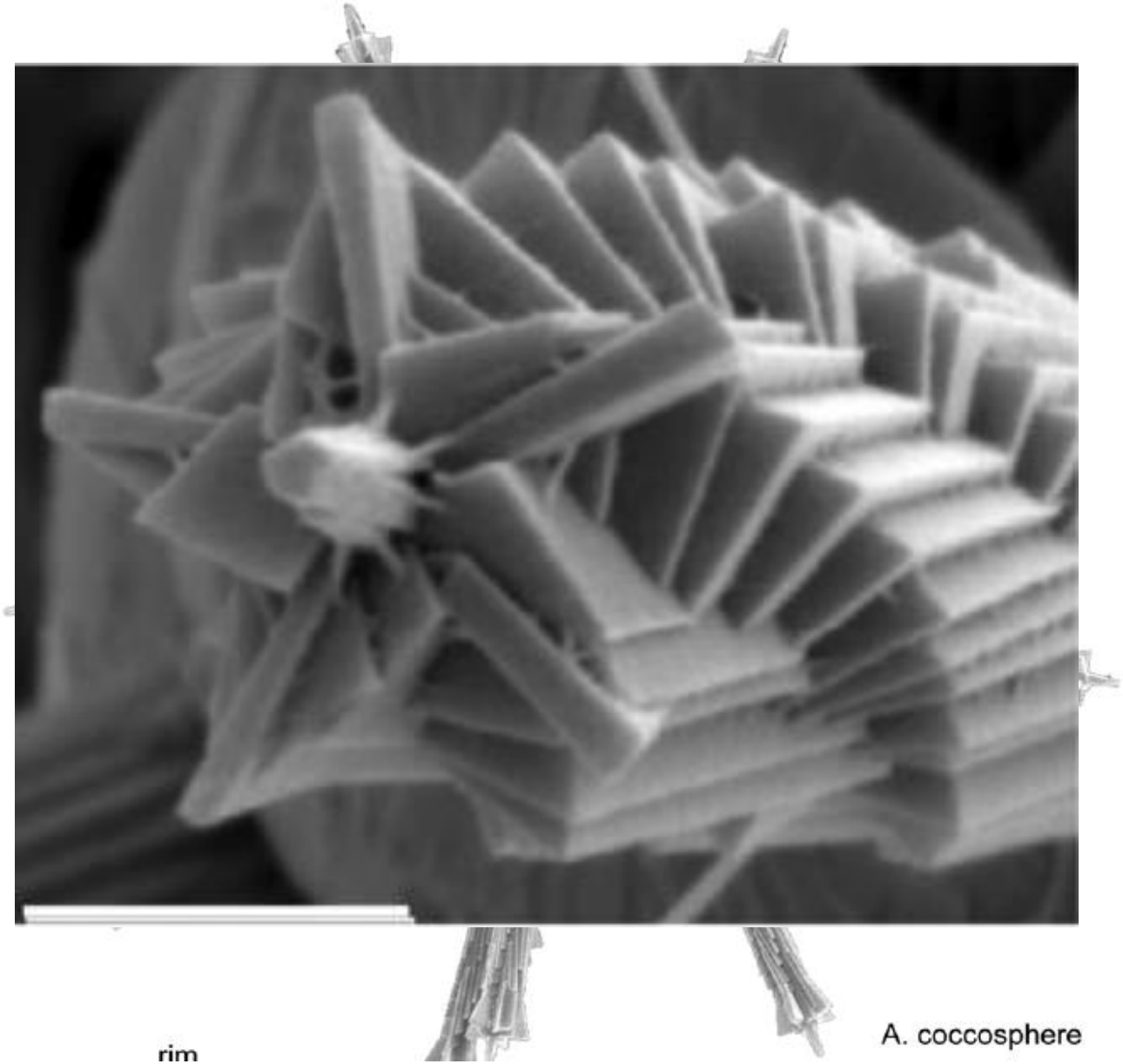
Stretchable Micropatterns and Microfluidic Systems

Stephen A. Morin
Department of Chemistry,
Nebraska Center for Materials and Nanoscience,
University of Nebraska – Lincoln

Brightlights Nanocamp,
June 15th 2015

UNIVERSITY OF Nebraska Lincoln

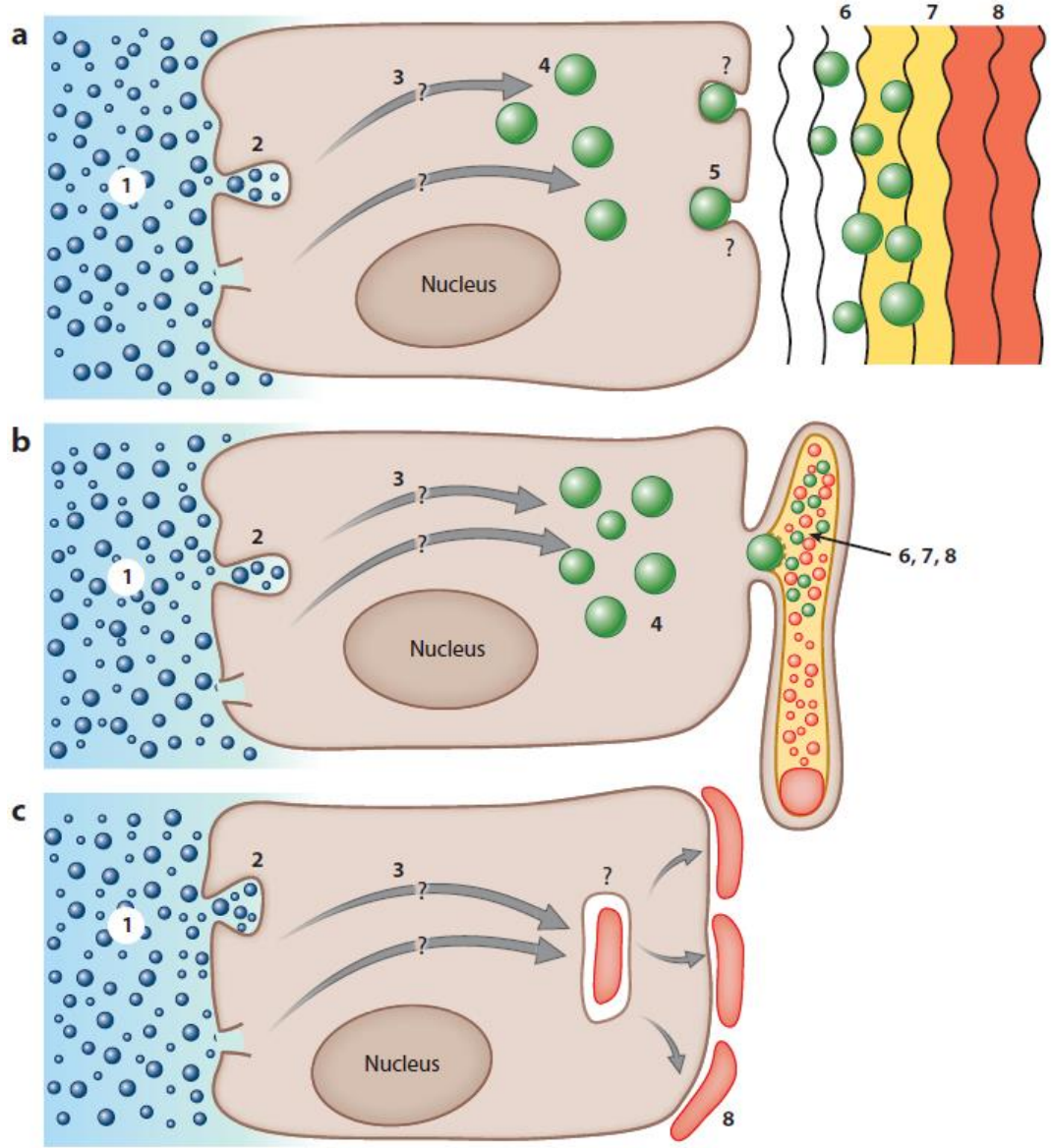
Inspiration



Biomineralization

- Controlled Nucleation
- Manipulation (transport)
- Deposition in three dimensions
- Cellular machinery

