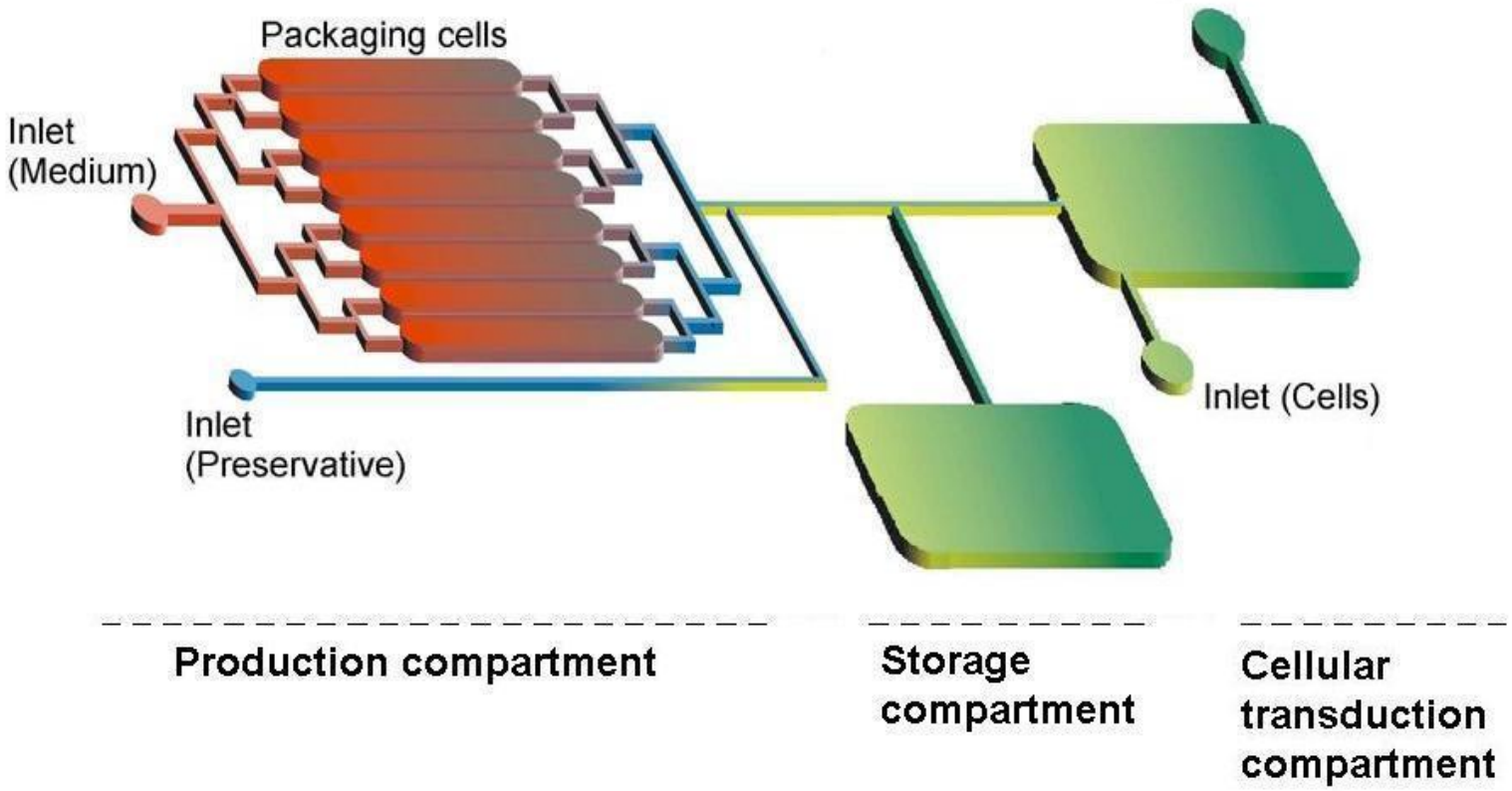
Presented at the COMSOL Conference 2010 Boston

