MURIs and What They Lead To

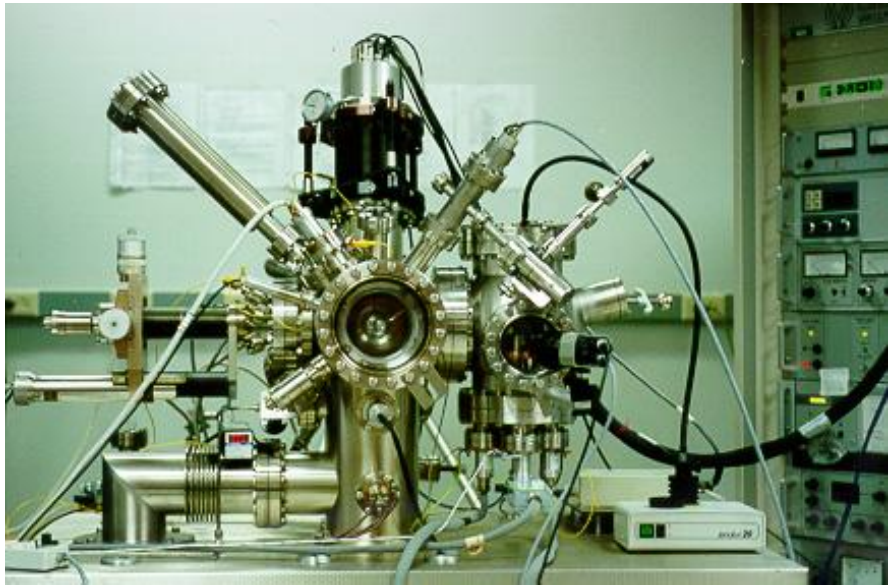
George M. Whitesides
Harvard University

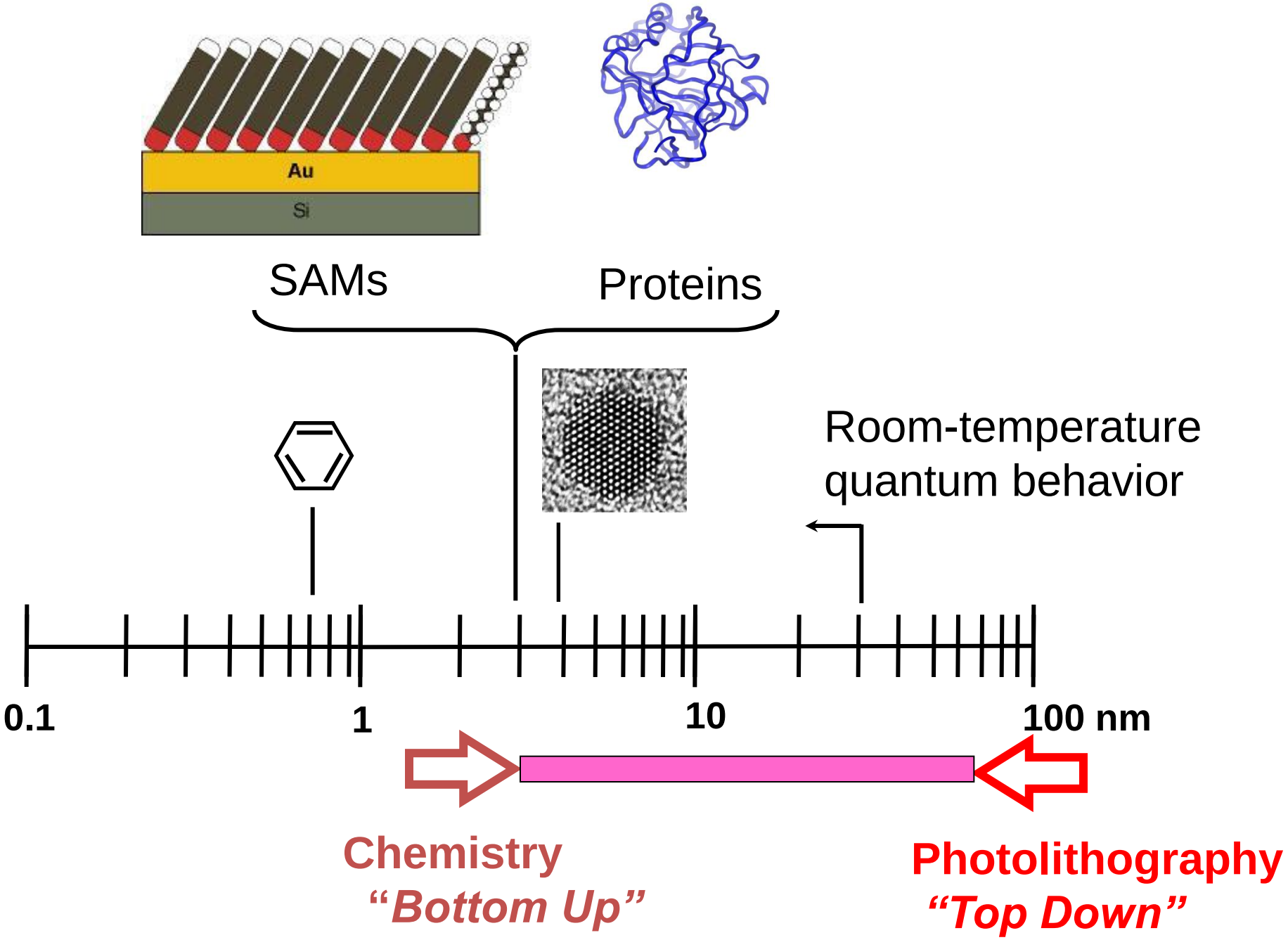
Impact? Curiosity? (Hits on Google, MM)

