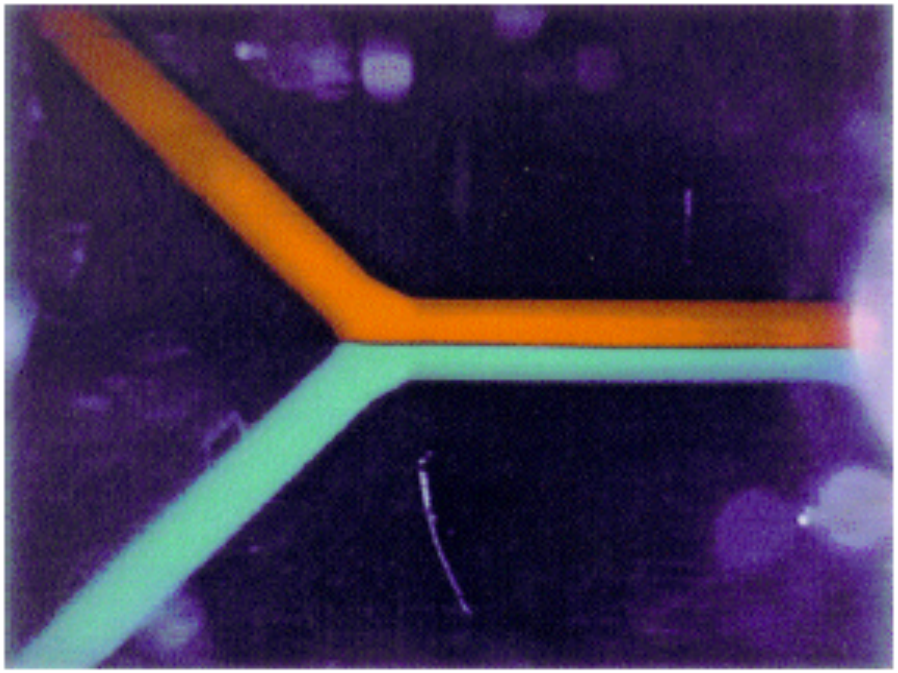
Parallel laminar flows

- Two parallel streams do not mix (except by diffusion)

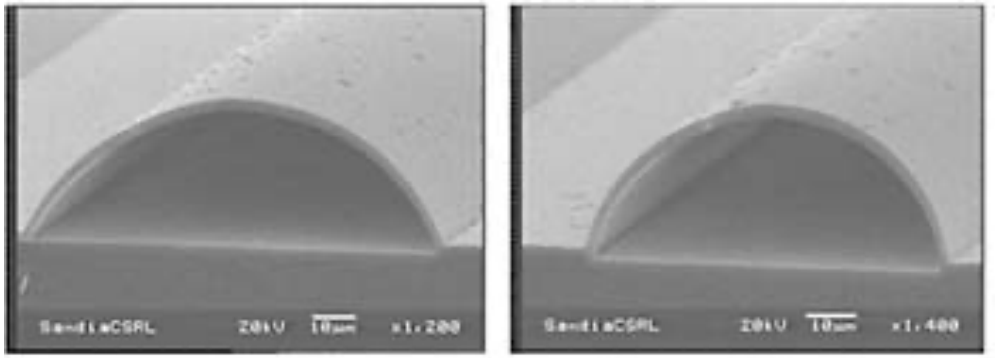


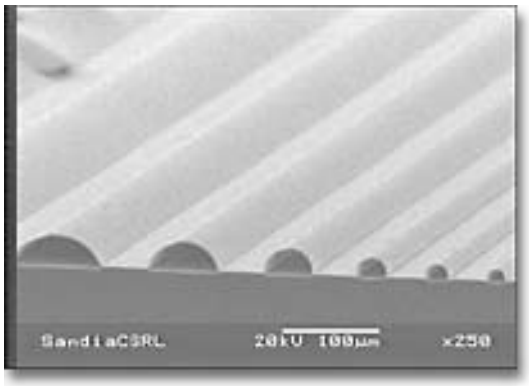
a) fluorescein-to-rhodamine B
flowrate ratio 0.5 : 0.5 mL/min
(8.3 μL/s);
$V_{chip} \approx 3\ \mu L \quad \Rightarrow \quad R_e \approx 23$

Lava flow:laminar flow in macroscale

MOTIVATION

- Macro scale = laminar, random, and turbulent flow
- Micro scale = laminar flow
- Laminar flow allows controlled mixing
- Low thermal mass
- Efficient mass transport
- Good (large) ratio of channel surface area: channel volume





http://www.spie.org/web/oer/august/aug00/microfluidics.ht

Microfluidic components

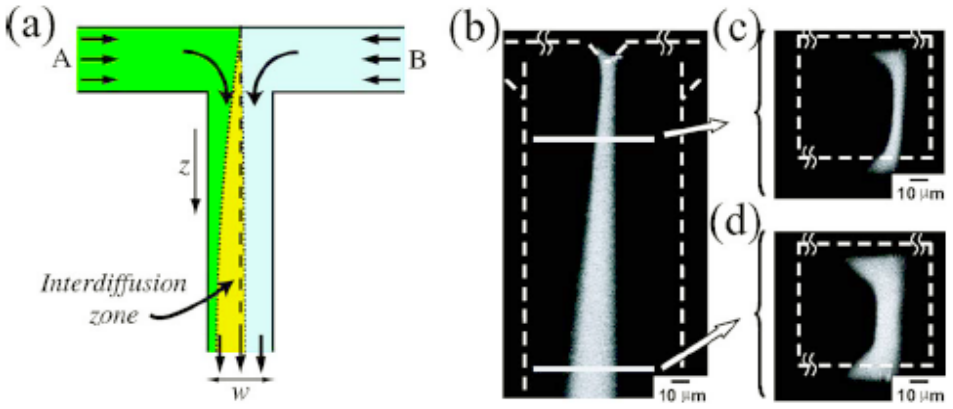
A very quick primer on basic components used in microfluidics:

1. Channels
2. Reservoirs
3. Pressure sources (often off chip)
4. Mixers
5. Filters
6. Valves

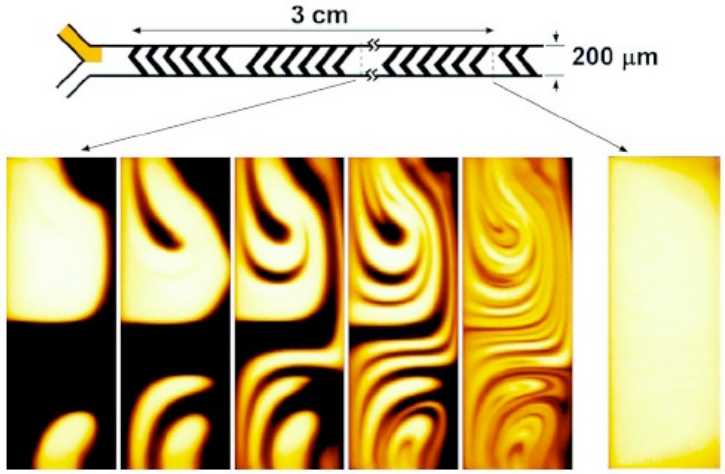
There will be a separate lecture on microfluidic components.

Microfluidic mixing

- Sometimes pure diffusive mixing
- Often diffusive mixing is not enough and assistance from special geometries is used.



Diffusive mixing



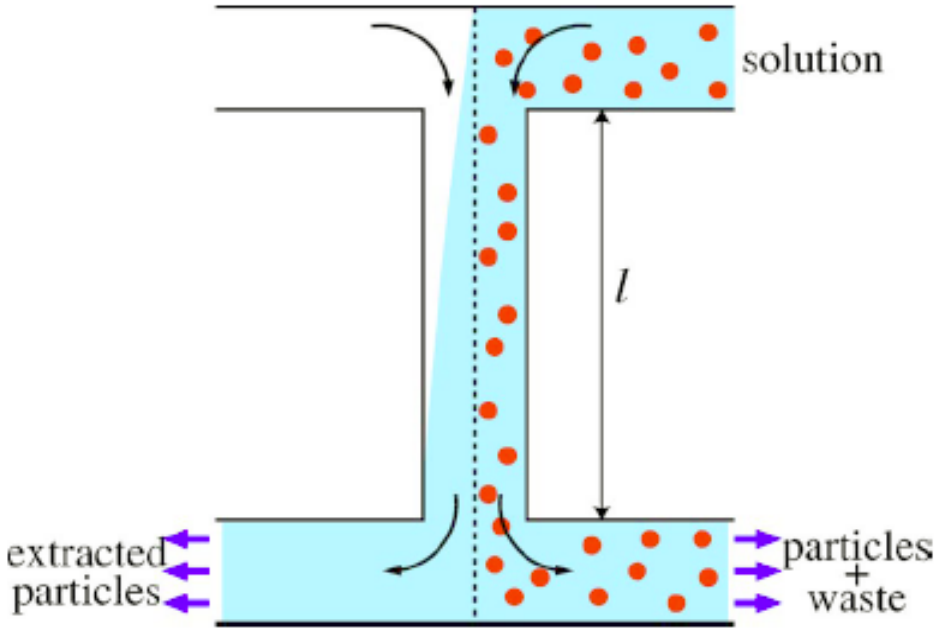
Enhanced mixing by "herringbone" structures

Ismagilov *et al.*, Appl. Phys. Lett. **76**, 2376. 2000

Stroock *et al.*, 2002, Science **295**, 647 2002.

H filter

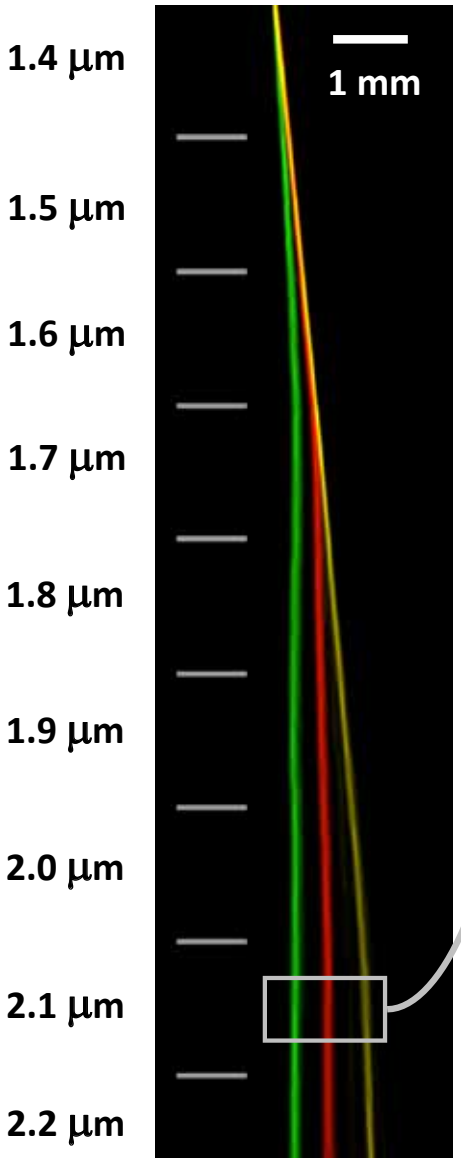
- Laminar flow and differences in diffusion constant lead to a possibility for filtering.



