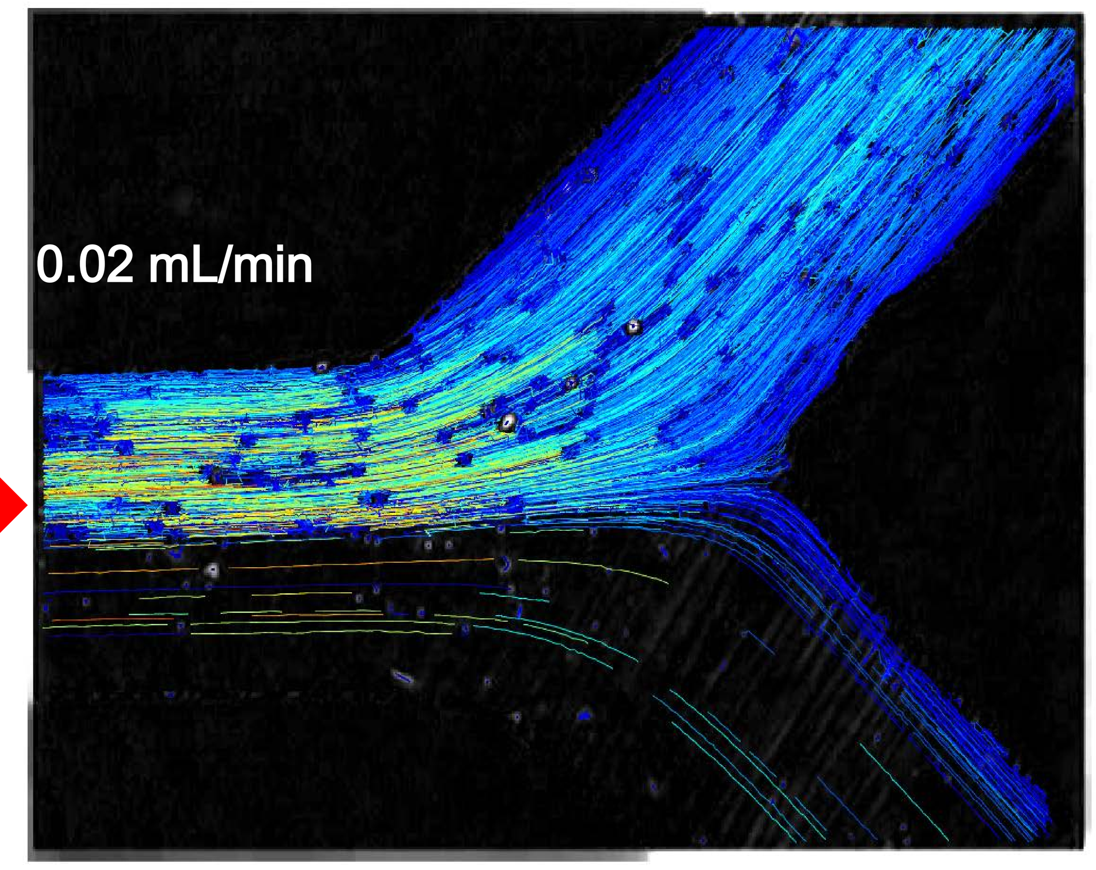
Image Processing →



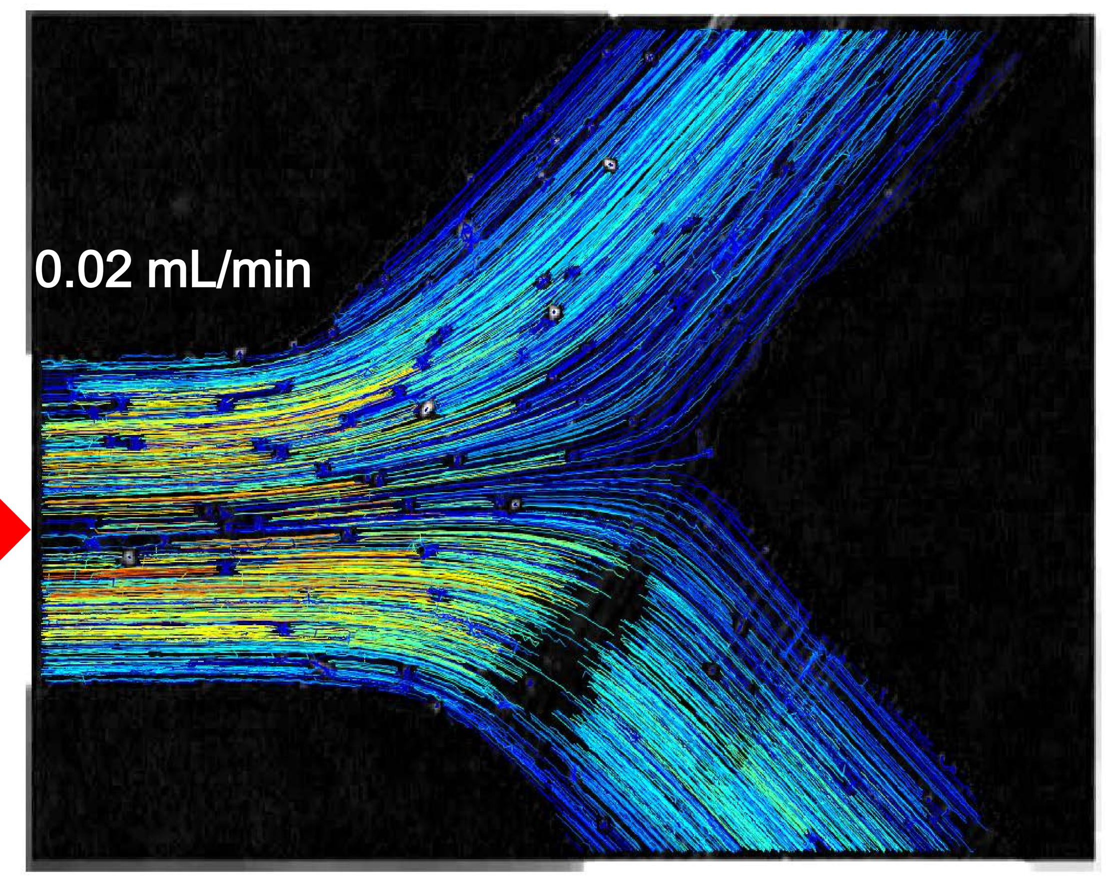
MATLAB Particle Tracking →



Pulsatory Mixing



No Resistor Firing



50 V, 10 µs, 50 Hz Firing

Abstract

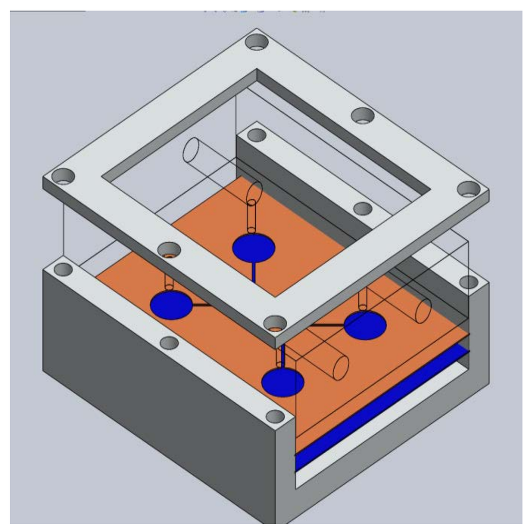