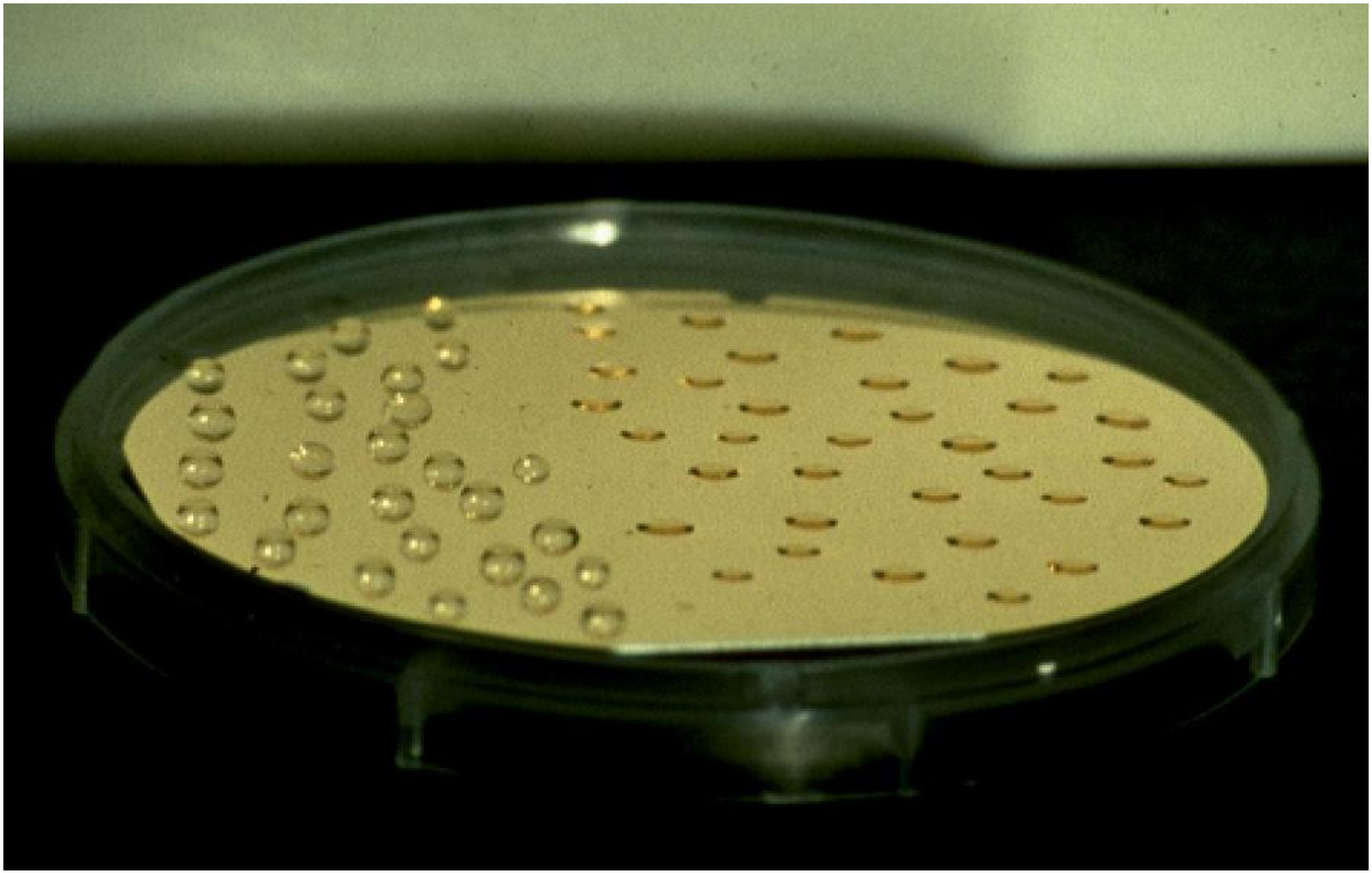
• Self-assembled monolayers	1.6
• Microcontact printing	0.24
• Soft lithography	0.22
– Dip Pen Nanolithography	0.54
– Imprint Nanolithography	0.44
• Microfluidics	1.45
• Optofluidics	0.55
• Paper Diagnostics	22.
– Diagnostics for All	77.
• Soft Robotics	(9.8)