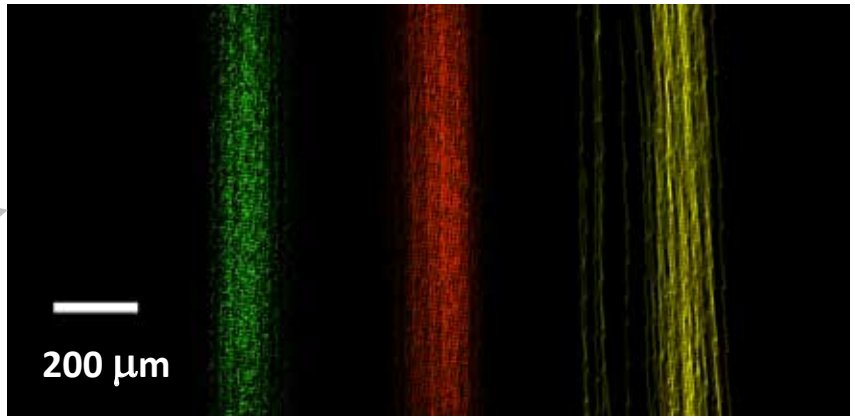
Brody, J. P., and P. Yager, 1997, Sens. Actuators, A **58**, 13.1997

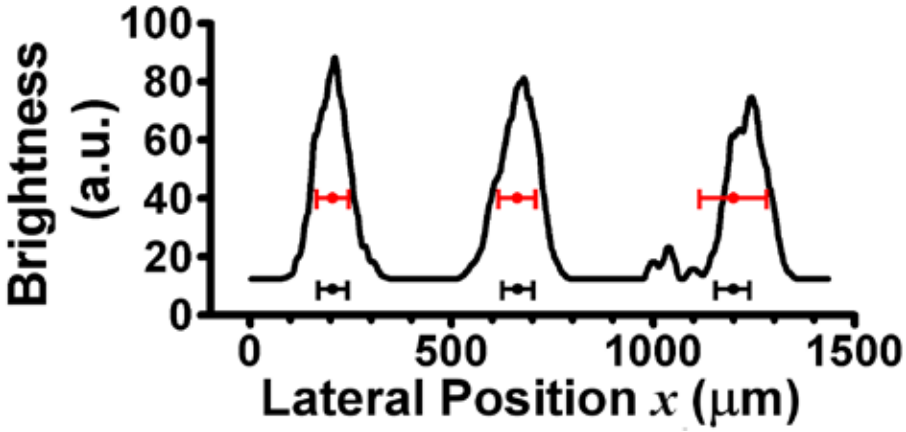
High Resolution Separation with Size - Position Correlation

Can include chirp to fractionate over a range of sizes by varying g or $\mathcal{E}$



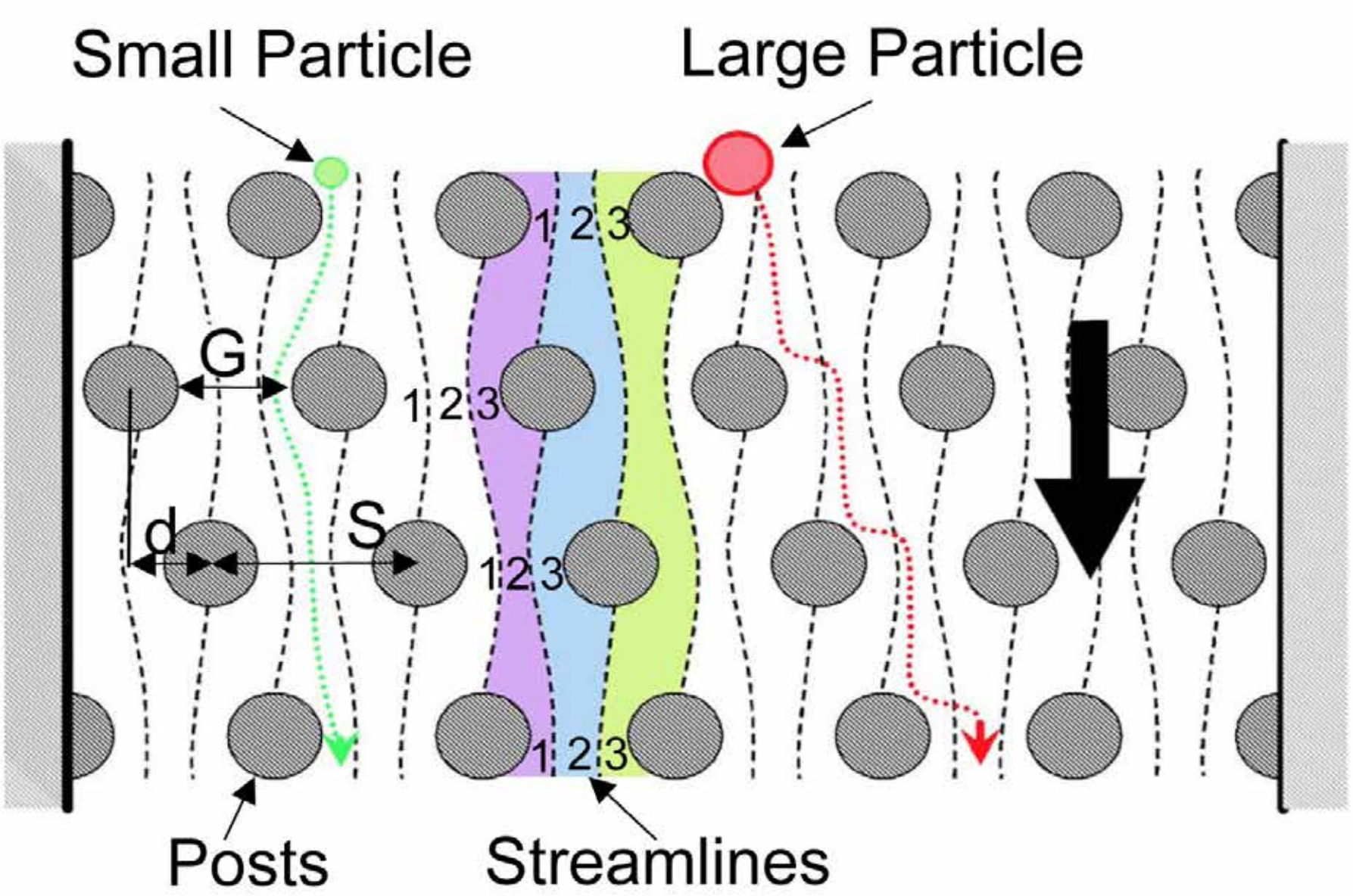
- Peak width ~10 nm
- No known method fractionates with such resolution.



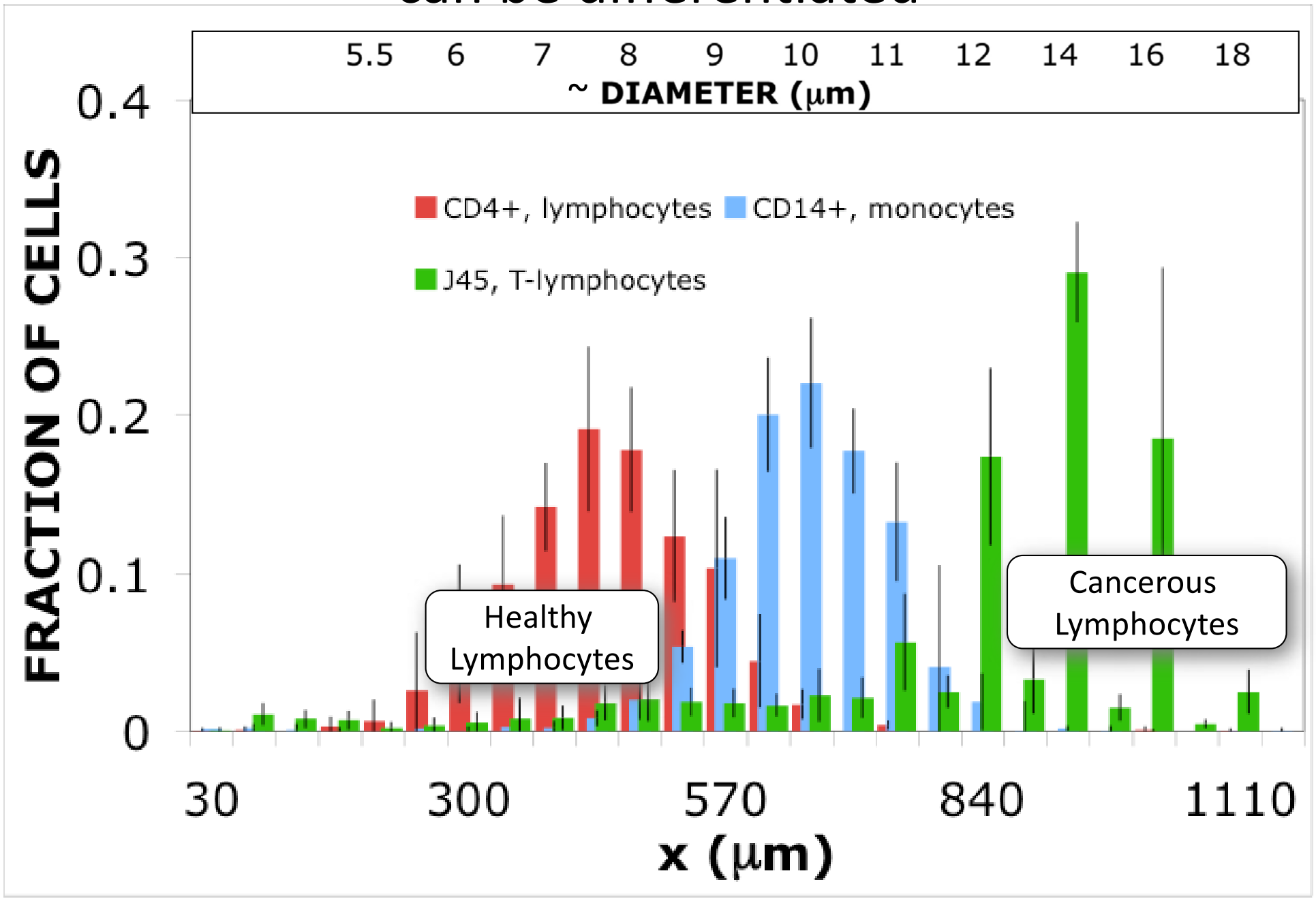


Huang et al, Science 2004

Cell Separation by Size

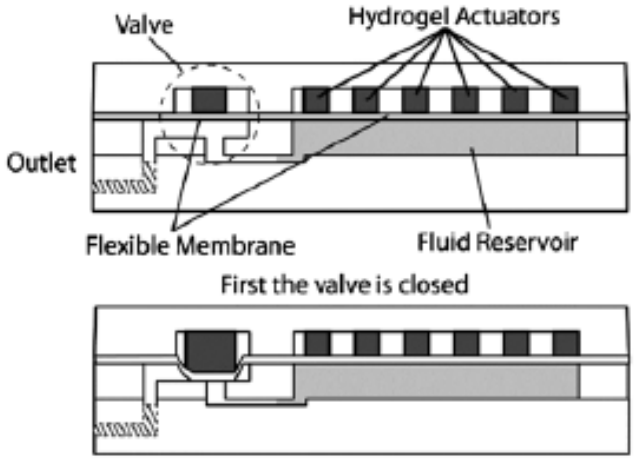


White blood cells come in different sizes and can be differentiated

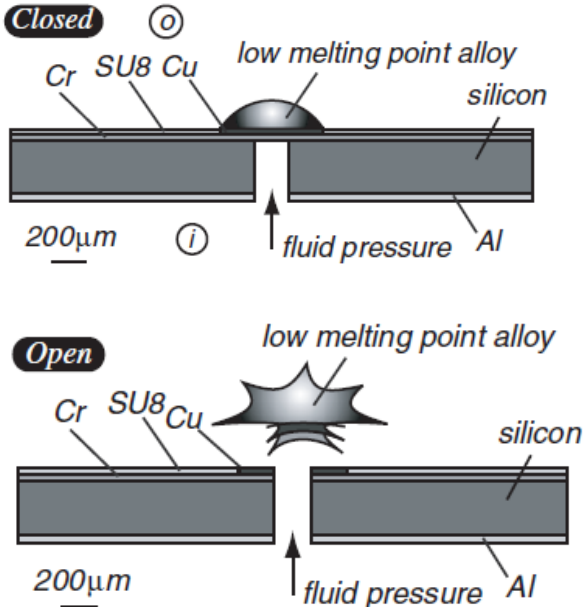


Valving

- Hundreds of different microvalves reported...
- Pneumatic, magnetic, electric, thermal, piezo, phase change, etc...
- Few examples:



pH sensitive hydrogen actuates a flexible membrane



one shot temperature operated valve

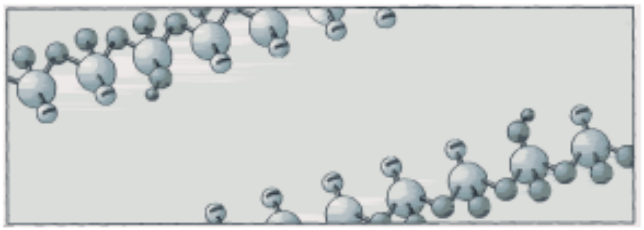
Flow actuation (pumping)

The most common flow types microfluidics:

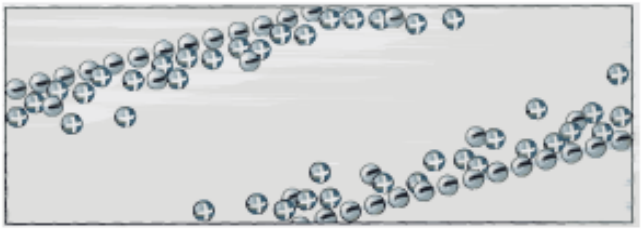
1. Pressure driven flow *(this lecture)*
2. Capillary flow *(next lecture)*
3. Electro-osmotic flow *(later lectures)*

Other alternatives:
centrifugal force, electrowetting, etc..