Objective: characterize the ability of inertial pumps to behave as an integrated micro-mixer

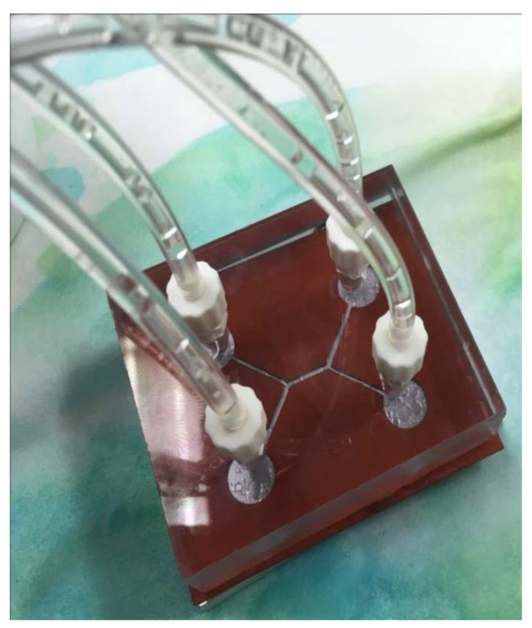
Outcome: characterization of inertial pumps behavior as a pulsatory micro-mixer, extension of RIT's microfluidic capabilities, publication with ASME YEP program