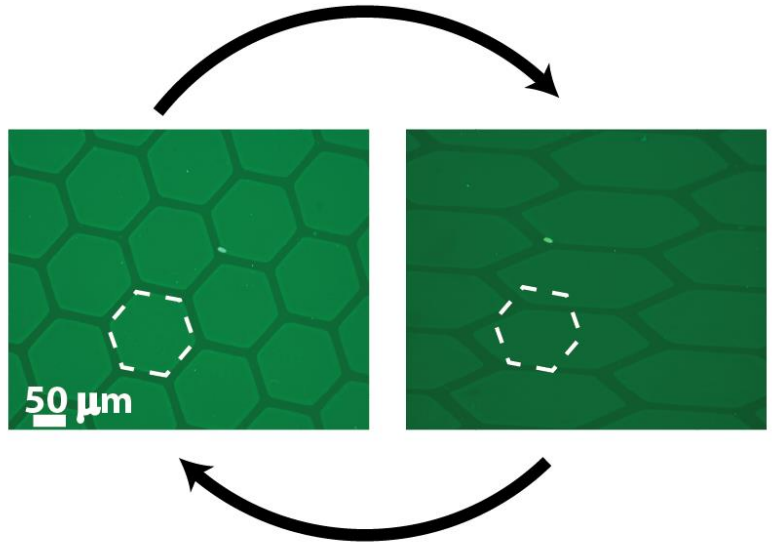
Dynamic, Adaptive, <u>Complex</u>



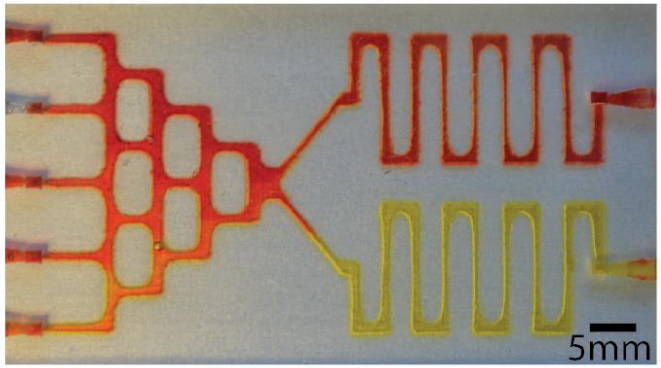
Weiner and Addadi *Annu. Rev. Mater. Res.* **2011** *41*, 21.

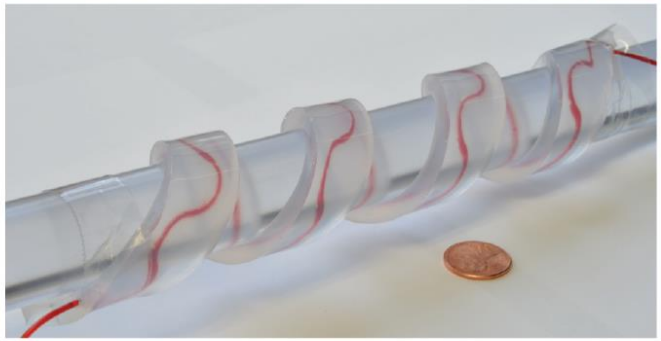
Research Thrusts

Active Surfaces from Soft, Mechano-Responsive Materials

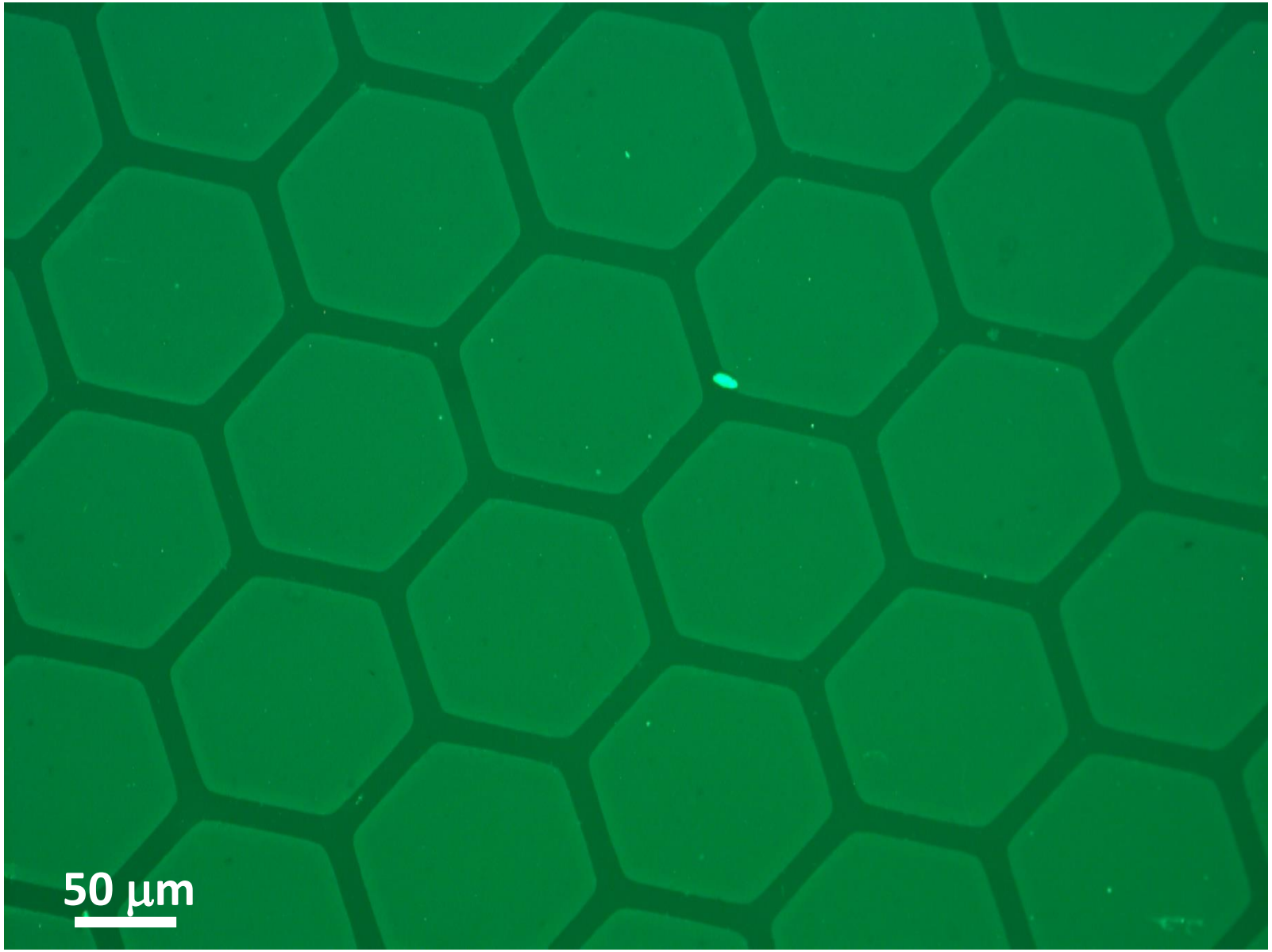


Soft Reactors and Strechable Microfluidics





“Stretchable” Chemical Pattern



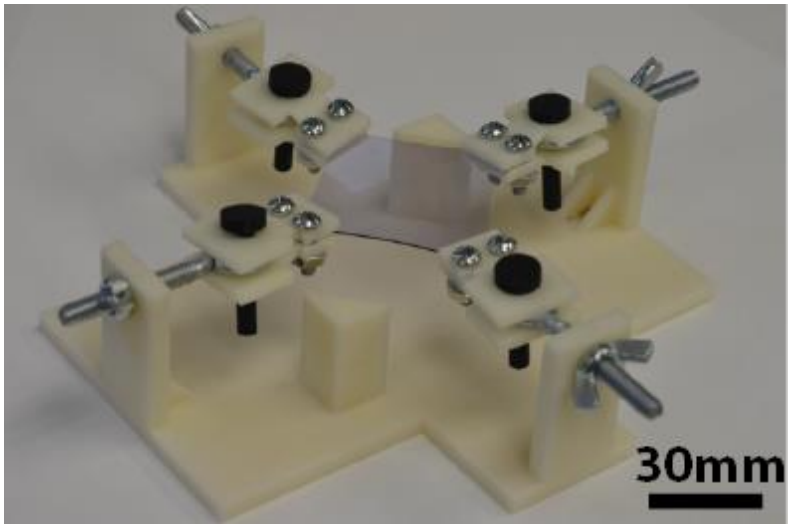
Bowen, J.J.; Taylor, J.; Morin, S.A.* *Submitted.*