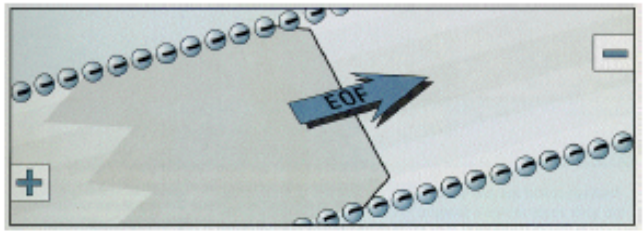
- Methods differ in flow profile, possible flow rates, required equipment and interconnections
- Different methods suited for different applications, sometimes combinations are used



a) deprotonated silanol groups (SiO-)



b) diffuse layer of counterions near surface



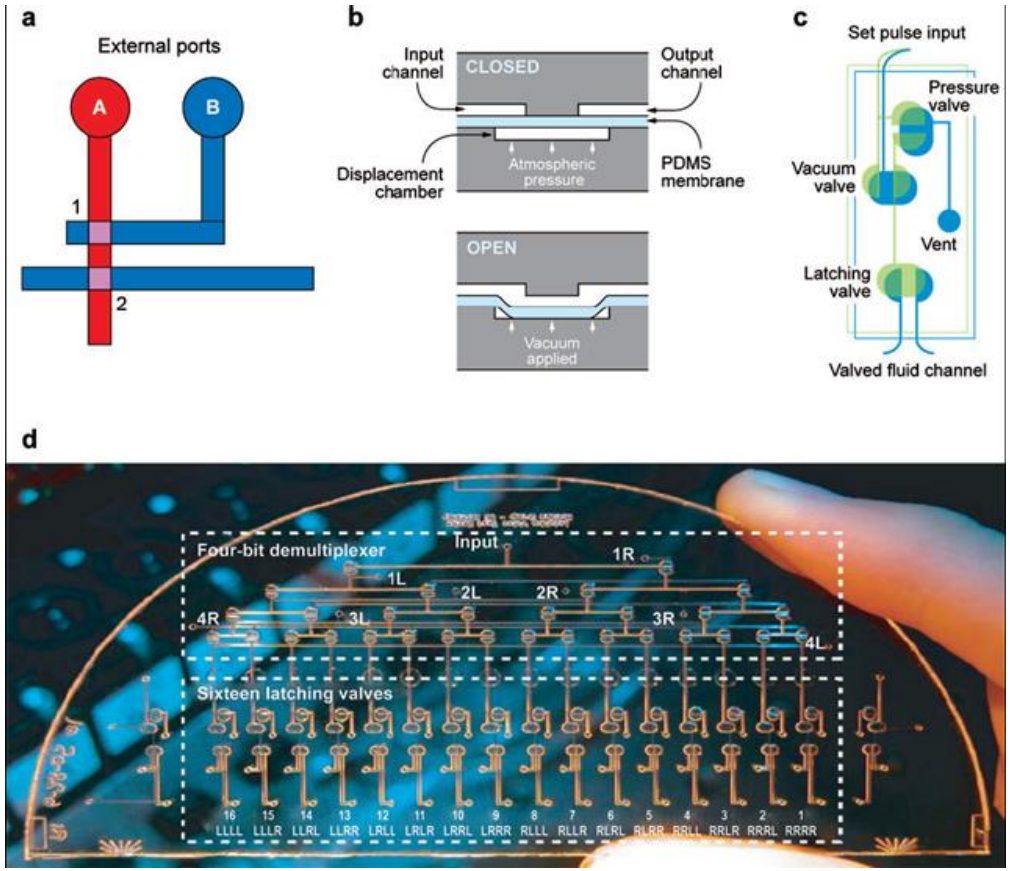
c) E applied, bulk flow towards cathode

Electro-osmotic flow

Automation for Lab-on-a-chip

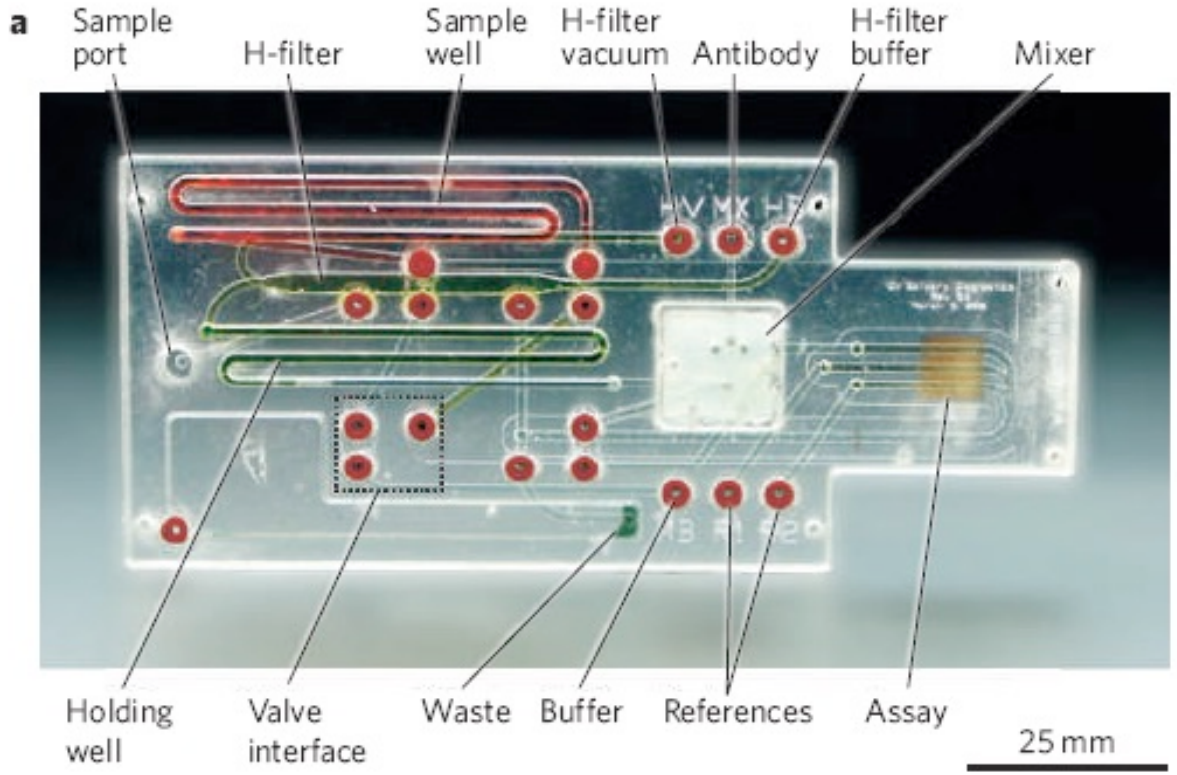
Development of **Microfluidic Large Scale Integration** with thousands of mechanical valves

Parallel Assays Made Easy!



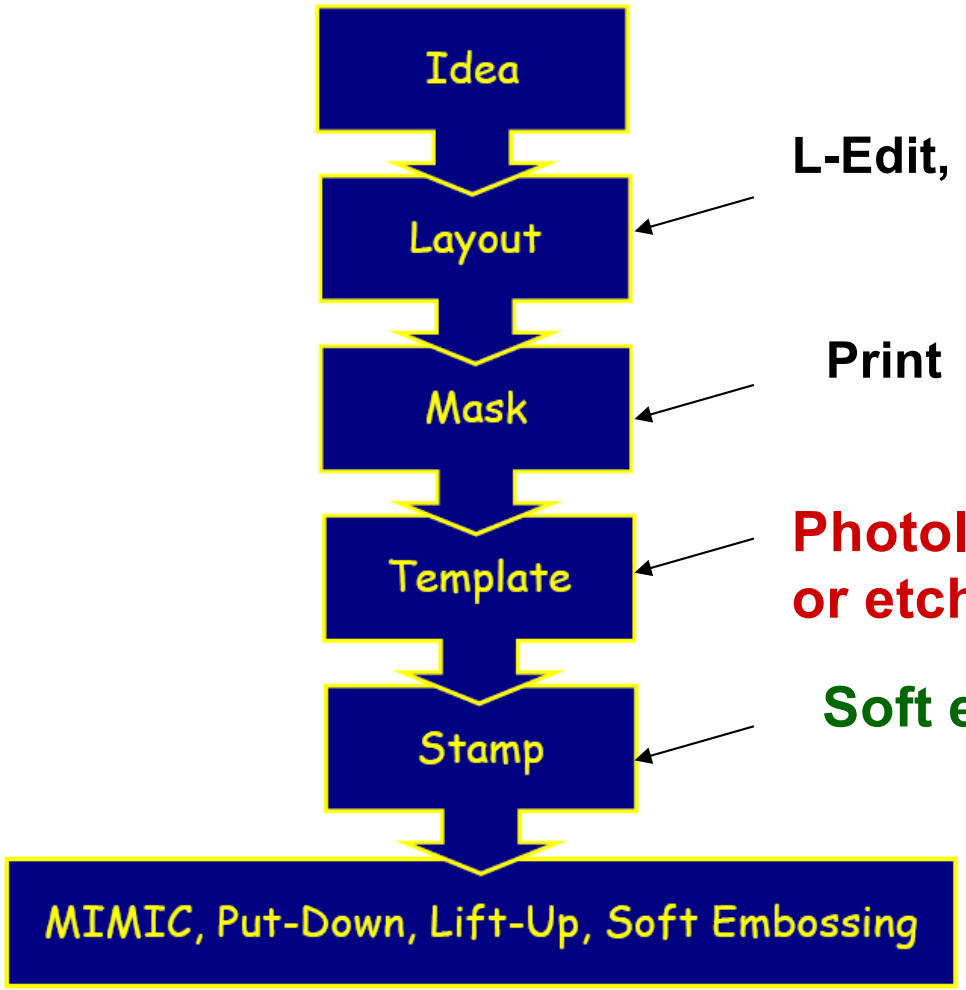
Microfluidic Diagnostic Methods

Portable Point-of-Care (POC) Medical Diagnostic Systems



The chips should be inexpensive, accurate, reliable and suited to the medical conditions in developing countries.

How to Prepare a Microfluidic Chip?