Finite Element Modeling of the Stress Field in a Cell-Seeded Microchannel

Guang-Chong Zhu & Yawen Li
Lawrence Technological University
Southfield, MI

COMSOL Conference, October 2010, Boston, MA

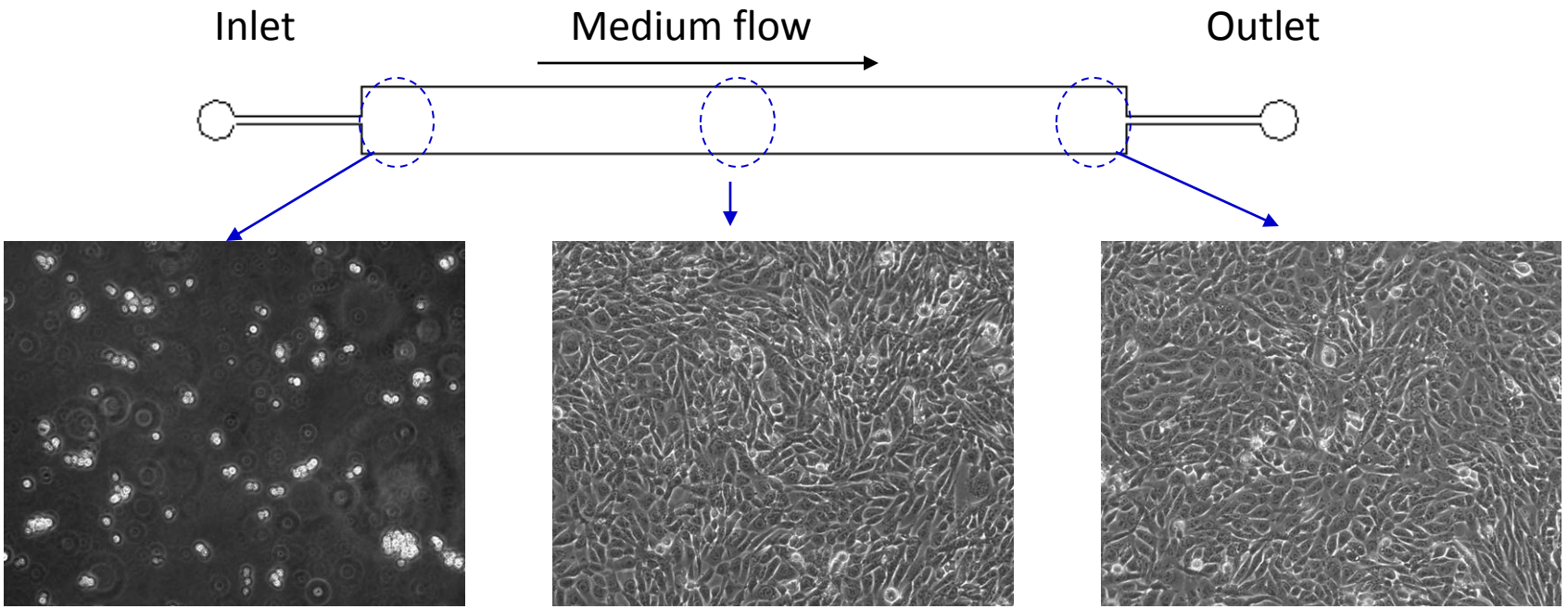
Microdevice for virus production and transduction



- Continuous removal and immediate cold storage
- *In situ* evaluation

Cell Viability

- Microchannel device, after 3 days' perfusion (1 μL/min)



Mathematical Model

Navier-Stokes equation:

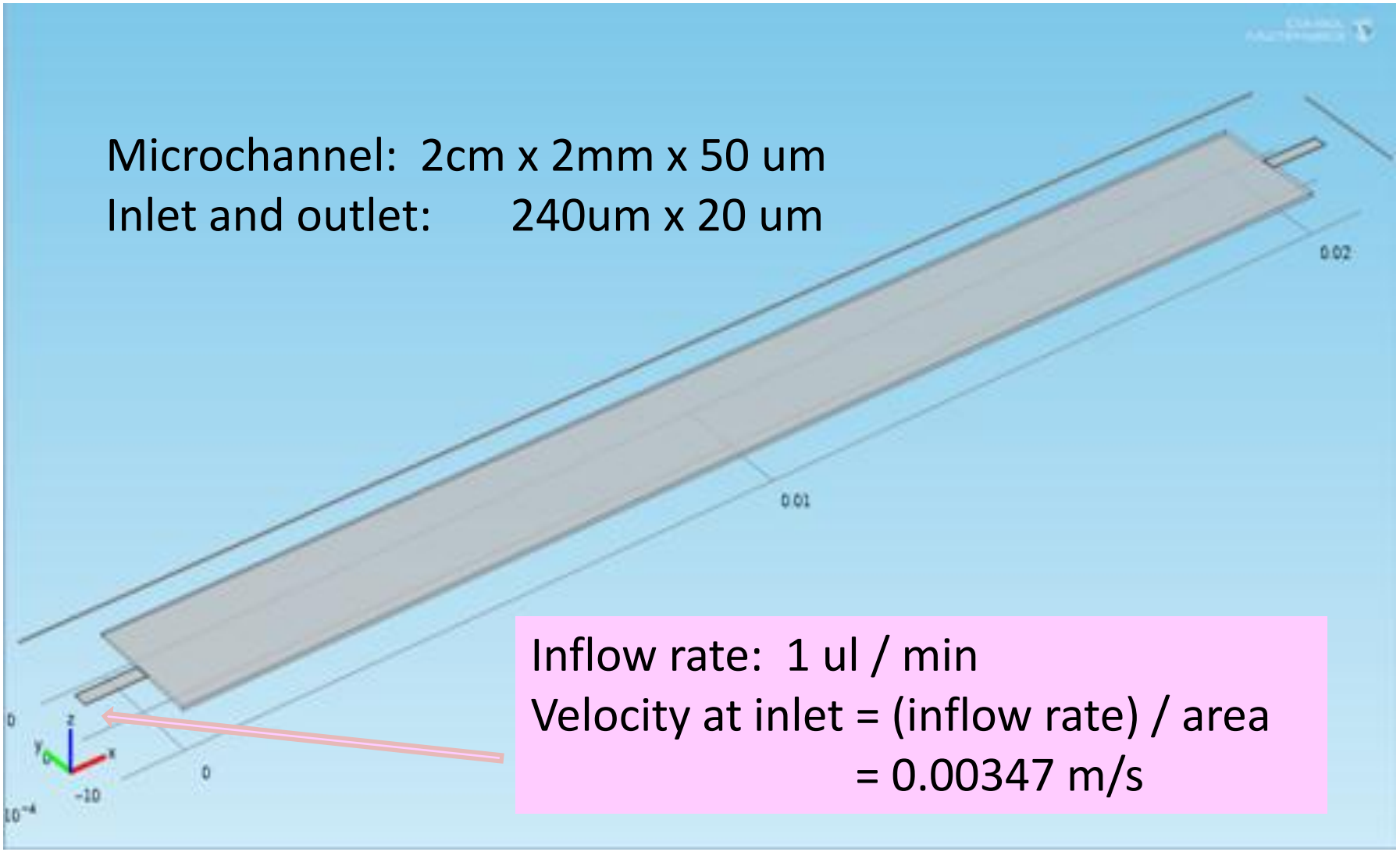
$$\rho\frac{\partial\vec{u}}{\partial t}-\nabla\cdot[-pI+\eta(\nabla\vec{u})+(\nabla\vec{u})^{T}]+\rho\vec{u}\cdot\nabla\vec{u}=\vec{F}$$