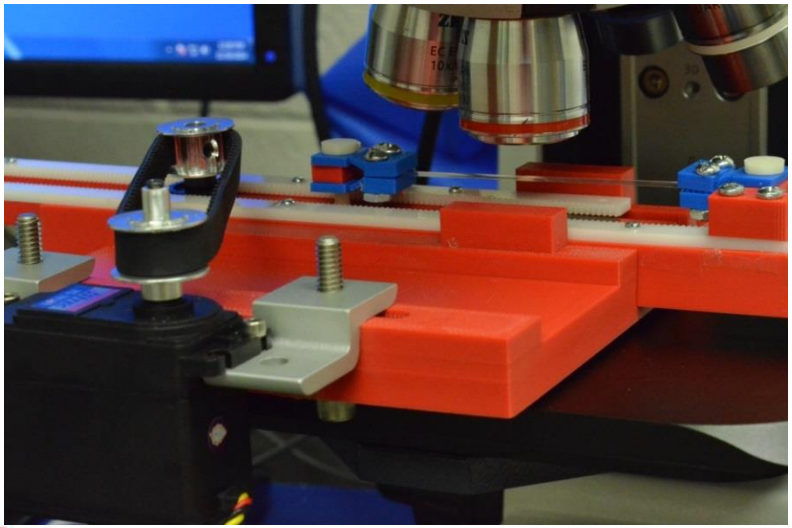
Controlled Deformations

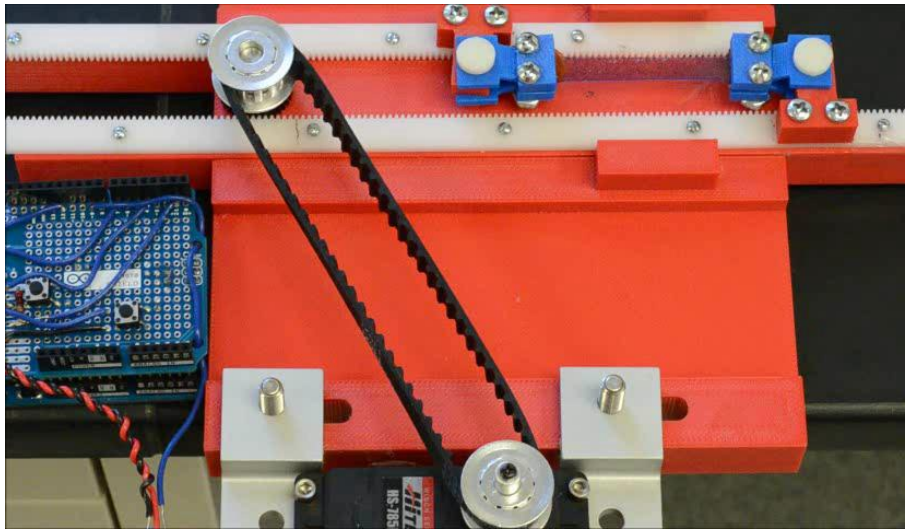
- Strain (σ):

$$\sigma = \frac{\Delta L + L}{L}$$

- Uniaxial and biaxial strain (on order of 1.5 to 2) investigated.
- Manual devices.
- Electromechanical devices.





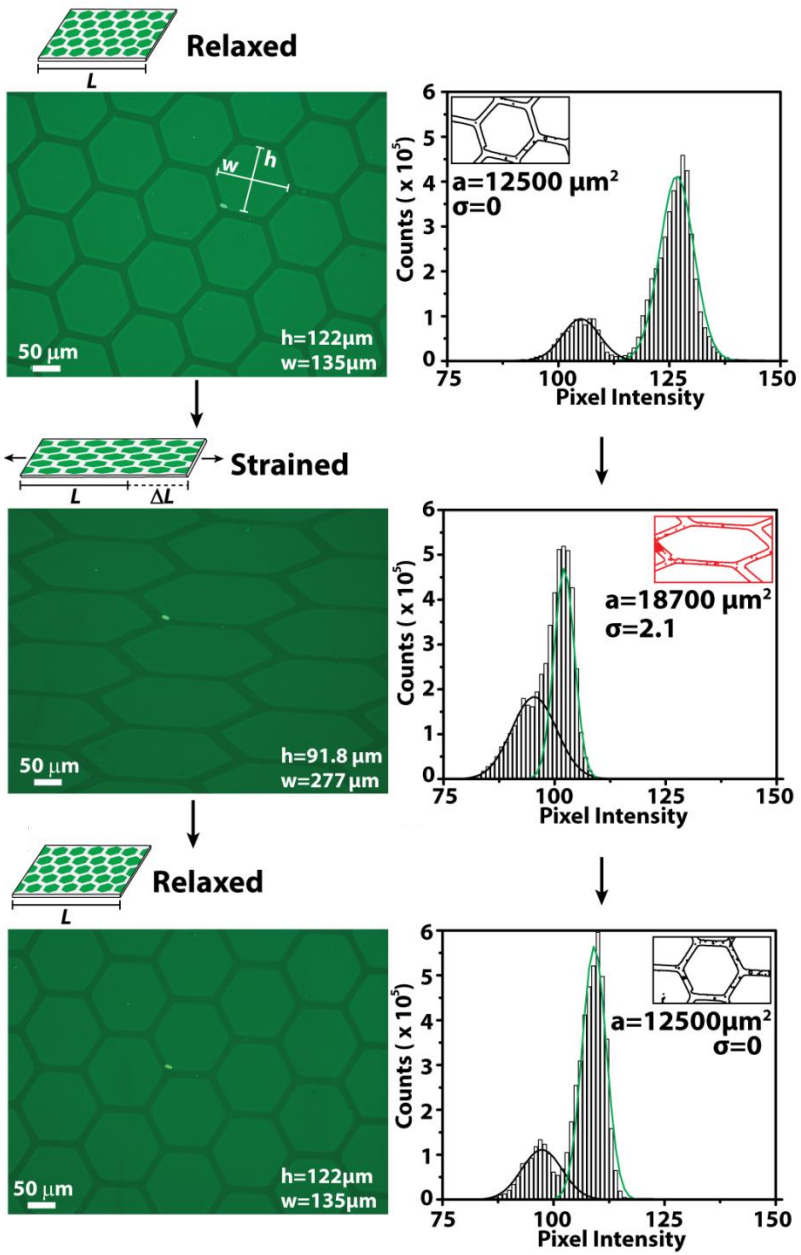


(1.5X playback)

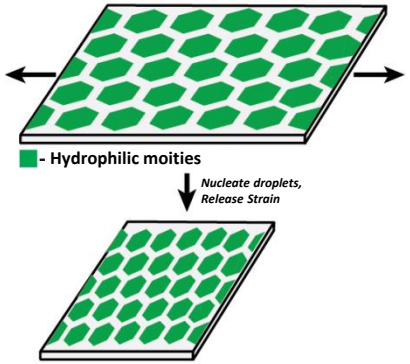
Uniaxial Deformation: *Decreased Molecular Density*