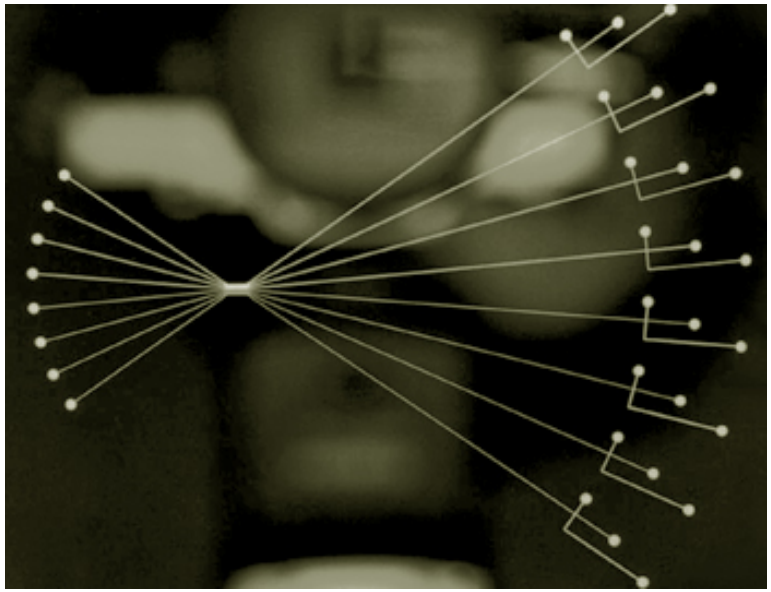


L-Edit, AutoCAD

Print

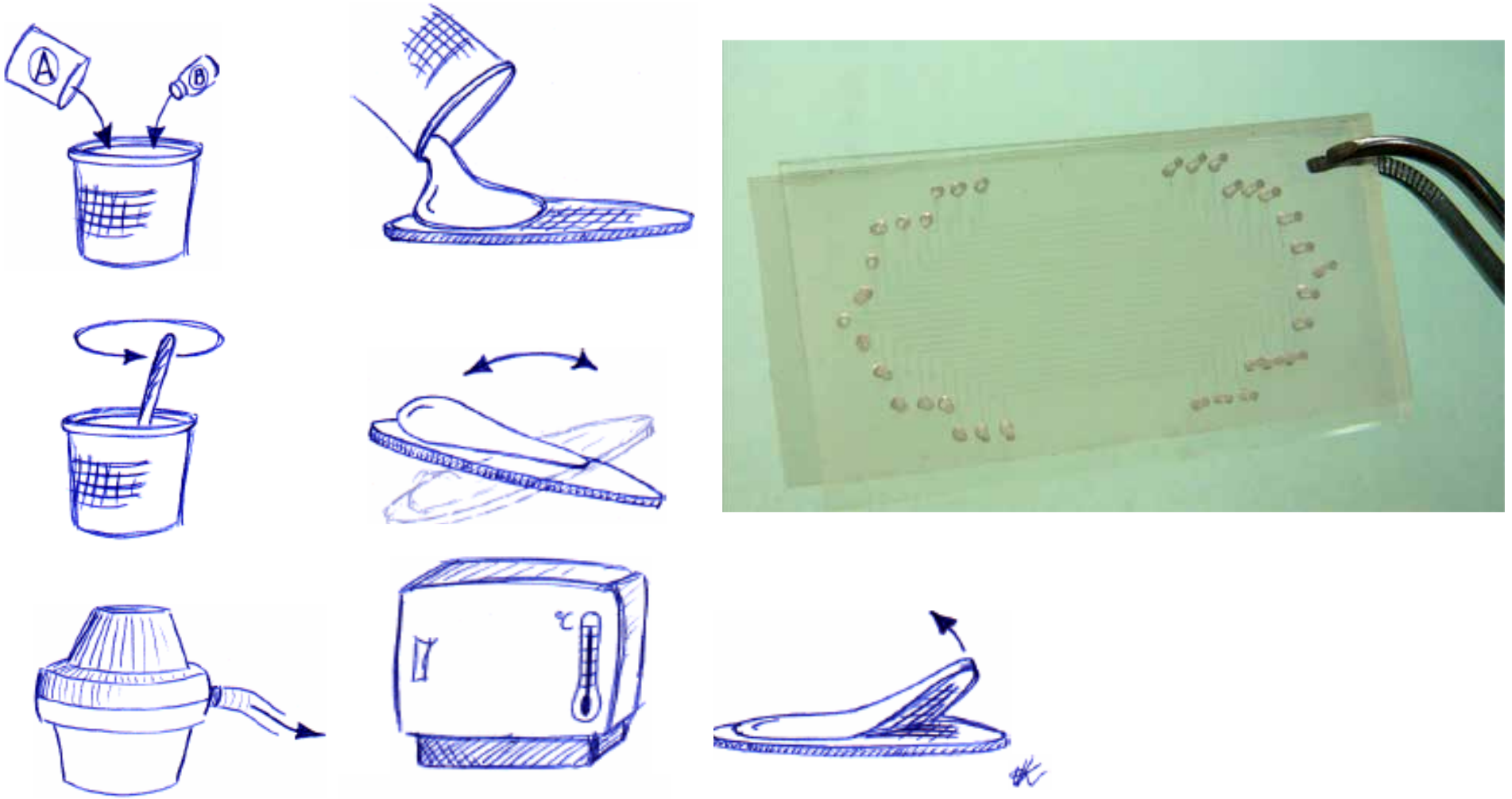
Photolithography or etching

Soft embossing



The Method for Preparing a Chip in Our Lab:

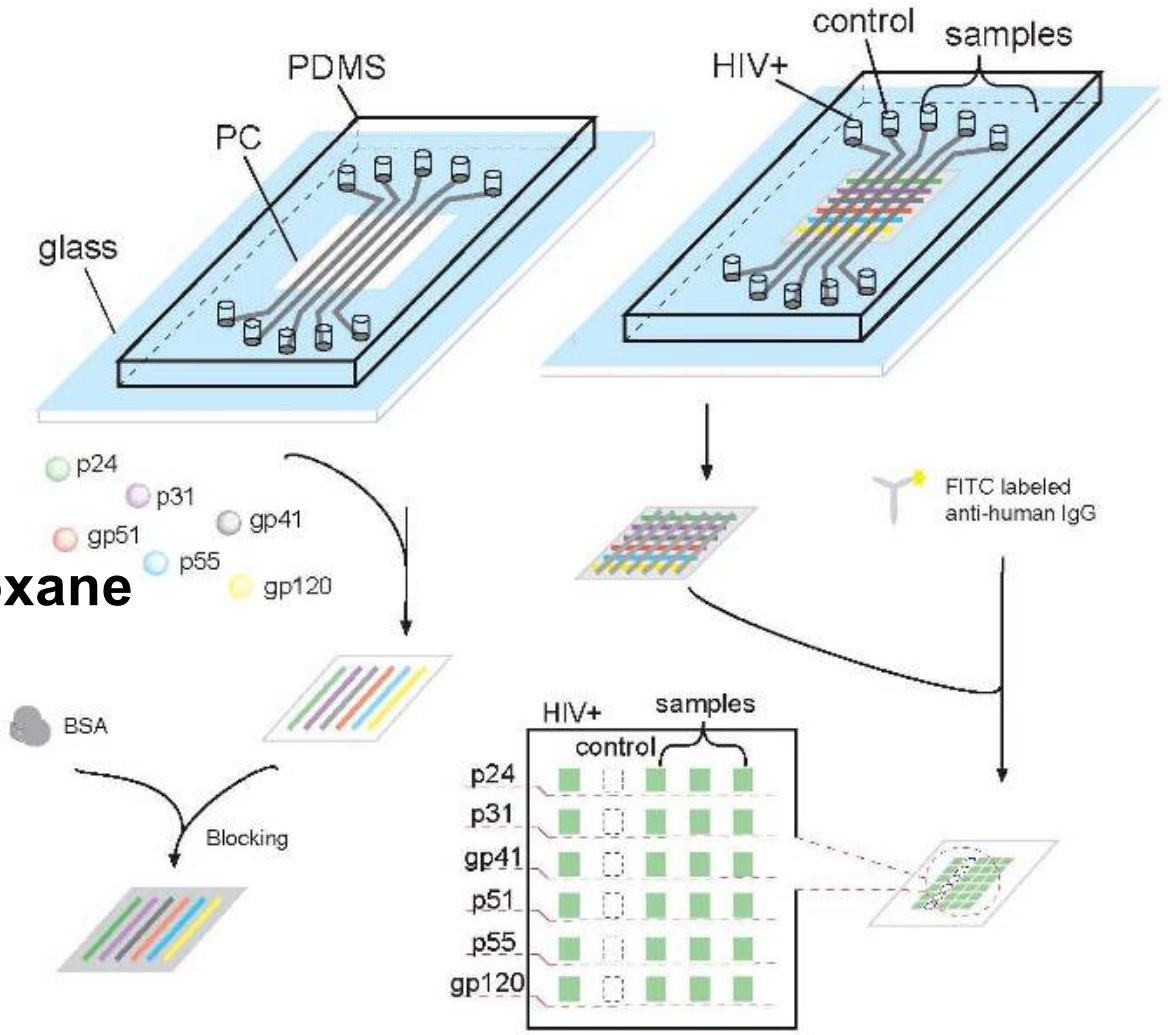
Soft embossing by polymer (PDMS etc.)



A method for analyzing HIV antibodies in microfluidic channels

PDMS:Polydimethylsiloxane

PC: Polycarbonates



Improved efficiency in assays

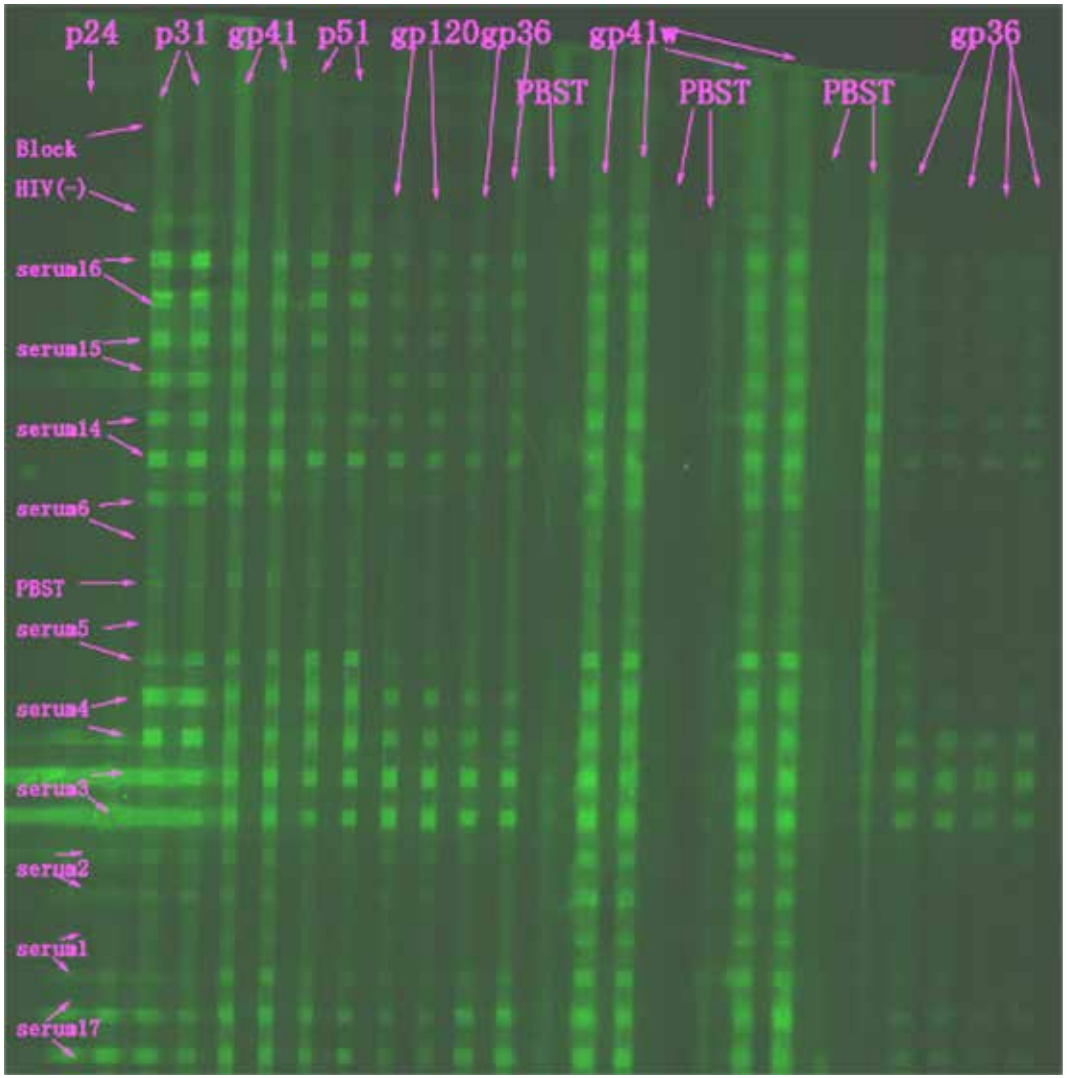
Immunoassay results on PC membrane

Advantages:

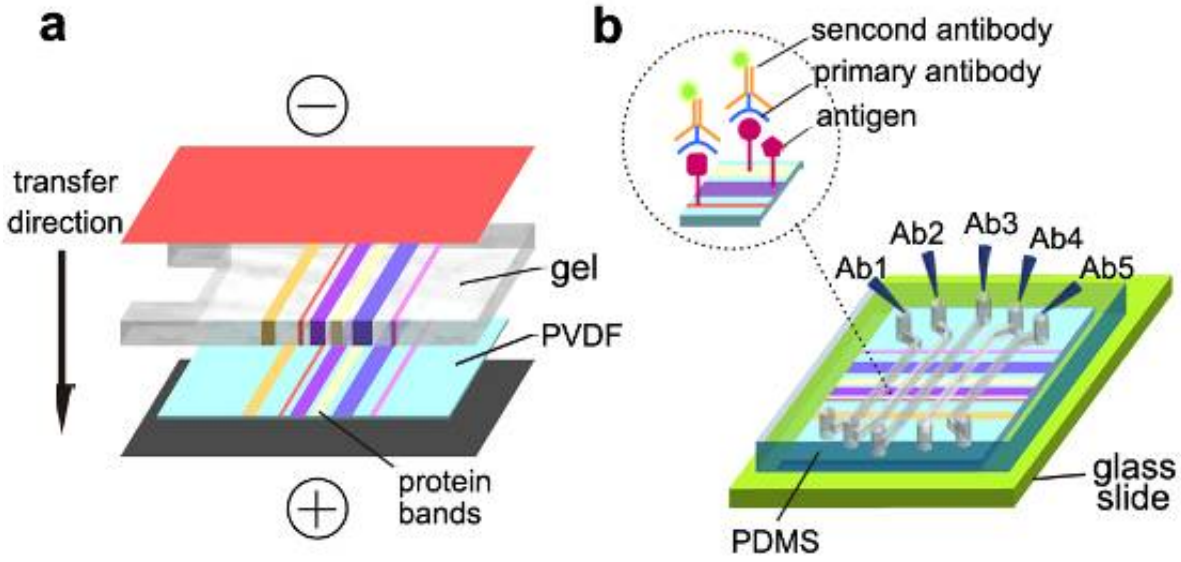
Fast (20 min.)