Self-Assembled Monolayers
SAMs

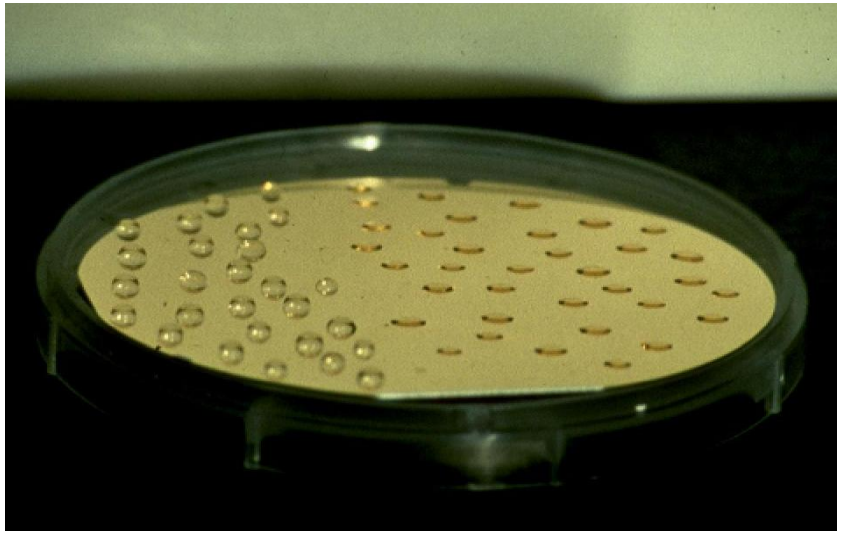
15KV
10000x
1.00μm
0063

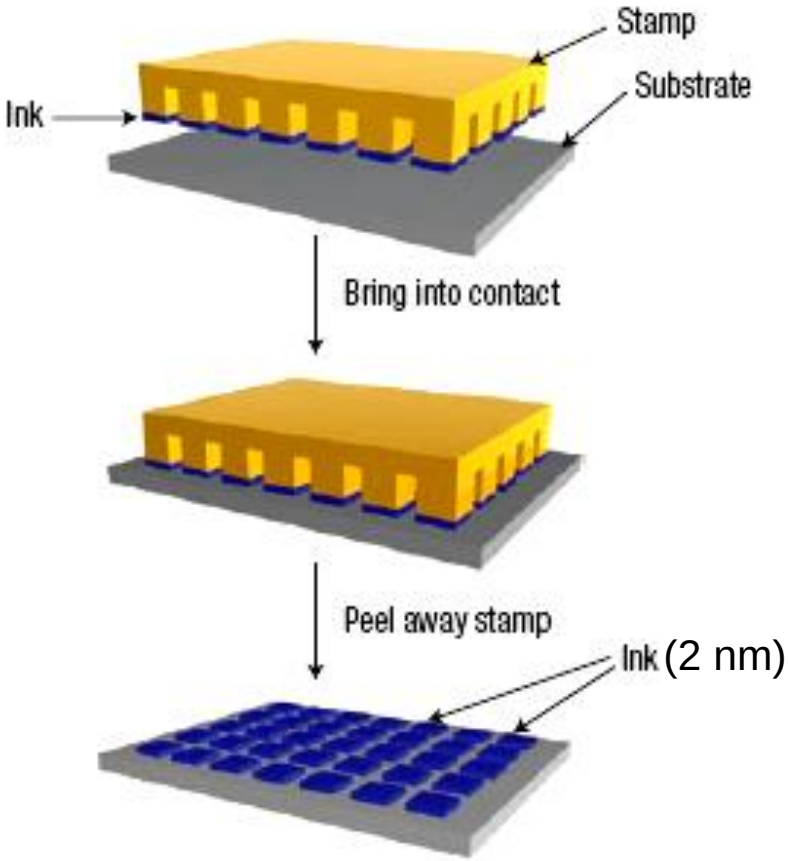



Au
Si
SAMs
Proteins
Room-temperature
quantum behavior
0.1
1
10
100 nm
Chemistry
"Bottom Up"
Photolithography
"Top Down"