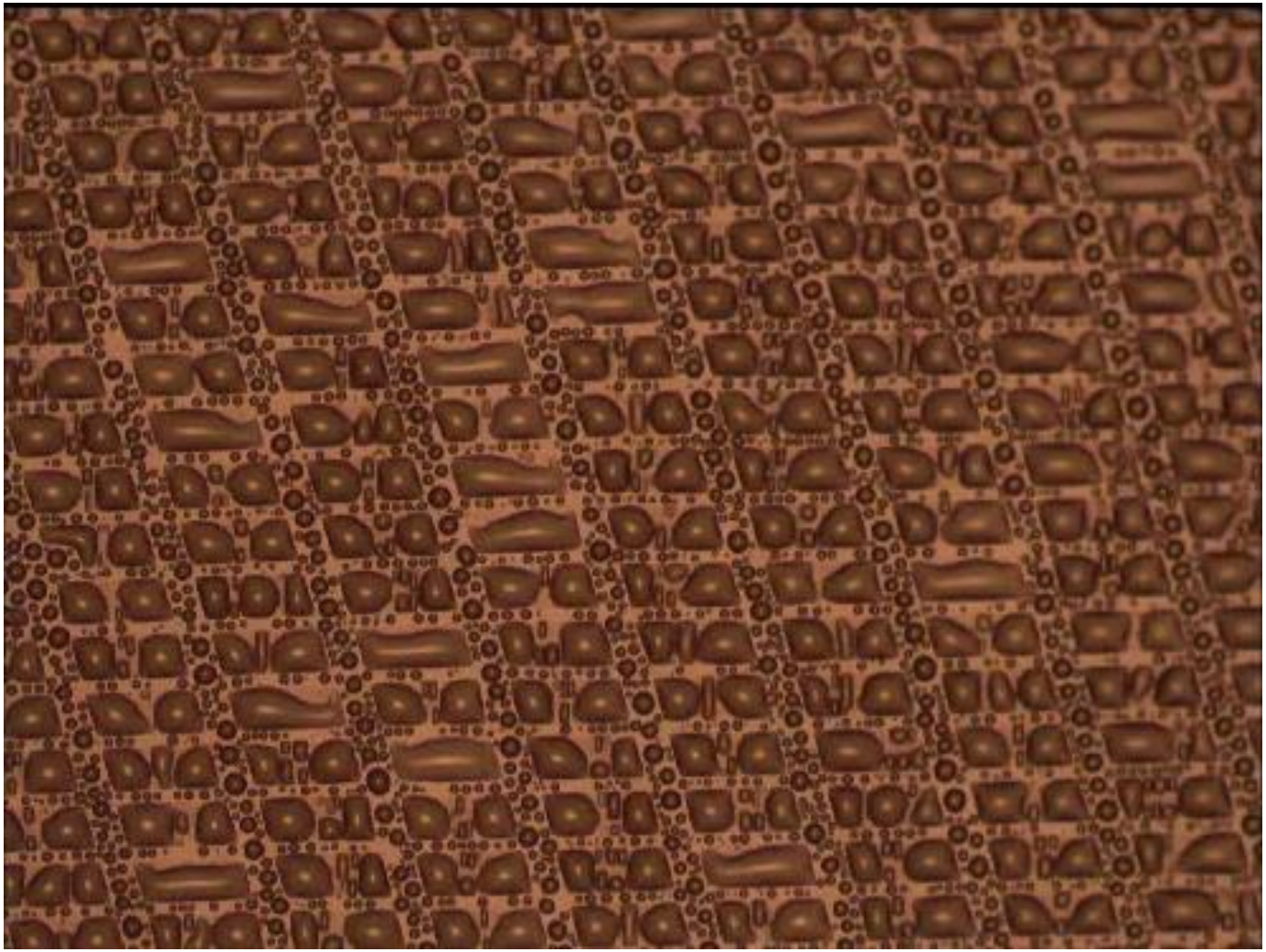
- Change in area: 6,200 μm^2 (49%)
- Decrease in fluorescence intensity enables estimate of change in molecular density of: 16%
- Complete recovery of original intensity not achieved due to photo-bleaching of the fluorophore.

- Key: Capability enabled by Poison's ration (~0.5).



Manipulation of Droplets

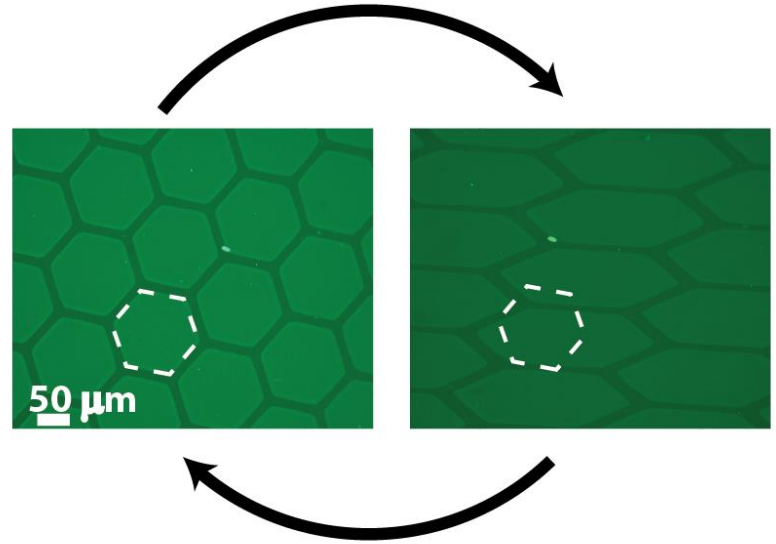




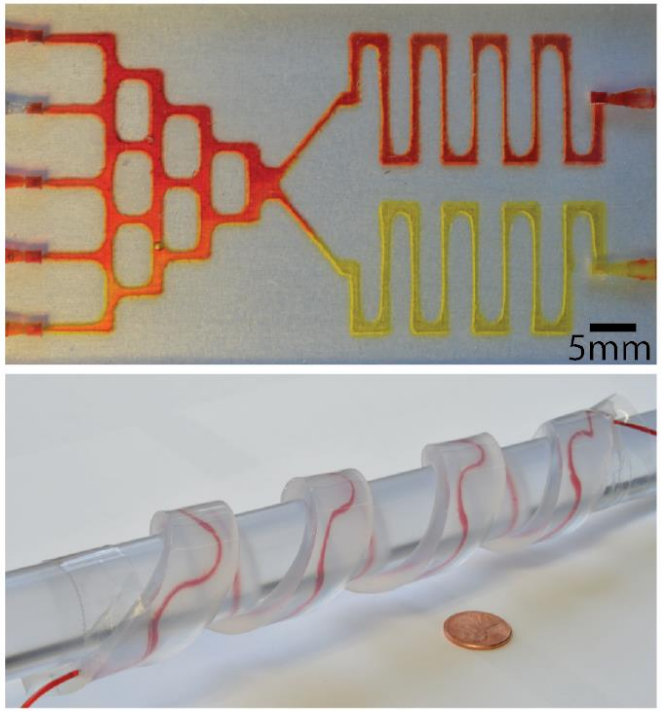
- Strained hydrophilic pattern used to heterogeonously nucleate droplets.
- Relaxation of elastomer organizes droplets.
- Geometry can then be manipulated.

Research Thrusts

Active Surfaces from Soft, Mechano-Responsive Materials



Soft Reactors and Strechable Microfluidics



3D Printing: A Makers Revolution

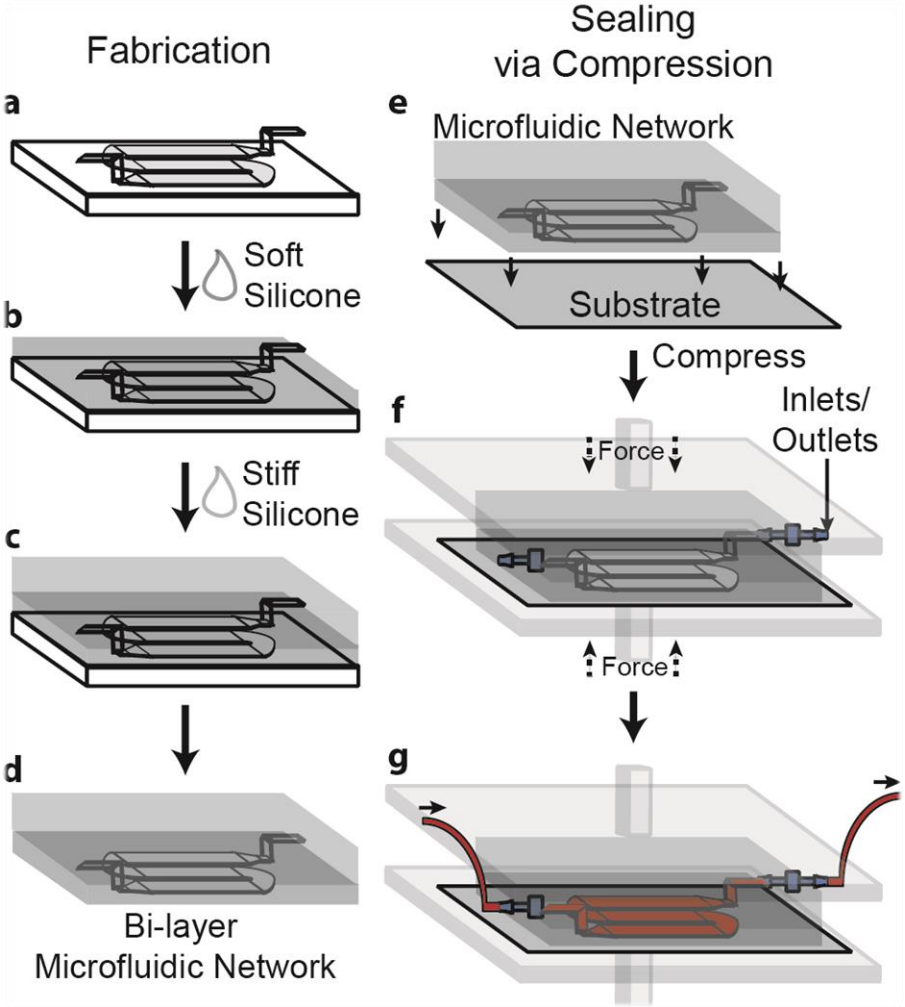
https://www.youtube.com/watch?v=33YdIe5JABA