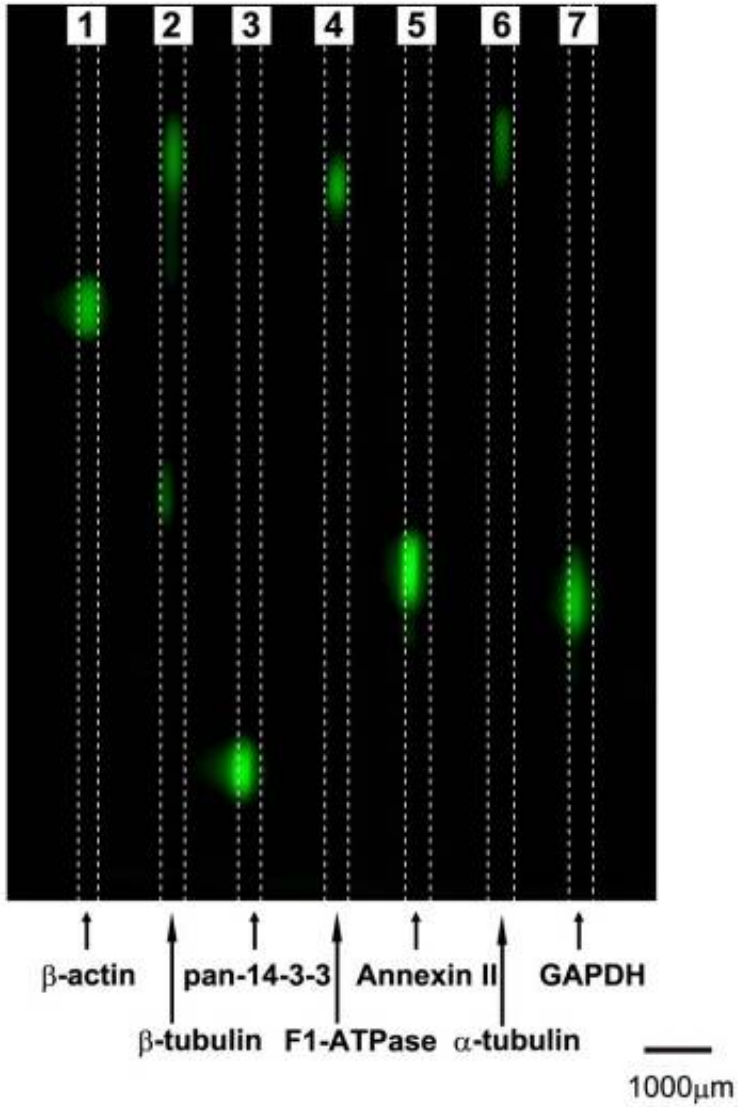
High throughput

Low cost



Micro Western blot for detecting multiple proteins on one chip

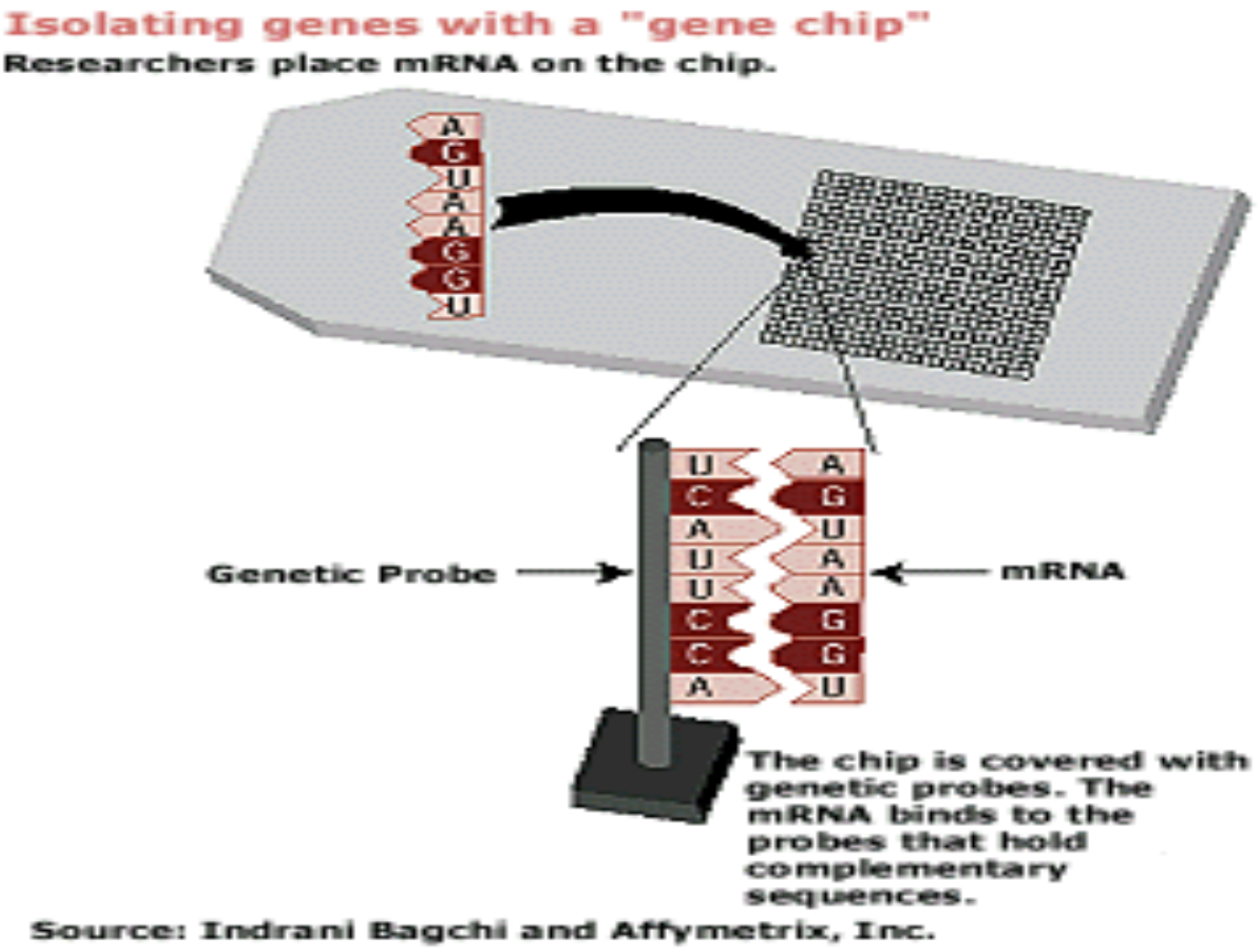




Detection of multi-proteins one time

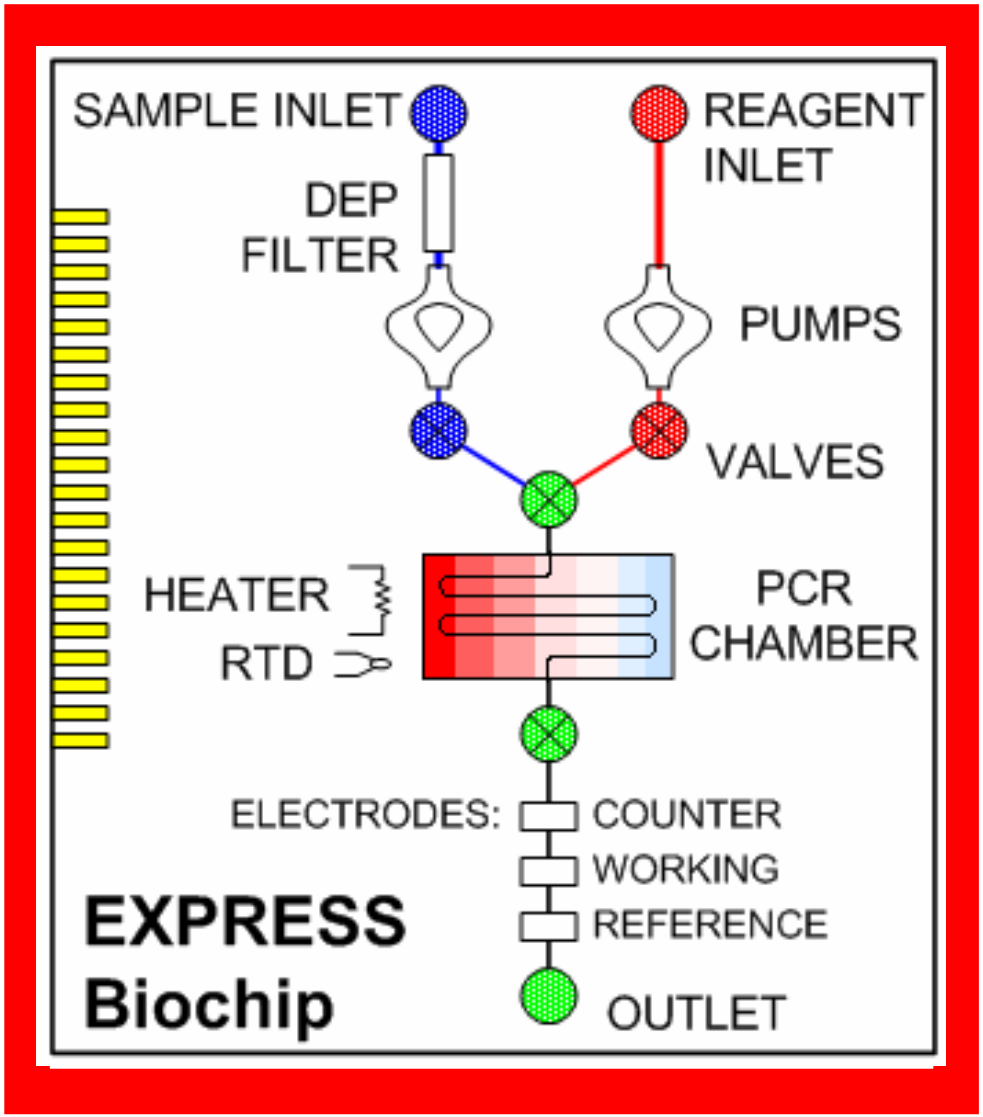
1-3μL Antibody solutions are required

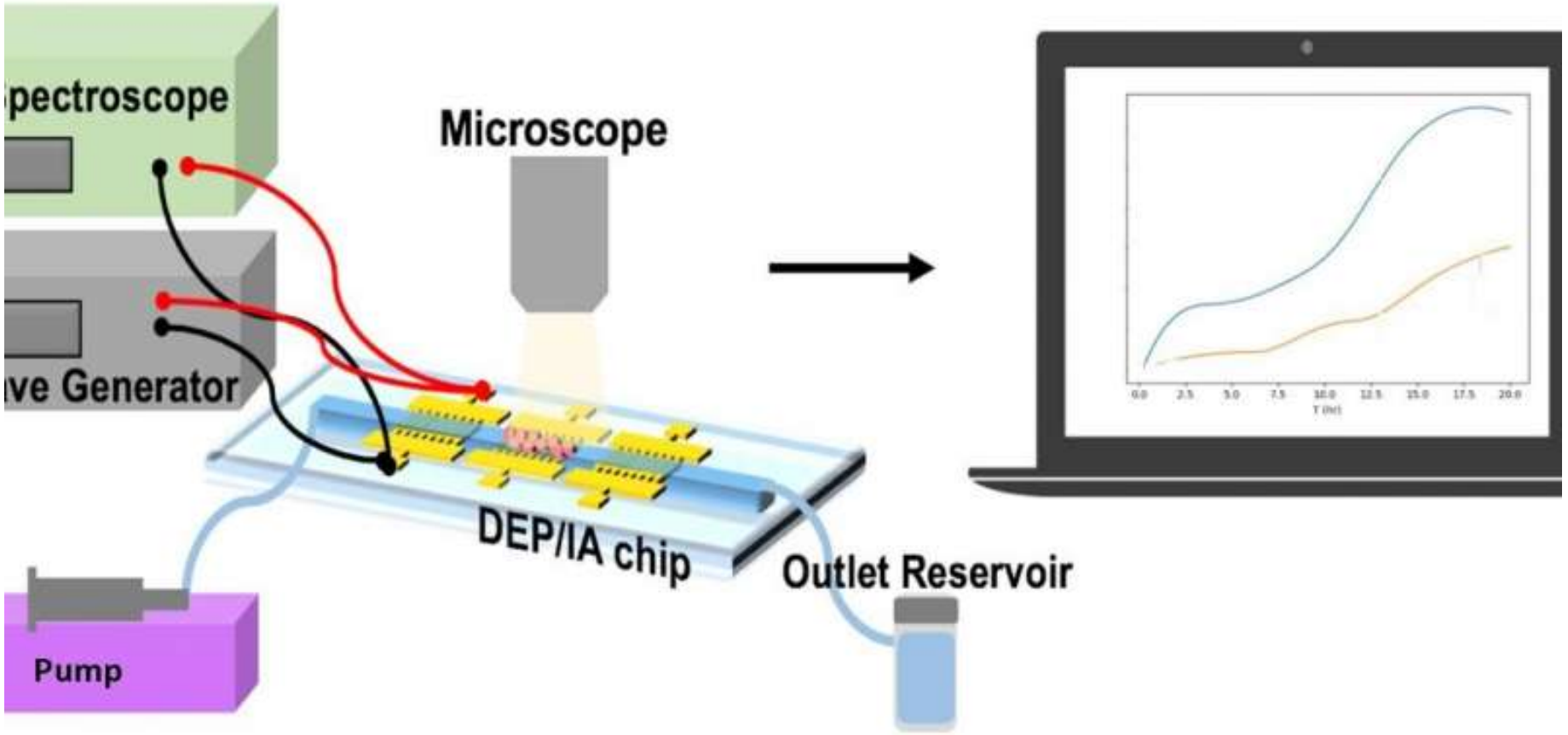
GENE CHIP



http://www.popcouncil.org/images/gene_chip.gif

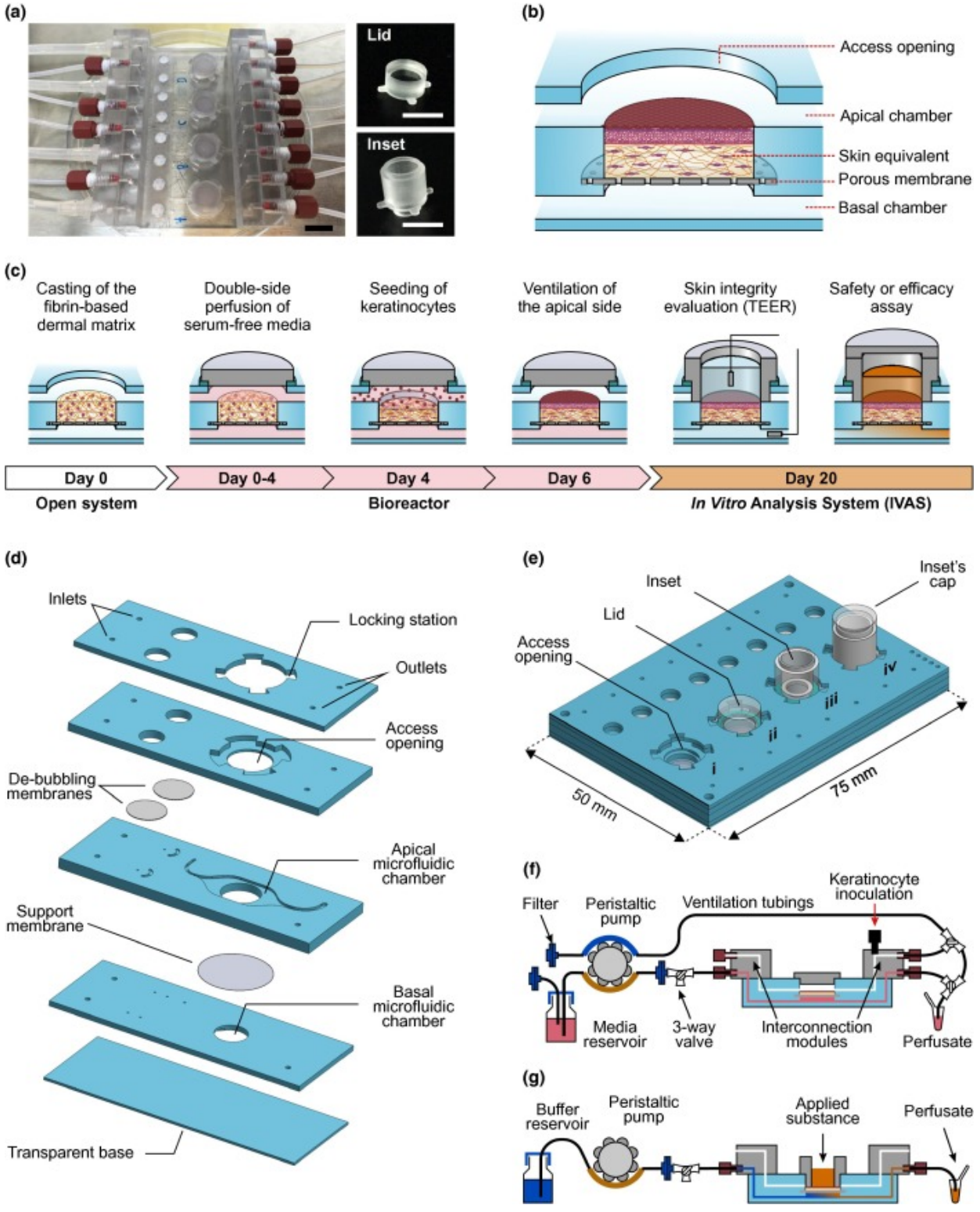
The Not-so-Distant Future

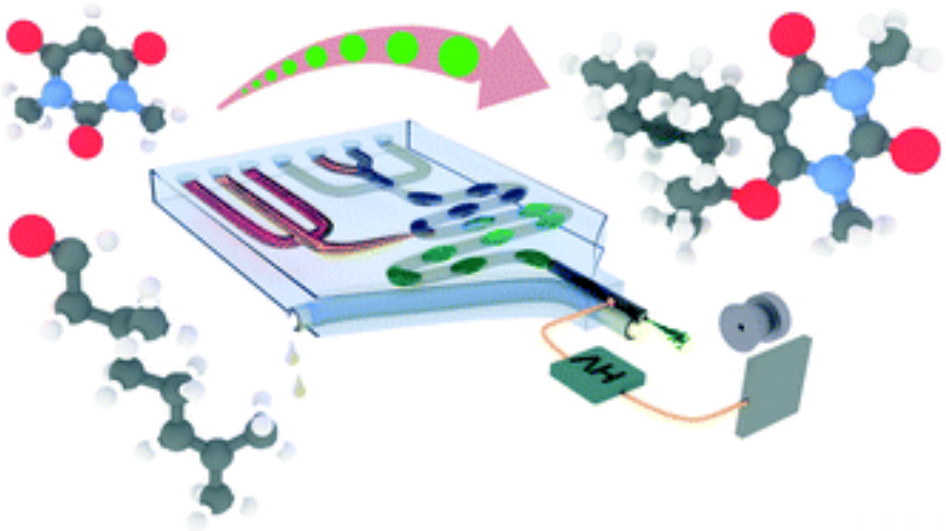


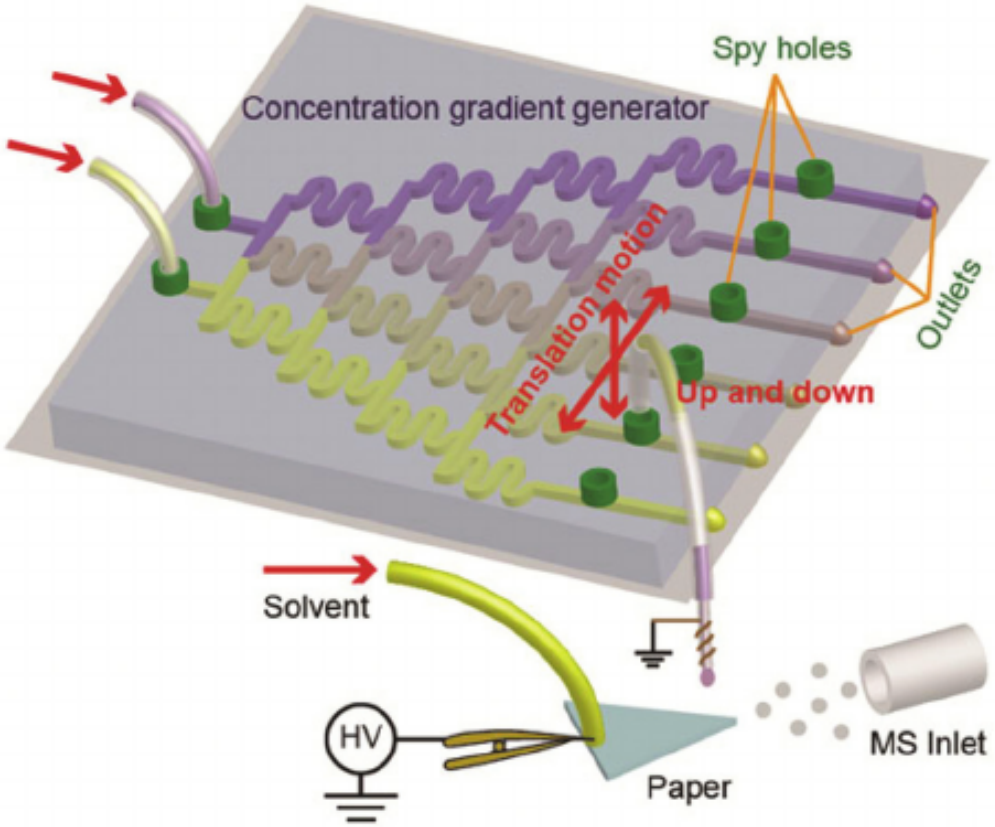


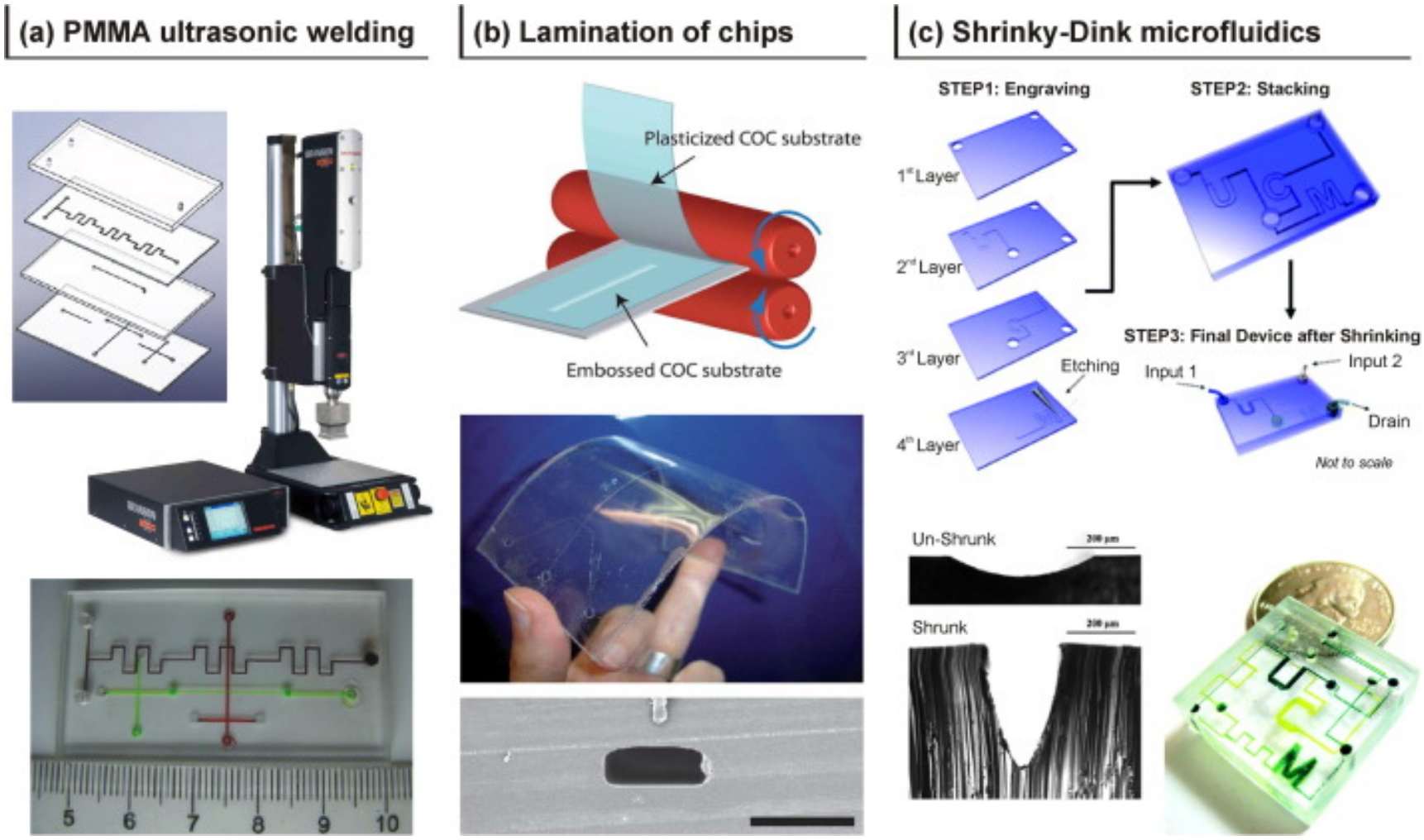
Researchers develop 'lab on a chip' for personalized drug efficacy monitoring

by Brian Bell, University of California, Irvine


(a)
Lid
Inset
(b)
Access opening
Apical chamber
Skin equivalent
Porous membrane
Basal chamber
(c)
Casting of the fibrin-based dermal matrix