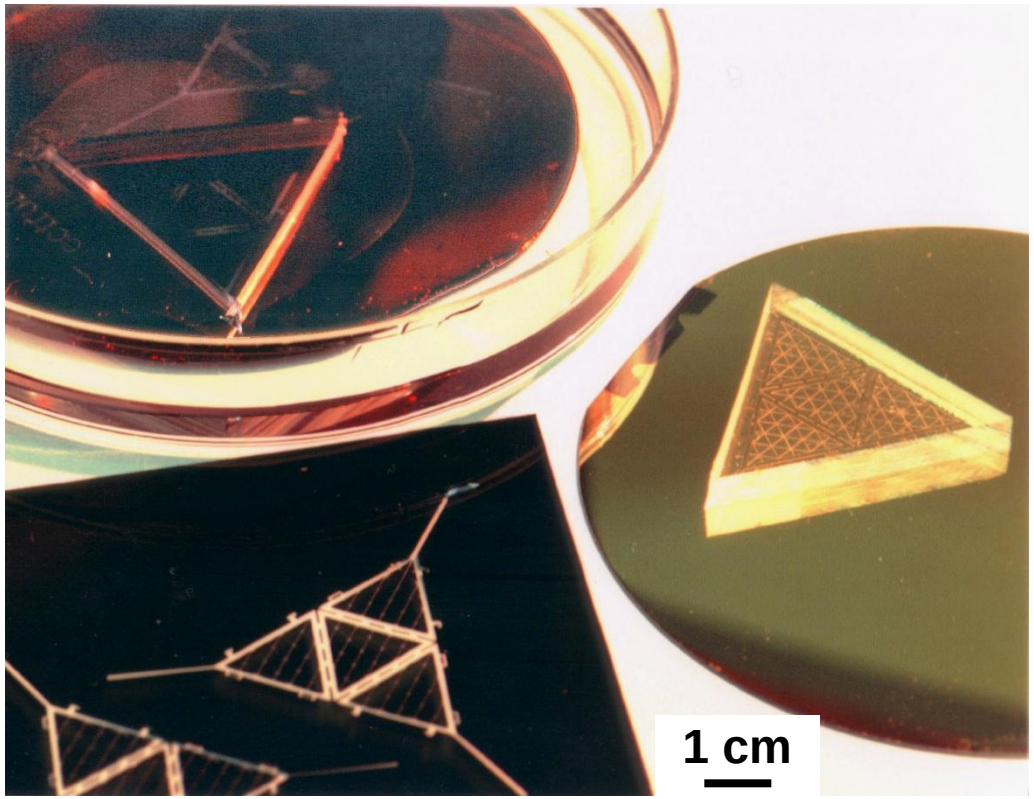
Microcontact Printing

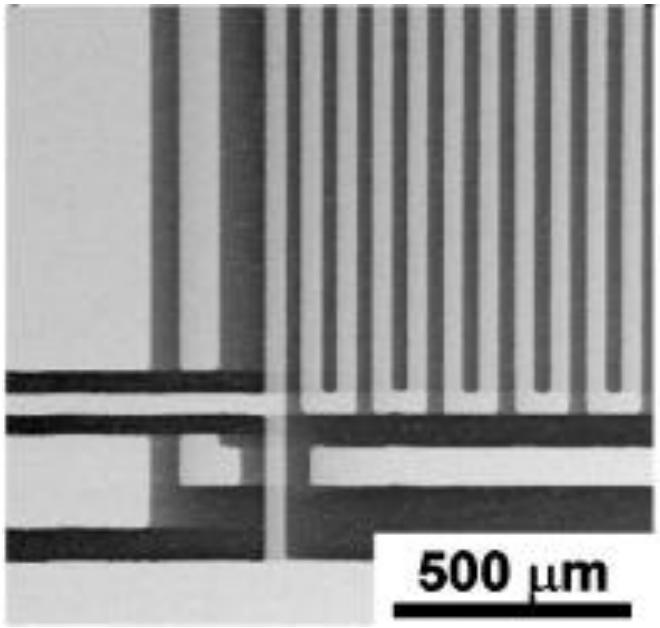