Approach - Solid Object Printing & Soft Lithography

- **Master: 3D Printer**
  - Acrylonitrile butadiene styrene (ABS) master
  - Flexibility in the fabrication of complex (three-dimensional) designs

** **Thickness of the layer depends on the surface it has to seal against**

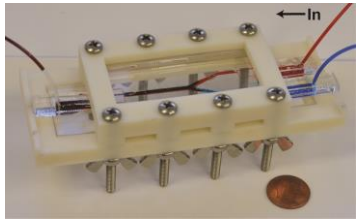
- **Compression based reversible sealing**
  - Seal against arbitrary substrates
  - Independent of the channel design
  - Reversible sealing technique



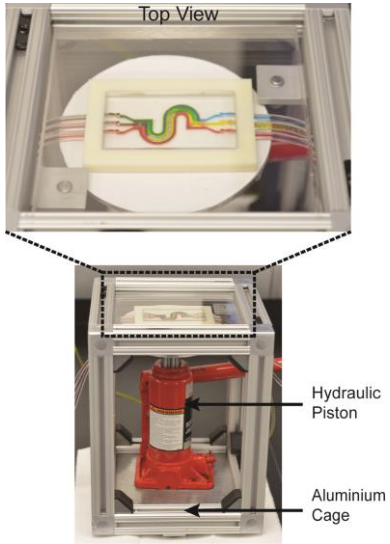
A. Konda, J. M. Taylor, M. A. Stoller, and S. A. Morin *Lab Chip* **2015**, *15*, 2009.