Incompressible condition: $\nabla\cdot\vec{u}=0$

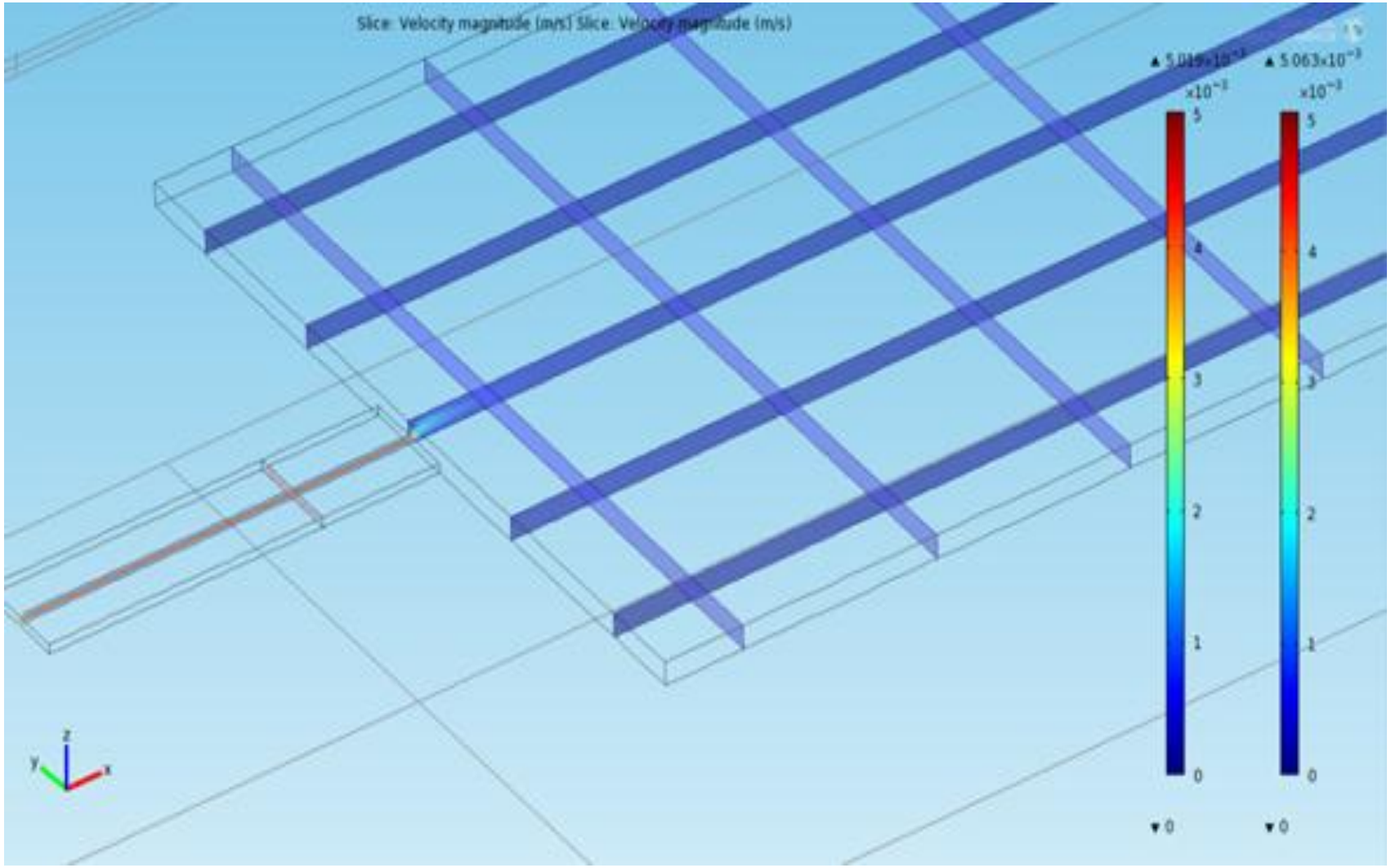
Viscous stress tensor:

$$\tau=\eta(\nabla\vec{u})+(\nabla\vec{u})^{T}$$

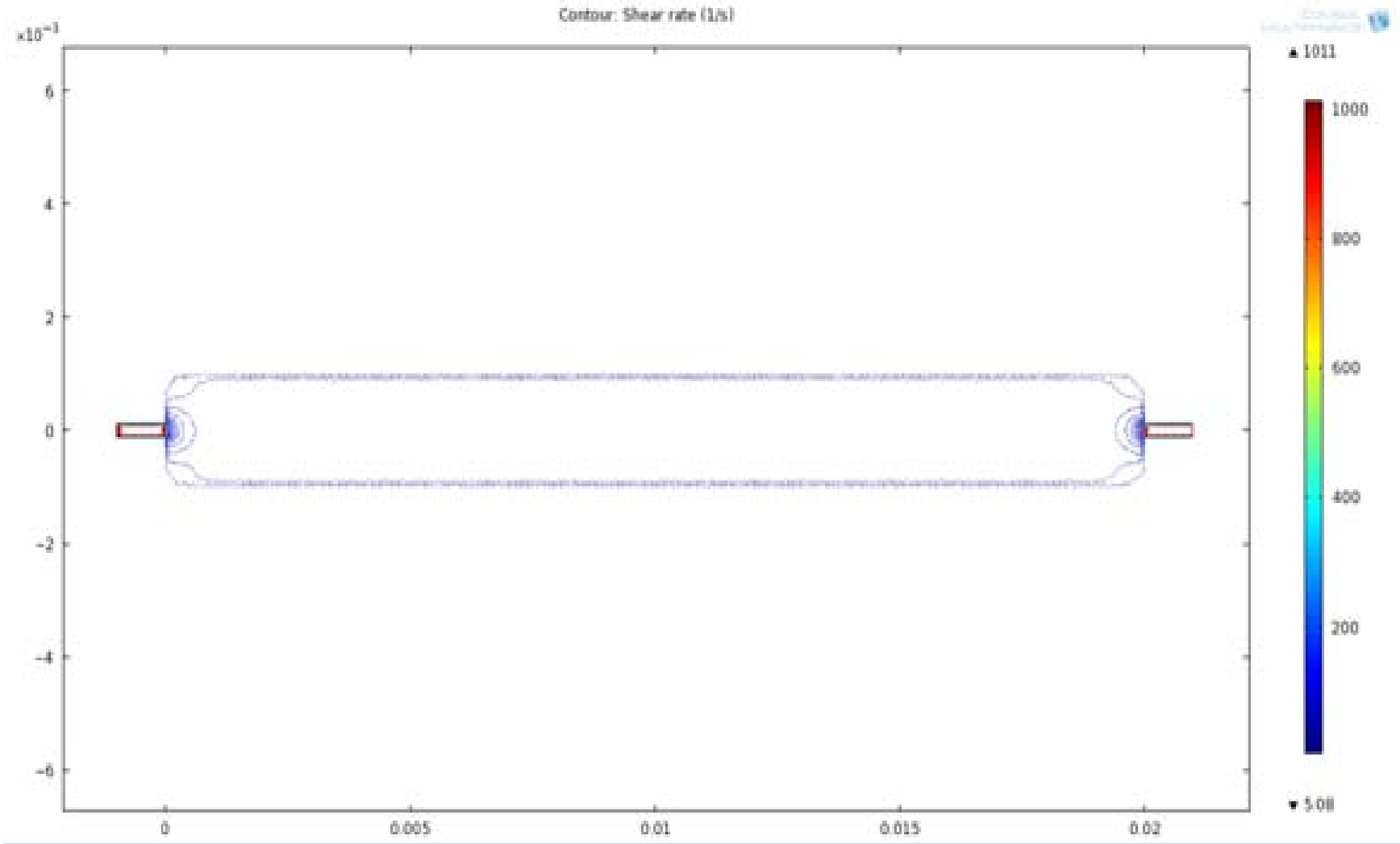
Geometry


Microchannel: 2cm x 2mm x 50 um
Inlet and outlet: 240um x 20 um
0.02
0.01
0
-10
Inflow rate: 1 ul / min
Velocity at inlet = (inflow rate) / area
= 0.00347 m/s