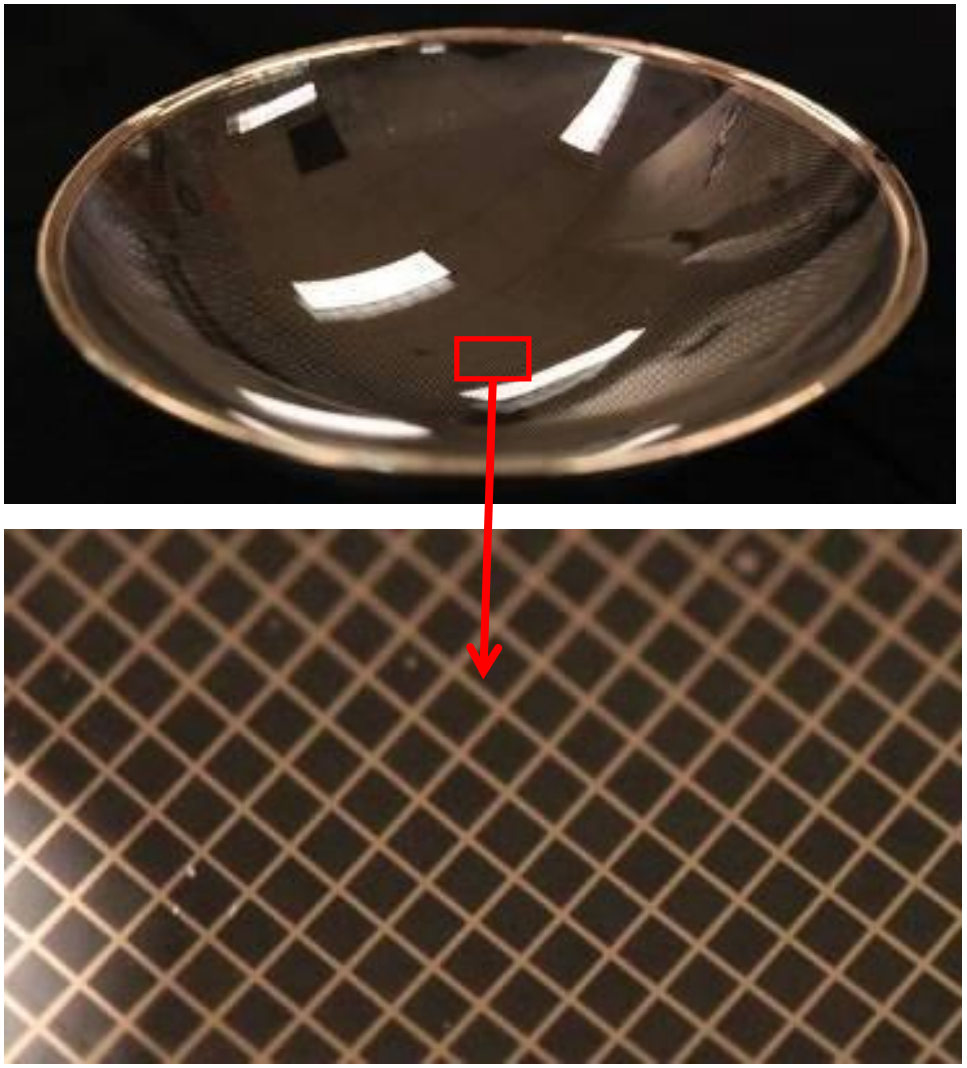


Abbott, Xia, Rogers, Aizenberg

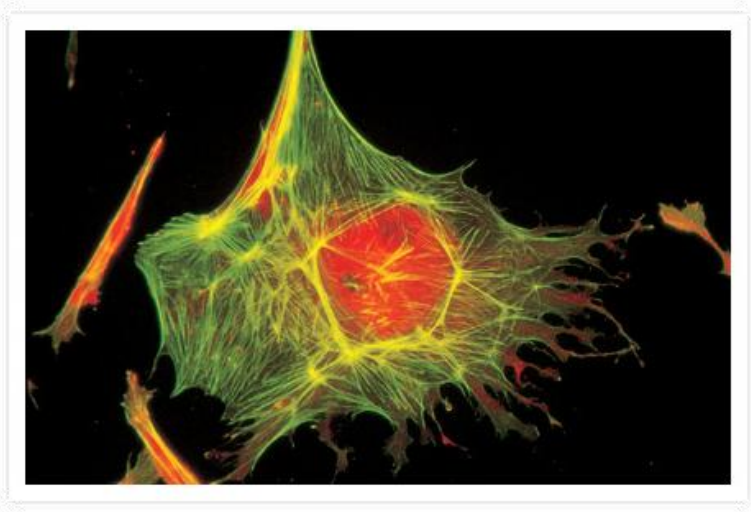
FRONT

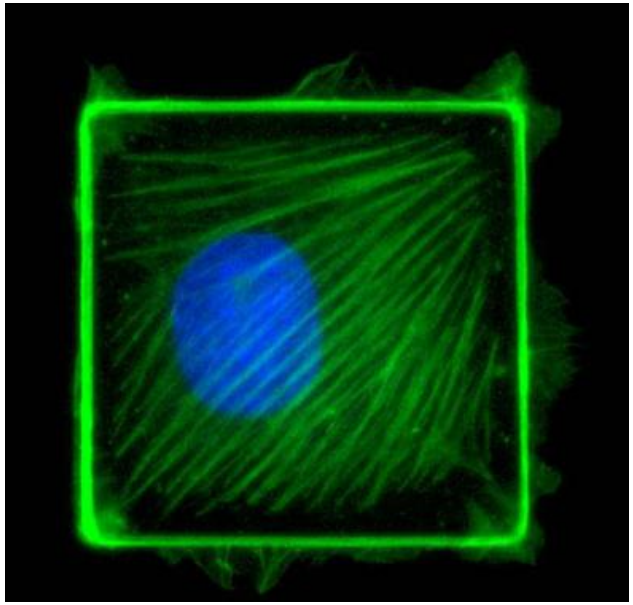