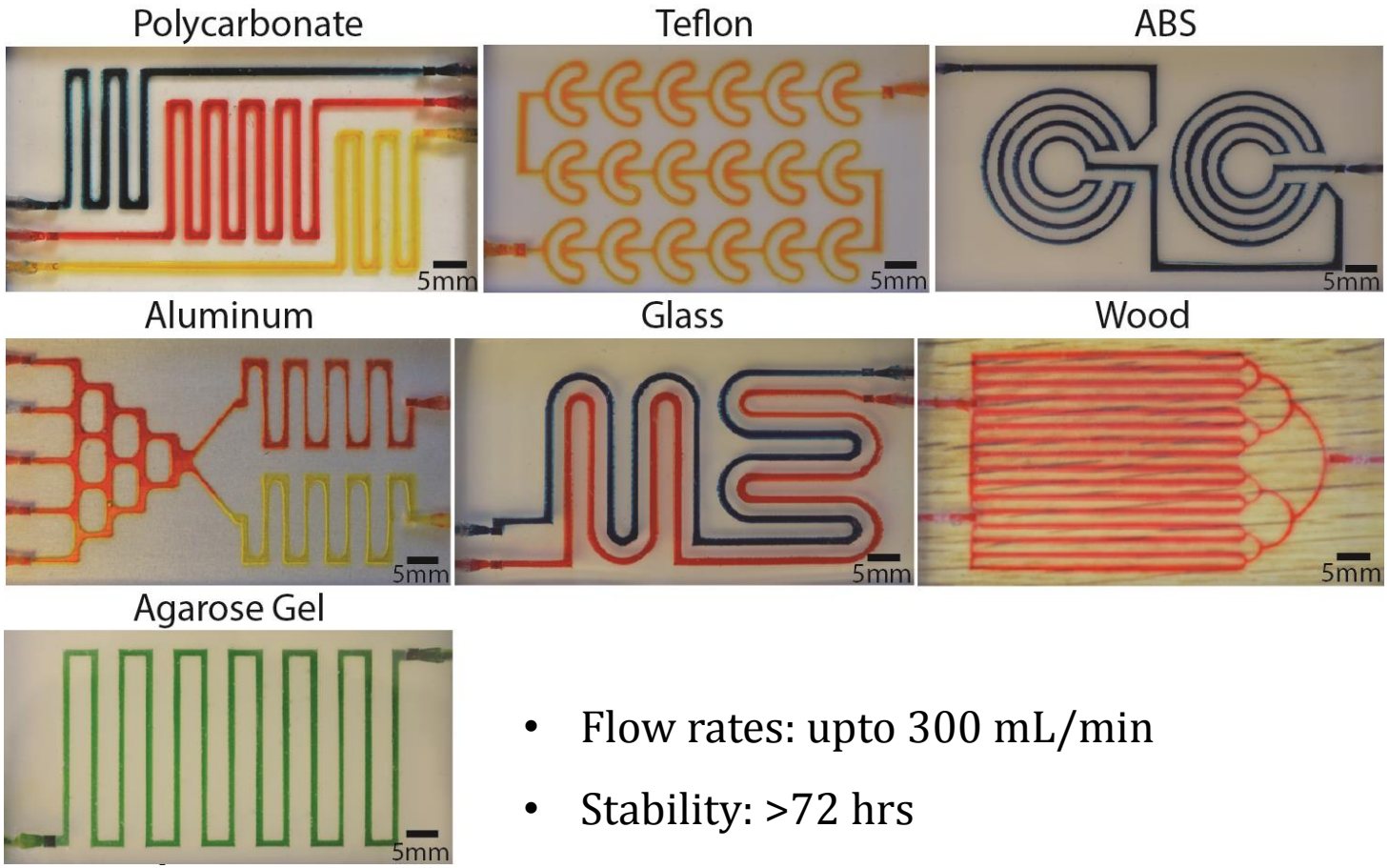
Sealing via Compression

Manual



Semi-automatic

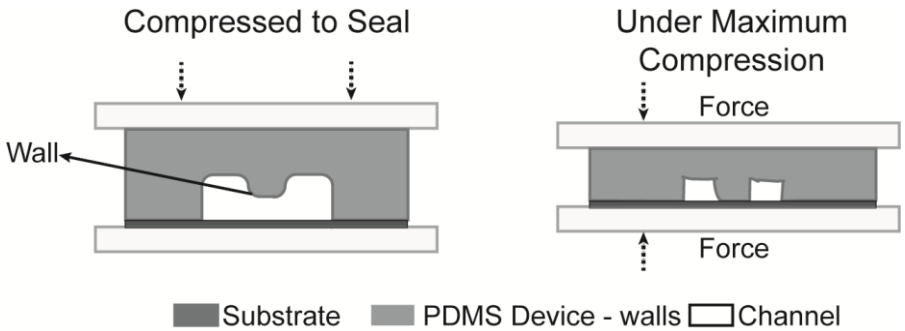


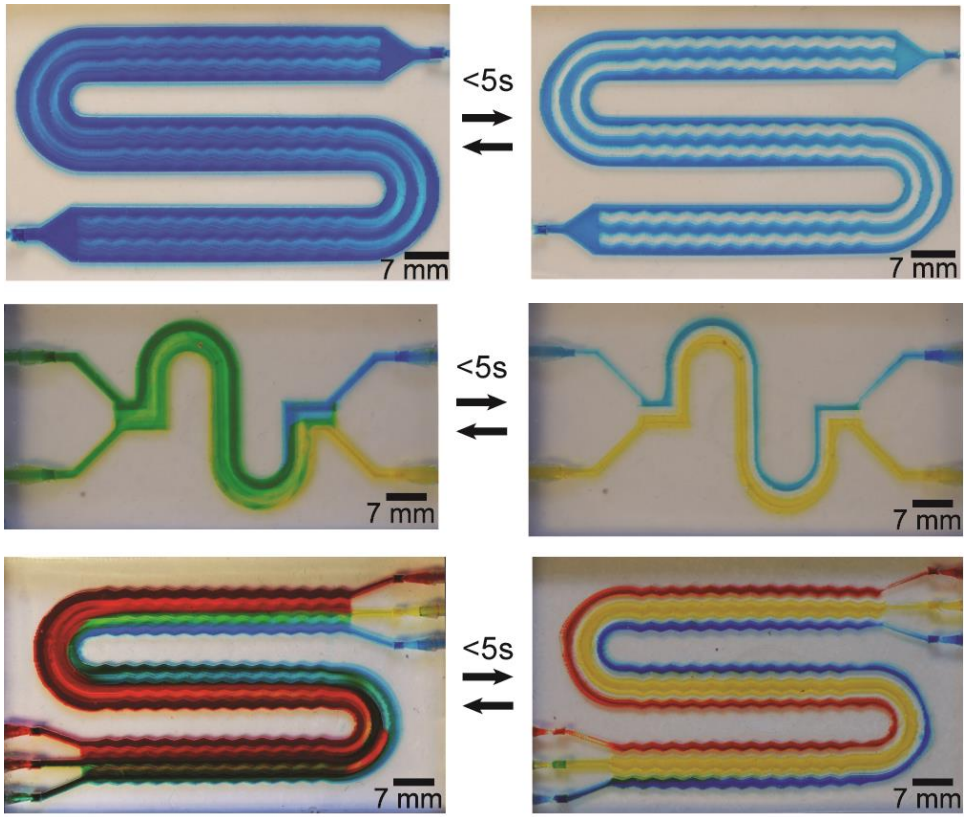


- Flow rates: upto 300 mL/min
- Stability: >72 hrs
- Temperature: 100 ^{o}C

A. Konda, J. M. Taylor, M. A. Stoller, and S. A. Morin *Lab Chip* **2015**, *15*, 2009.

Reconfigurable Fluid Pathways





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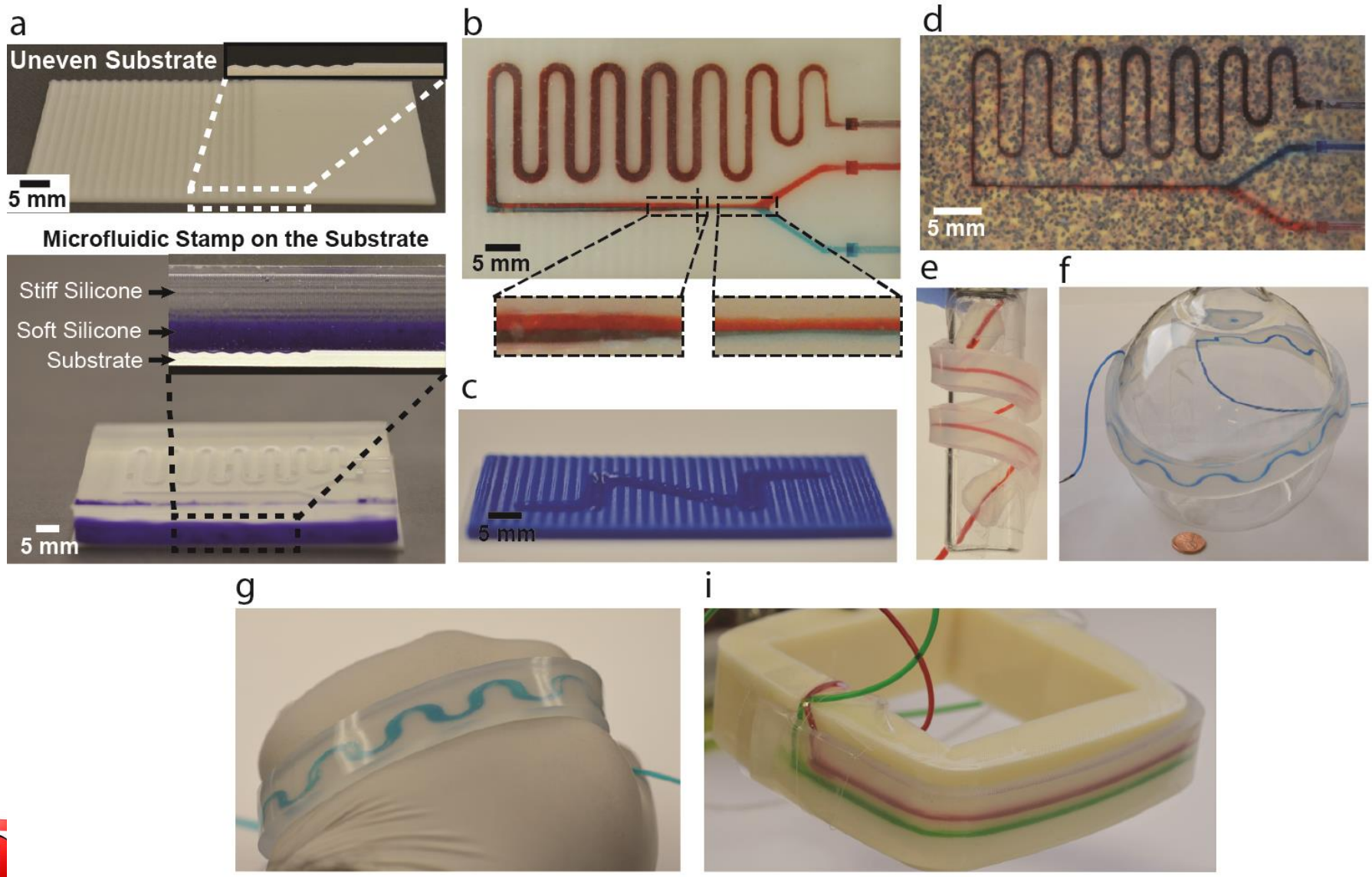
Sealing on Rough/Uneven Substrates & 3D Objects

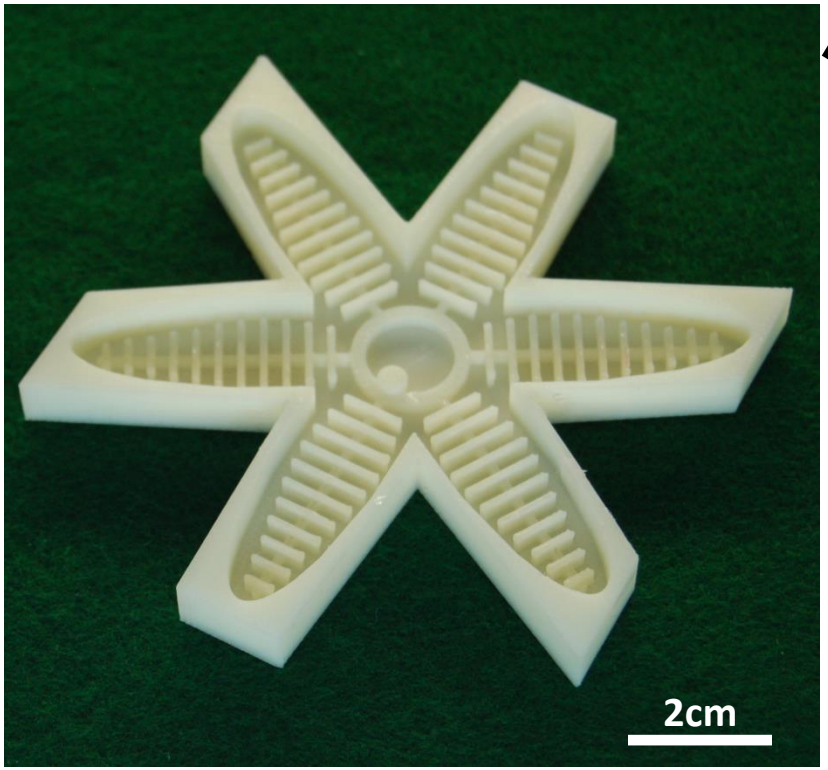


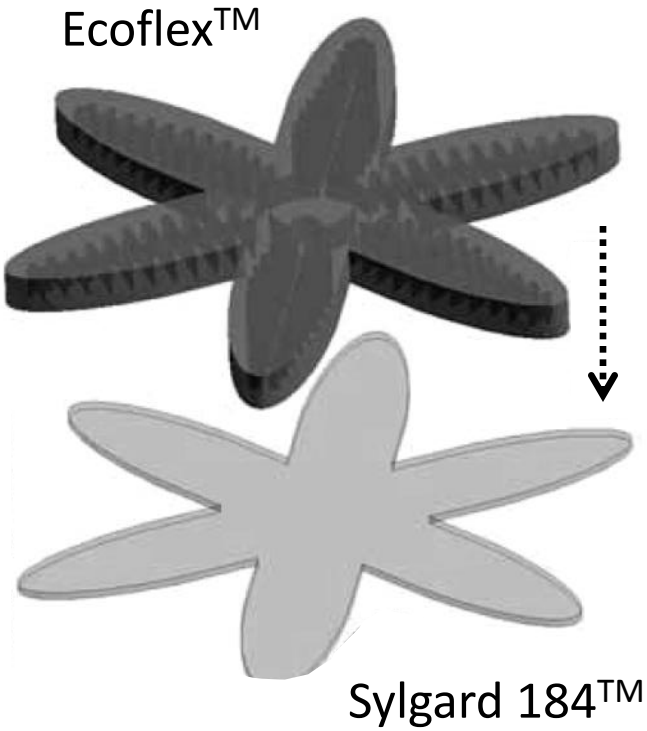
A. Konda, J. M. Taylor, M. A. Stoller, and S. A. Morin *Lab Chip* **2015**, *15*, 2009.