Double-side perfusion of serum-free media
Seeding of keratinocytes
Ventilation of the apical side
Skin integrity evaluation (TEER)
Safety or efficacy assay
Day 0
Day 0-4
Day 4
Day 6
Day 20
Open system
Bioreactor
In Vitro Analysis System (IVAS)
(d)
Inlets
Locking station
Outlets
Access opening
De-bubbling membranes
Apical microfluidic chamber
Support membrane
Basal microfluidic chamber
Transparent base
(e)
Inset
Inset's cap
Lid
Access opening
i
ii
iii
iv
50 mm
75 mm
(f)
Filter
Peristaltic pump
Ventilation tubings
Keratinocyte inoculation
Media reservoir
3-way valve
Interconnection modules
Perfusate
(g)
Buffer reservoir
Peristaltic pump
Applied substance
Perfusate

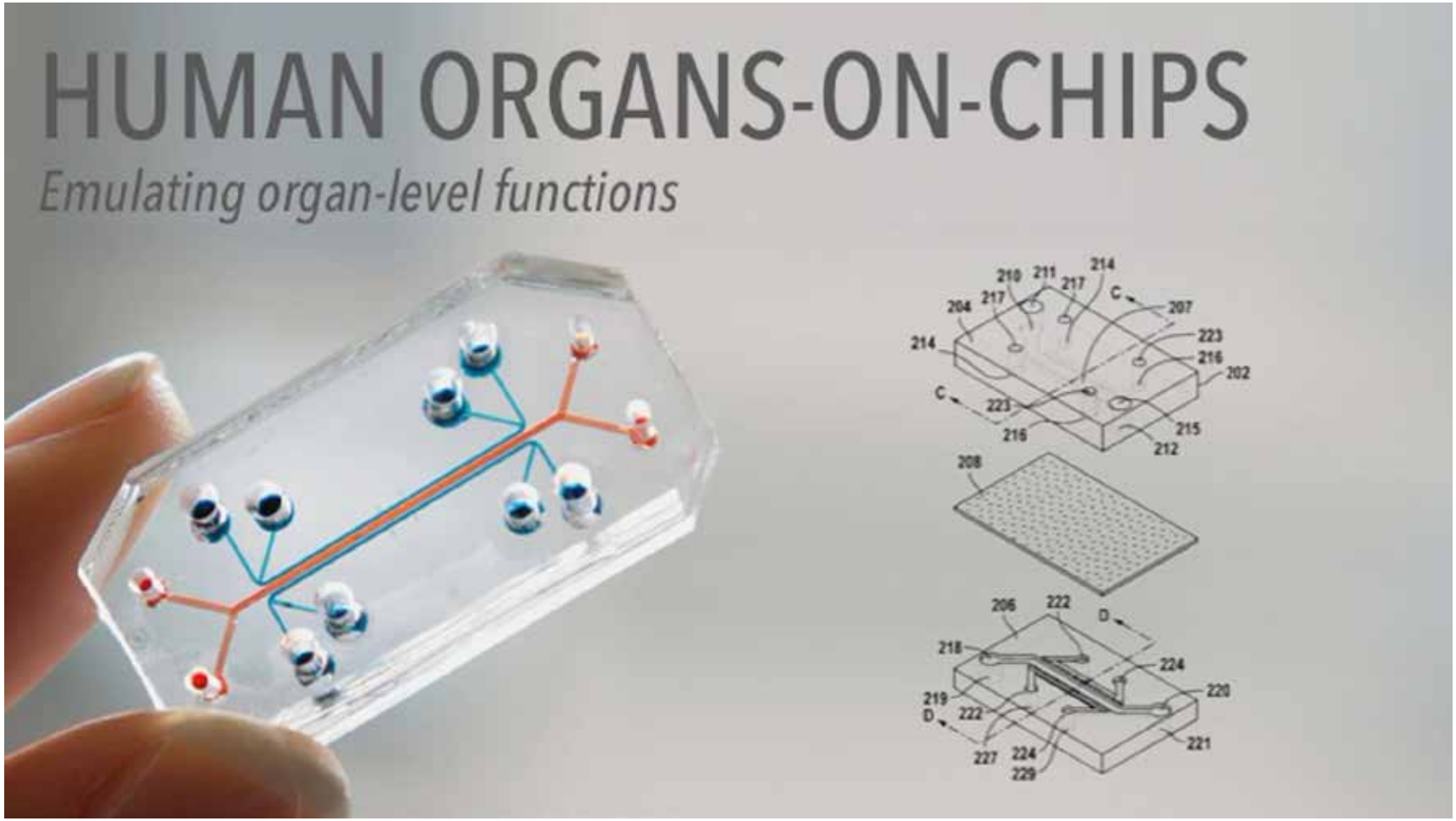



Spy holes
Concentration gradient generator
Translation motion
Outlets
Up and down
Solvent
HV
Paper
MS Inlet