1 cm


500 μm



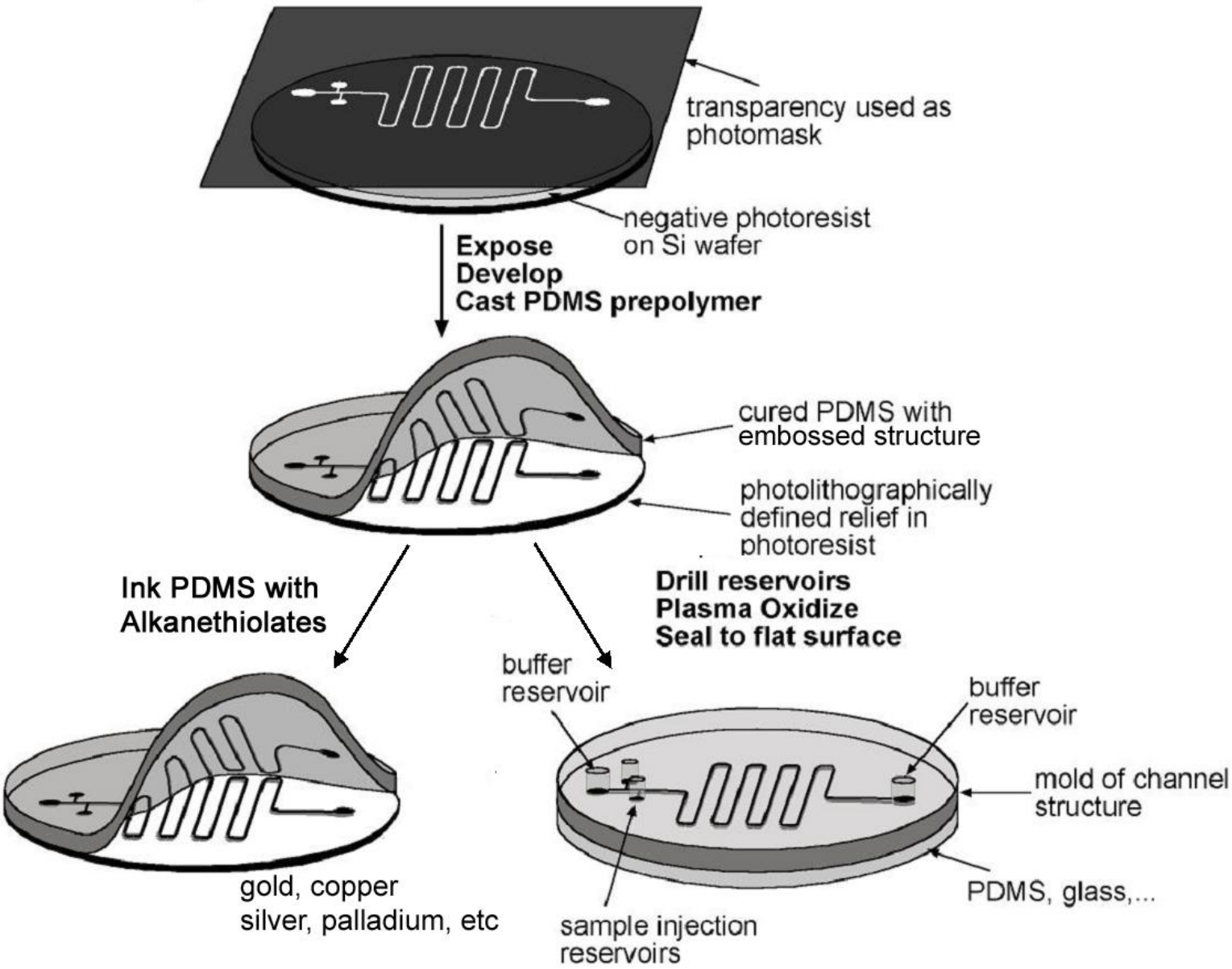
20-µm Au lines
EM shielding
X100? Cost reduction