Other applications of Microfluidics

Soft machine "gripper"

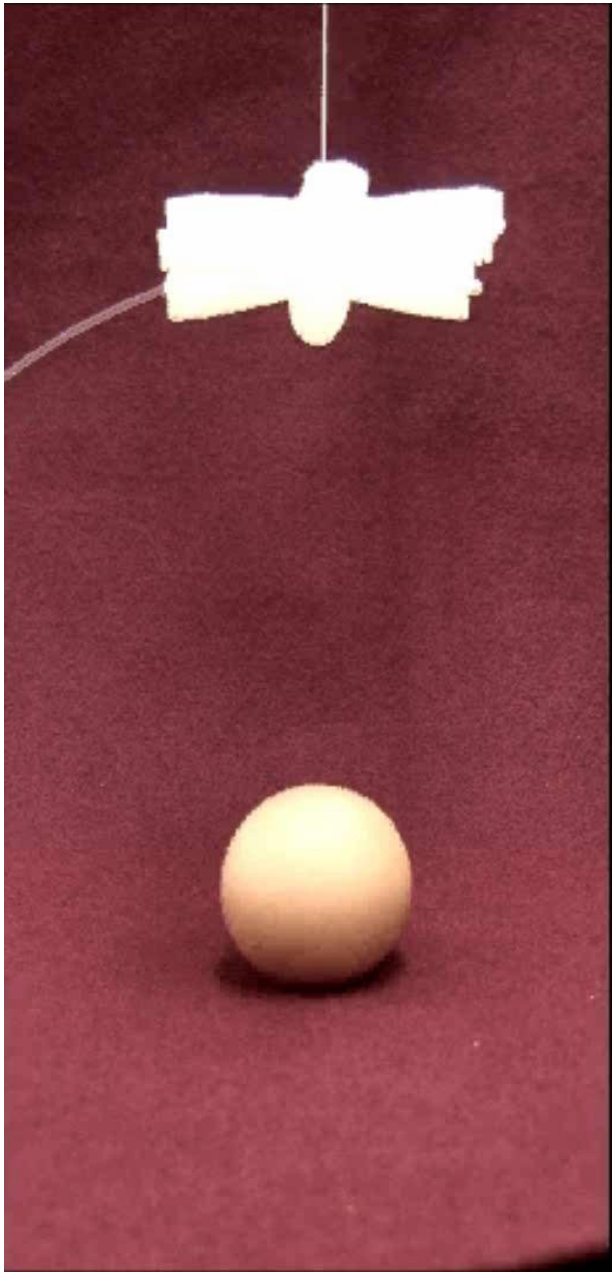
3D Printed Mold





F. Ilievski et al. *Angew. Chem. Int. Ed.* **2011**, *50*, 1890.

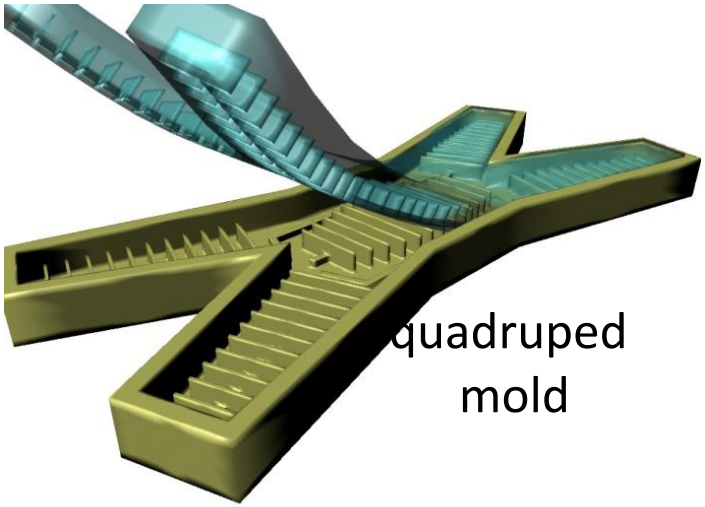
Soft machine "gripper"

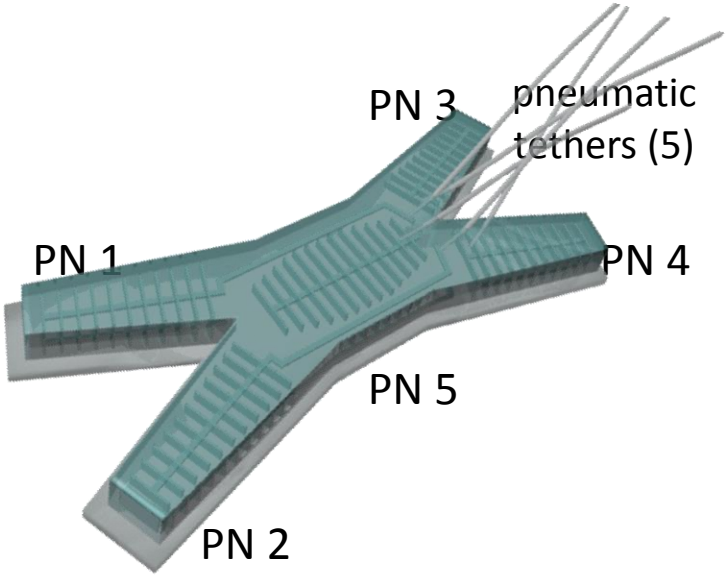


F. Ilievski et al. *Angew. Chem. Int. Ed.* **2011**, *50*, 1890.

Soft machine "walkers"

- Soft lithography is used to construct systems of pneu-nets.





Undulation – 13 ± 0.6 m/s

Crawling – 24 ± 3 m/s

Shepherd, R.F. *et al*. *P. Natl. Acad. Sci. USA* **2011**, *108*, 20400-20403.

Soft machine "walkers"