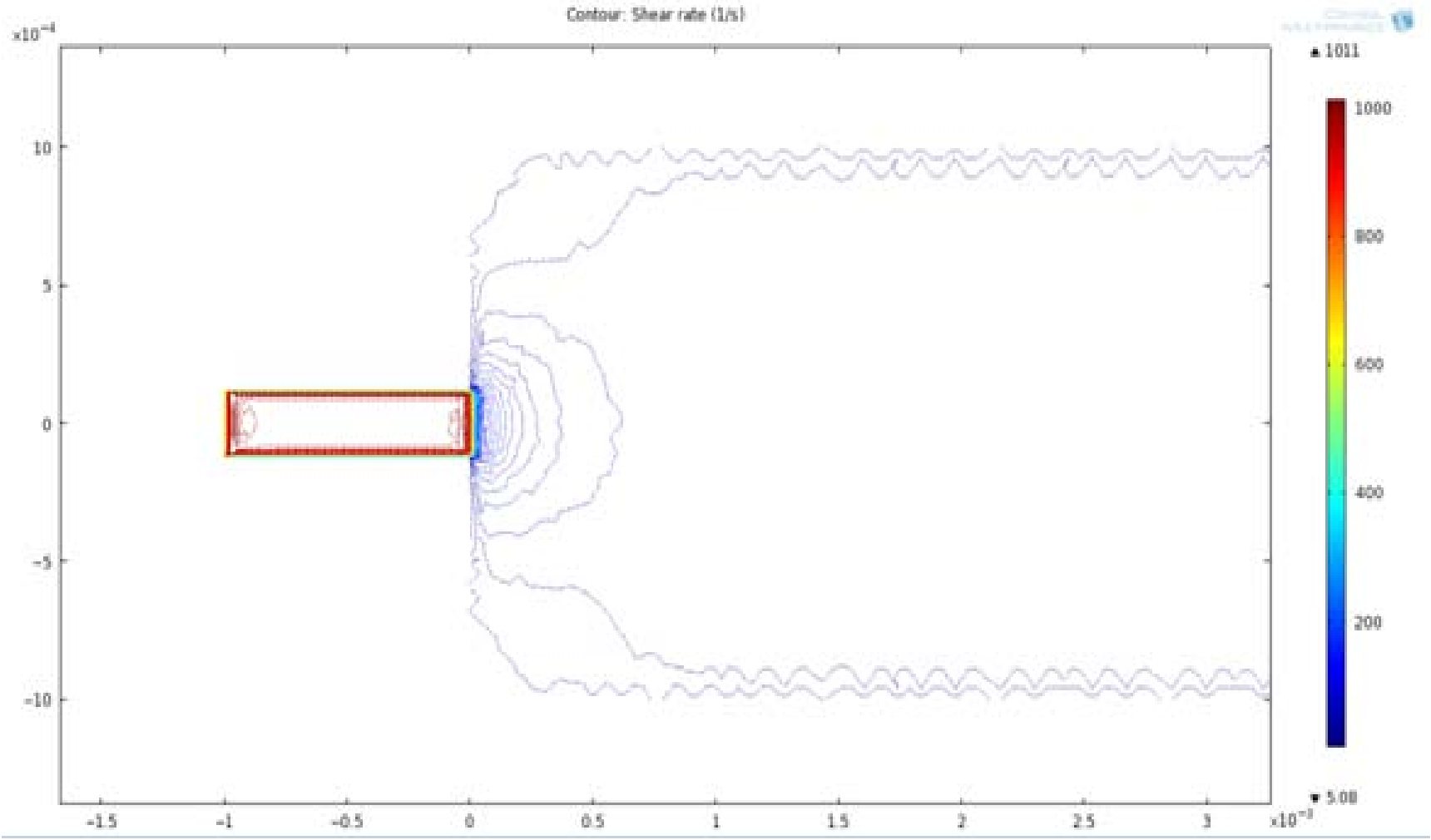
Velocity Field



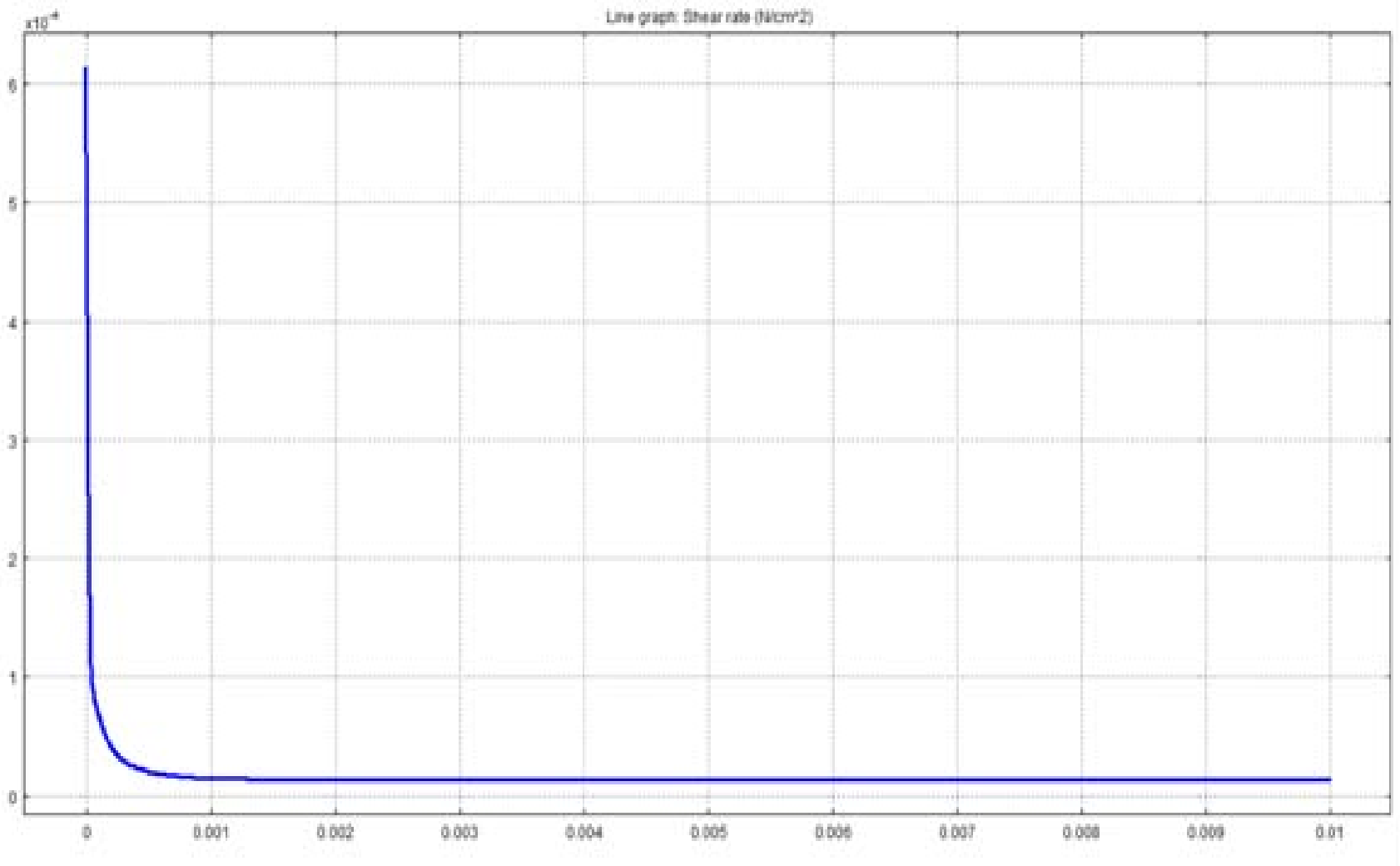
Shear Rate Contour Plot



Shear Rate Contour Plot



Shear Stress Distribution



Discussion

- Conjecture on cell viability purely due to shear stress is not supported by simulation results.

- Stress levels near both ends should be comparable, but obvious difference has been observed in the cell viability in these two regions.

- Other possible reasons?
  - Outlet condition
  - Contamination

Acknowledgements

- Lawrence Technological University
  - Dr. Hsiao-Ping Moore, Dean, College of Arts and Sciences
  - Dr. Nabil Grace, Dean, College of Engineering
  - Dr. David Bindschadler, Chair, Dept of Math and Computer Science
  - Seed Grant

- COMSOL Support
  - Dr. Lei Chen