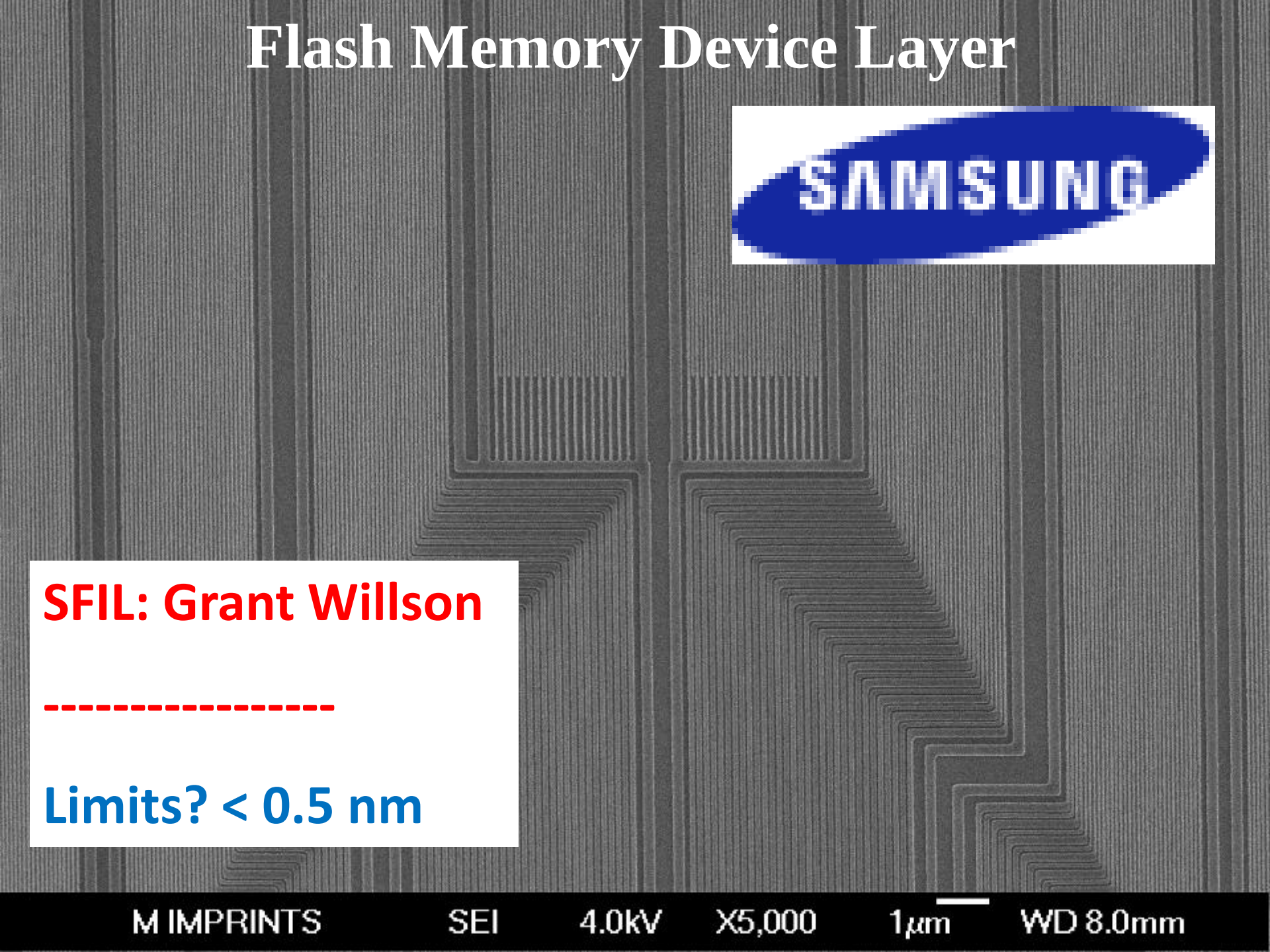


Mrksich, Ingber

Soft Lithography


transparency used as photomask
negative photoresist on Si wafer
Expose
Develop
Cast PDMS prepolymer
cured PDMS with embossed structure
photolithographically defined relief in photoresist
Ink PDMS with Alkanethiolates
Drill reservoirs
Plasma Oxidize
Seal to flat surface
buffer reservoir
buffer reservoir
mold of channel structure
gold, copper silver, palladium, etc
PDMS, glass,...
sample injection reservoirs