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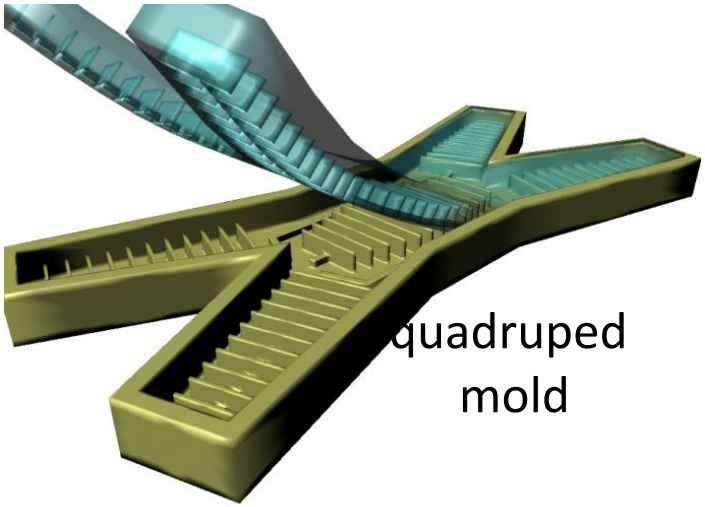
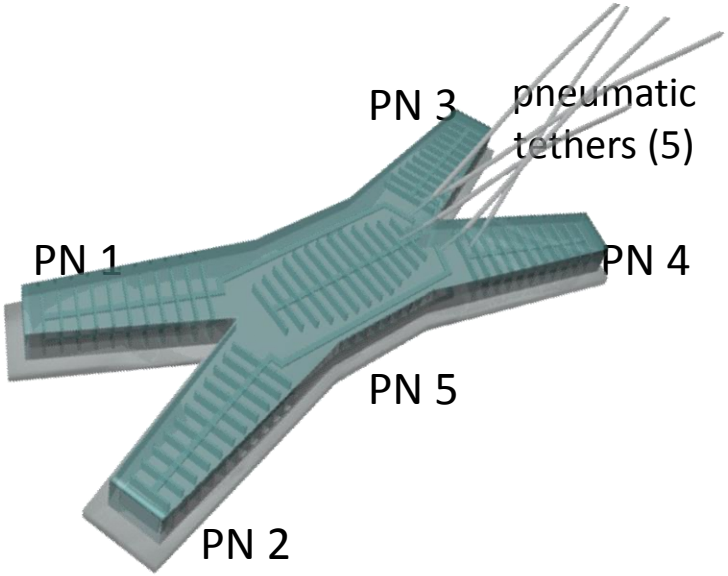
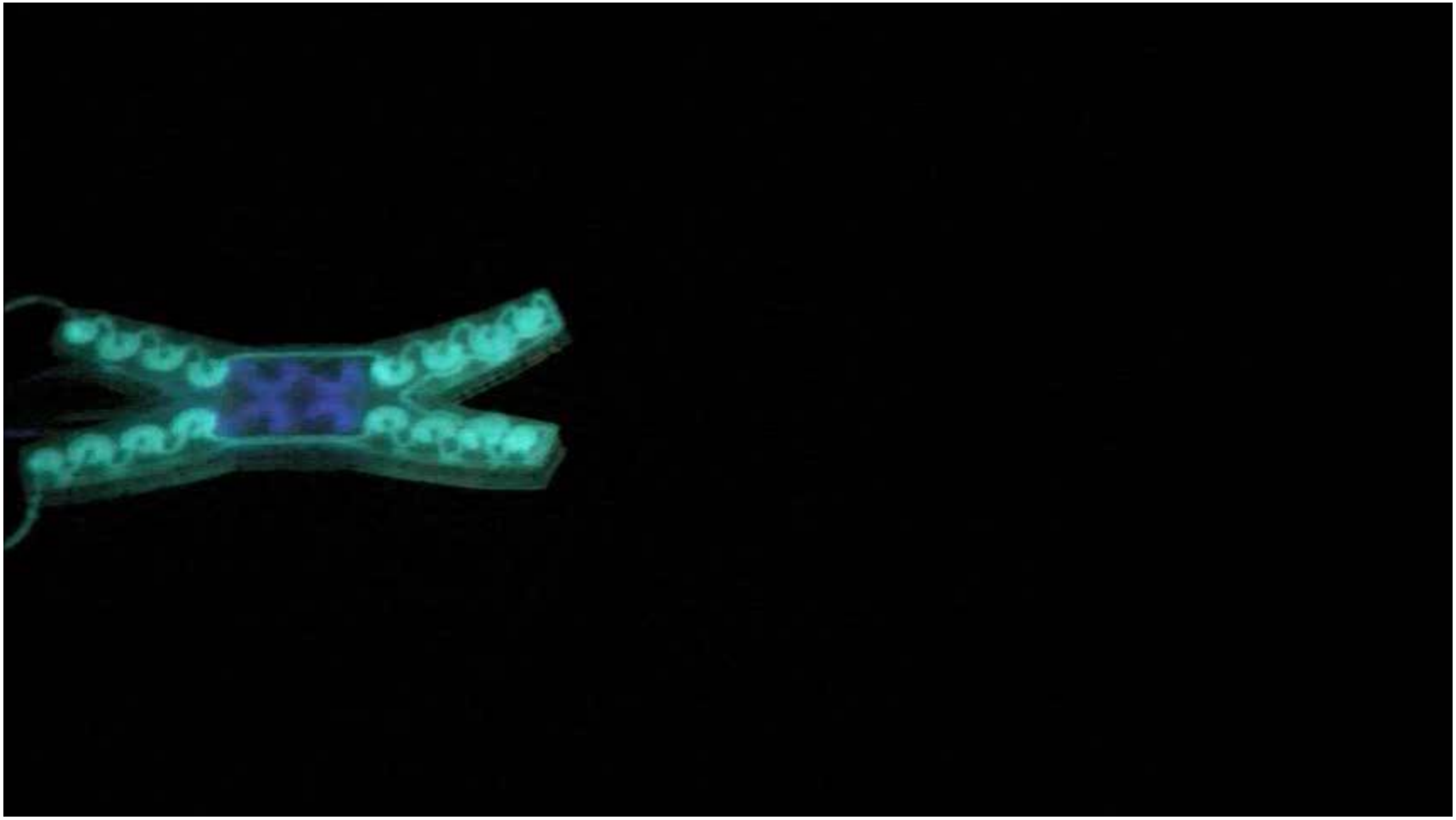




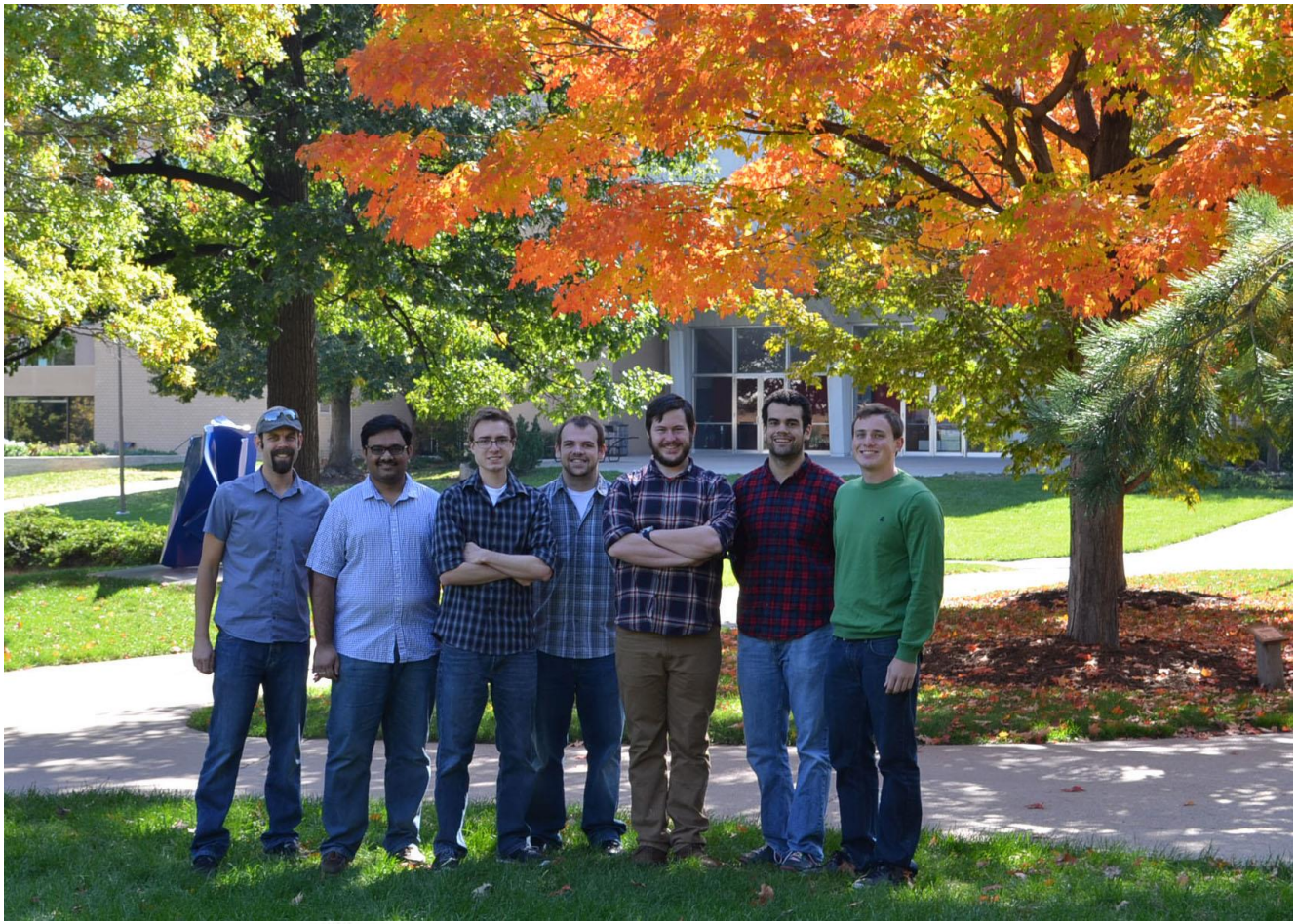
Shepherd, R.F. *et al*. *P. Natl. Acad. Sci. USA* **2011**, *108*, 20400-20403.

Display using microfluidics



Morin, S.A. et al. *Science* **2012**, *337*, 828-832.

Acknowledgments



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