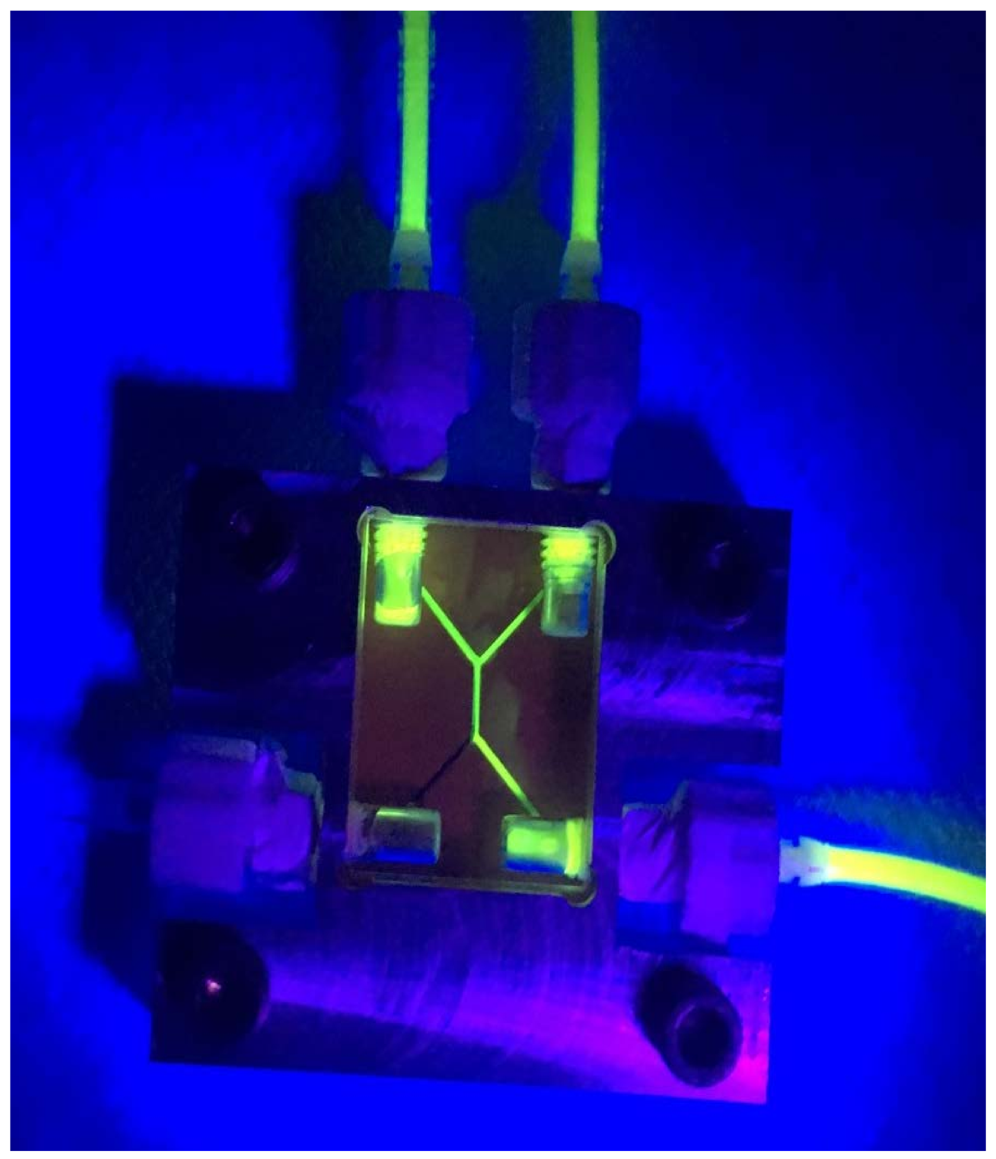
Acknowledgements:

- HP Support and Team
- SMFL Staff
- RIT Faculty Labs supporting this project

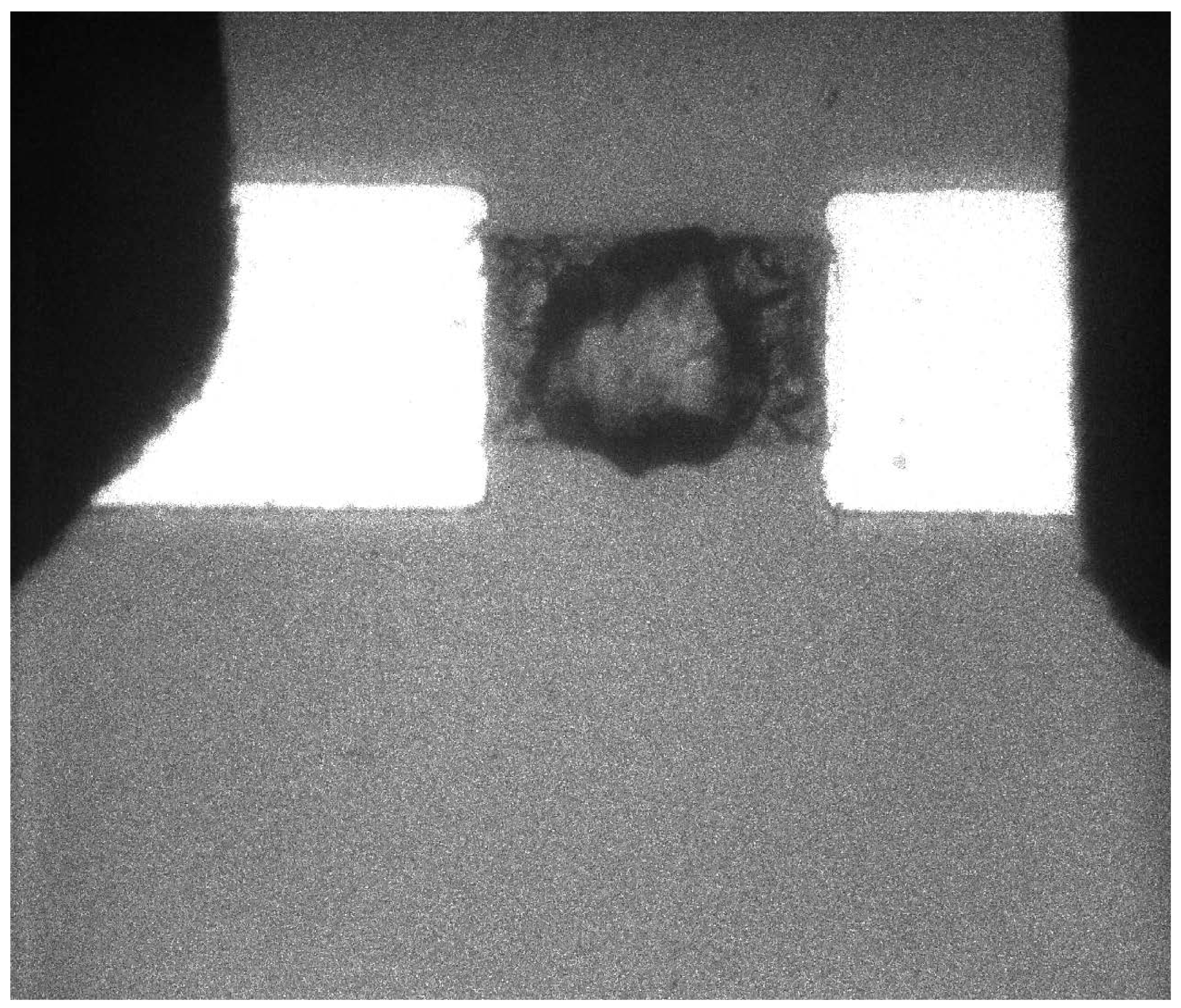
Setup and Fabrication







Drive Bubble Firing



65 V with pulse width of 10 µs

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