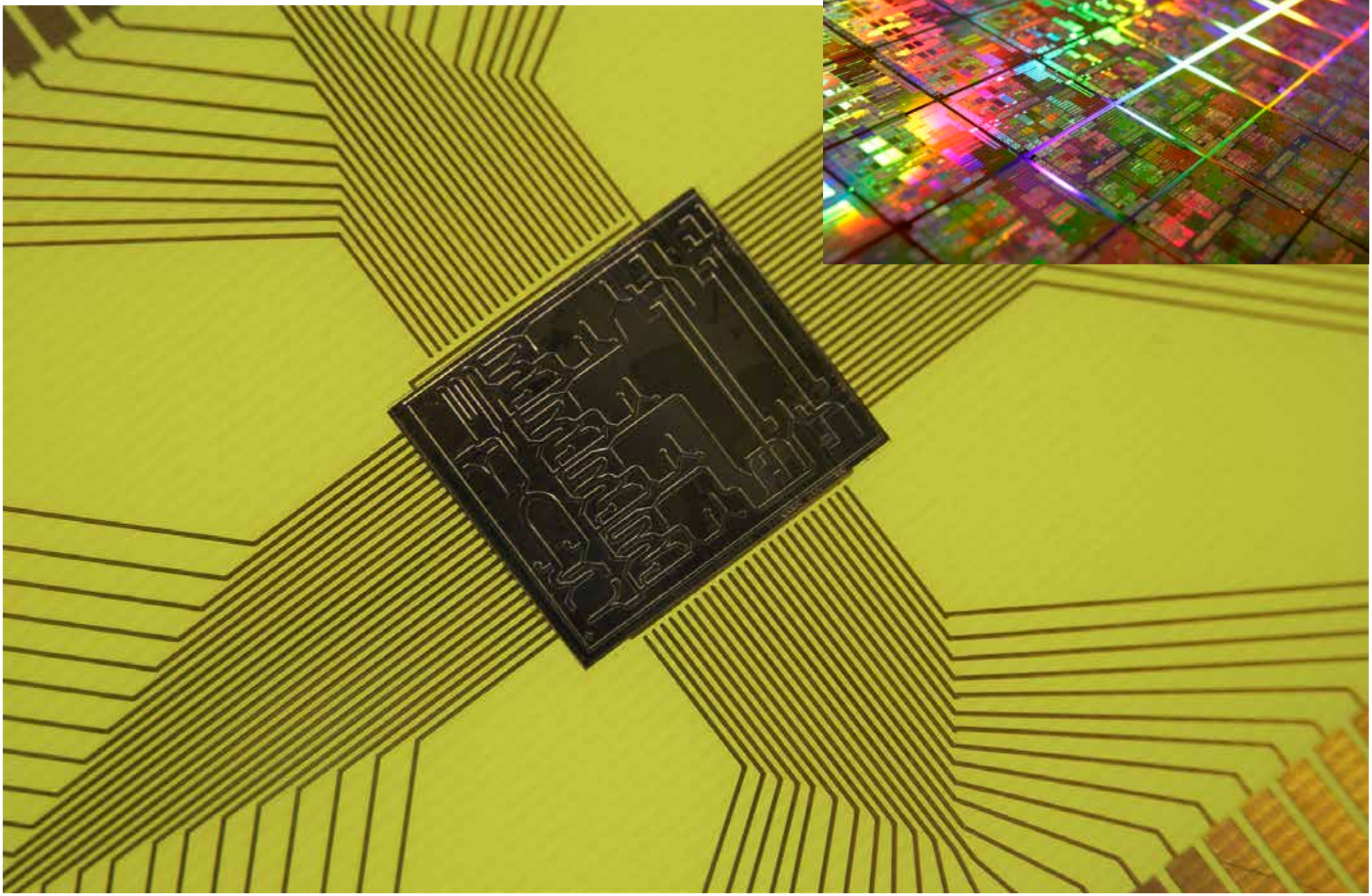
Lab-on-a-chip devices: How to close and plug the lab?

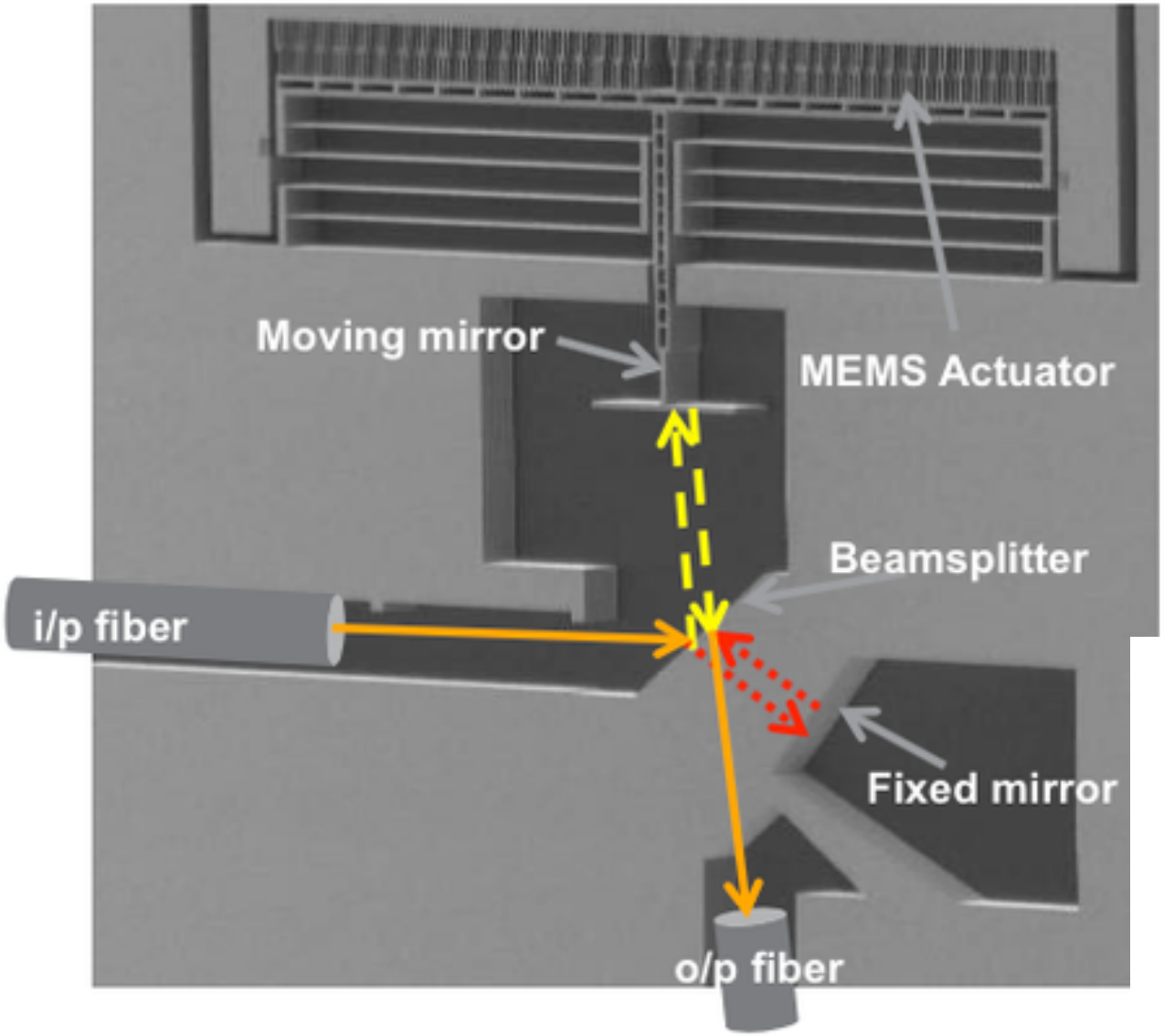
Author links open overlay panelYukselTemiz
Robert D.LovchikGovind V.KaigalaEmmanuelDelamarche



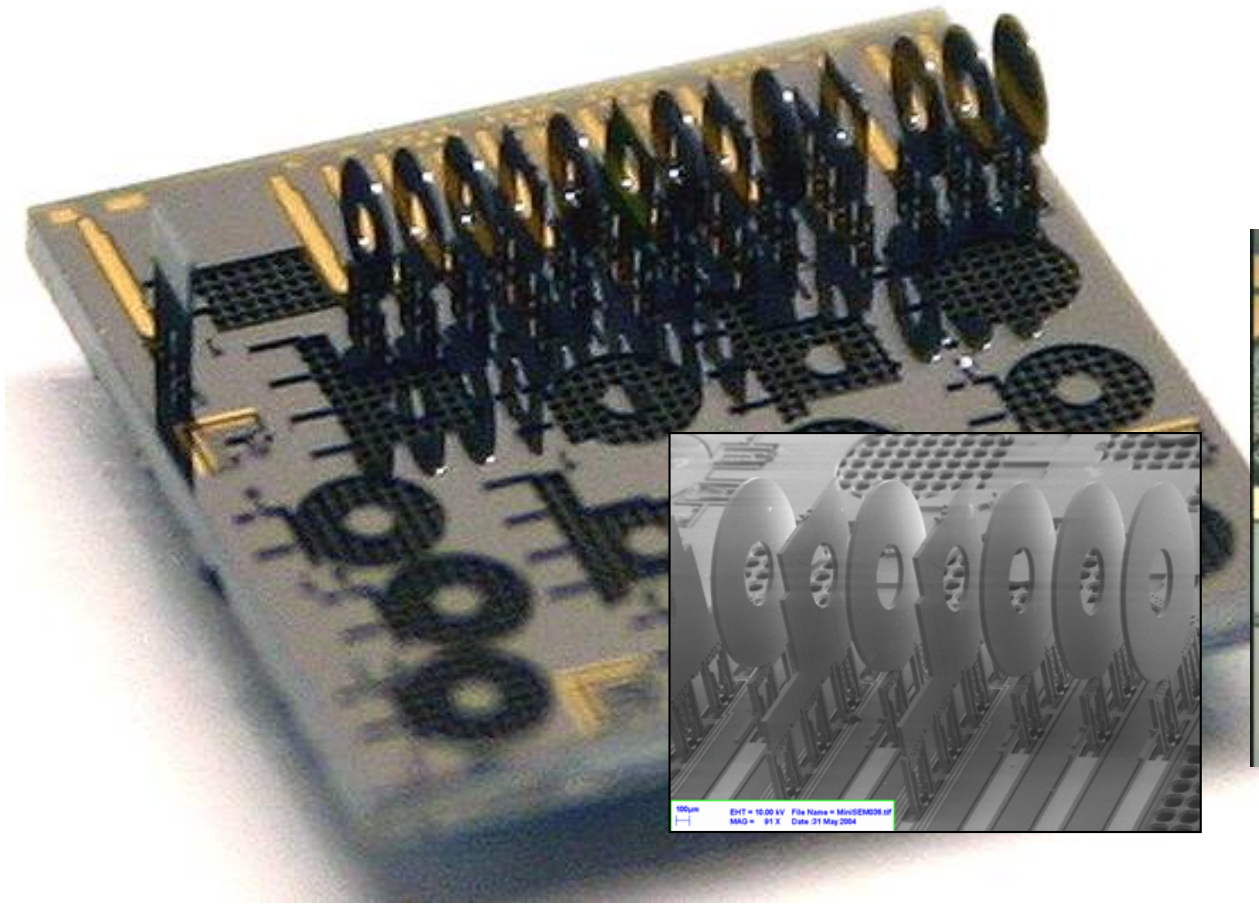
Microfluidic devices lined with living human cells for drug development, disease modeling, and personalized medicine

https://wyss.harvard.edu/technology/human-organs-on-chips/

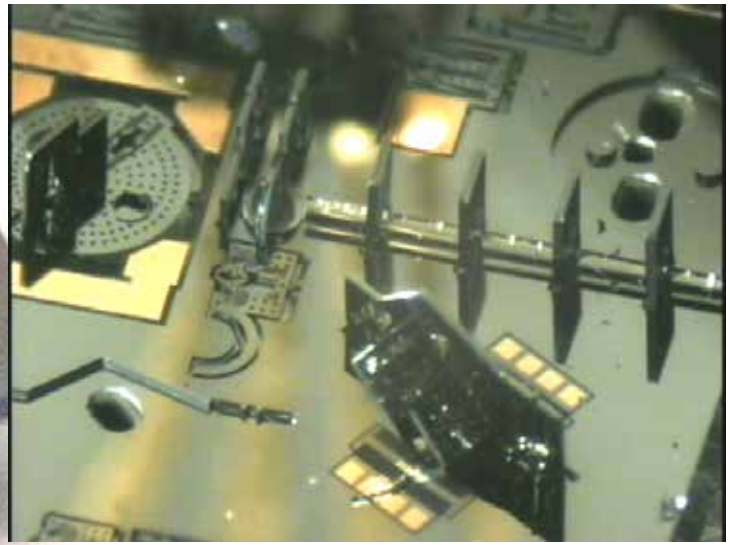



Moving mirror
MEMS Actuator
Beamsplitter
i/p fiber
Fixed mirror
o/p fiber

New Doped Silicon Micro-Electro-Mechanical System (MEMS) Methods



MEMS Microcolumn for SEM



MEMS Spectrometer

zyvex®