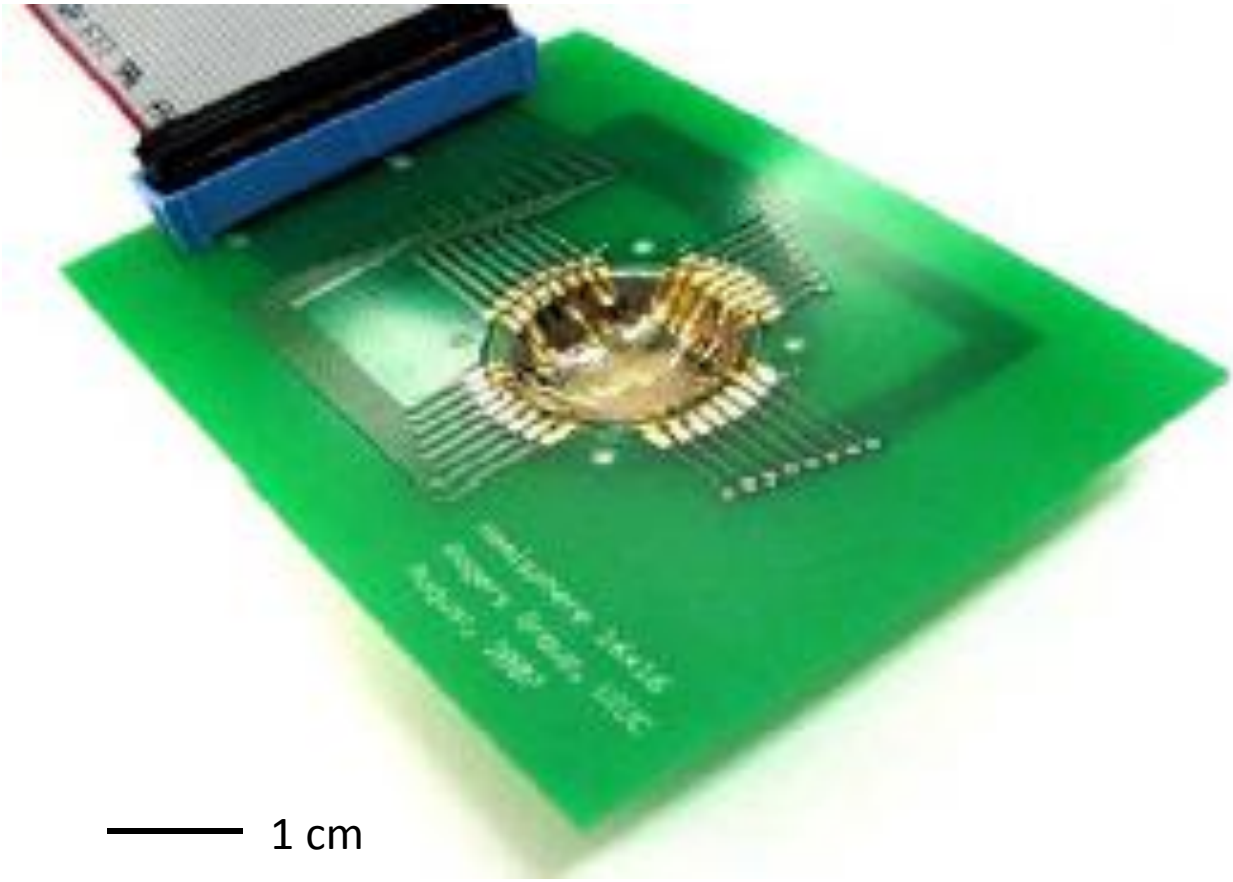
Flash Memory Device Layer

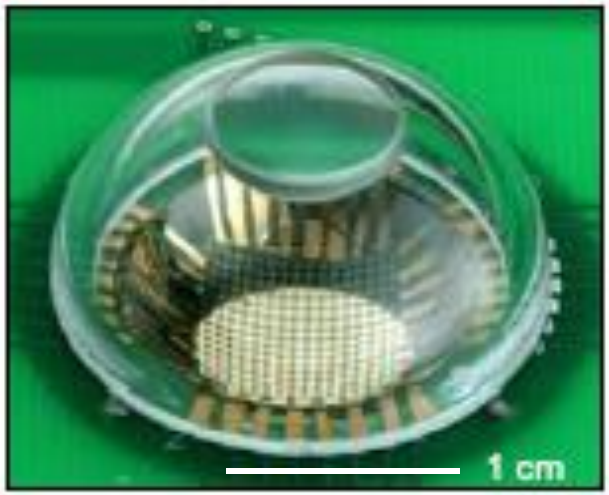


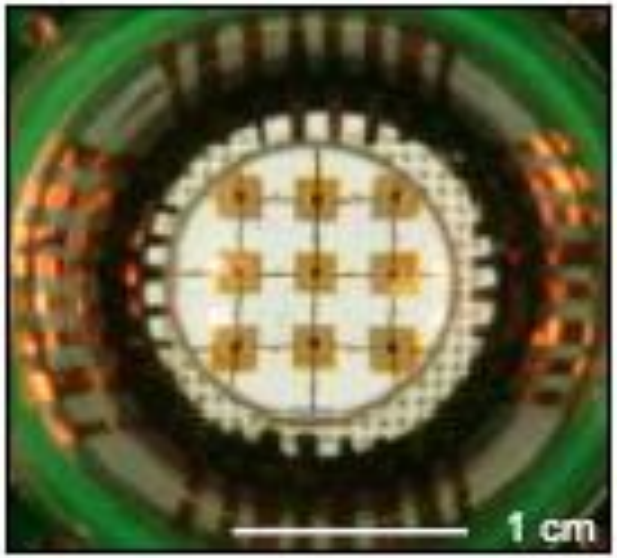
SFIL: Grant Willson

Limits? < 0.5 nm

Electronic Eyeball Camera via Stretchable Electronics



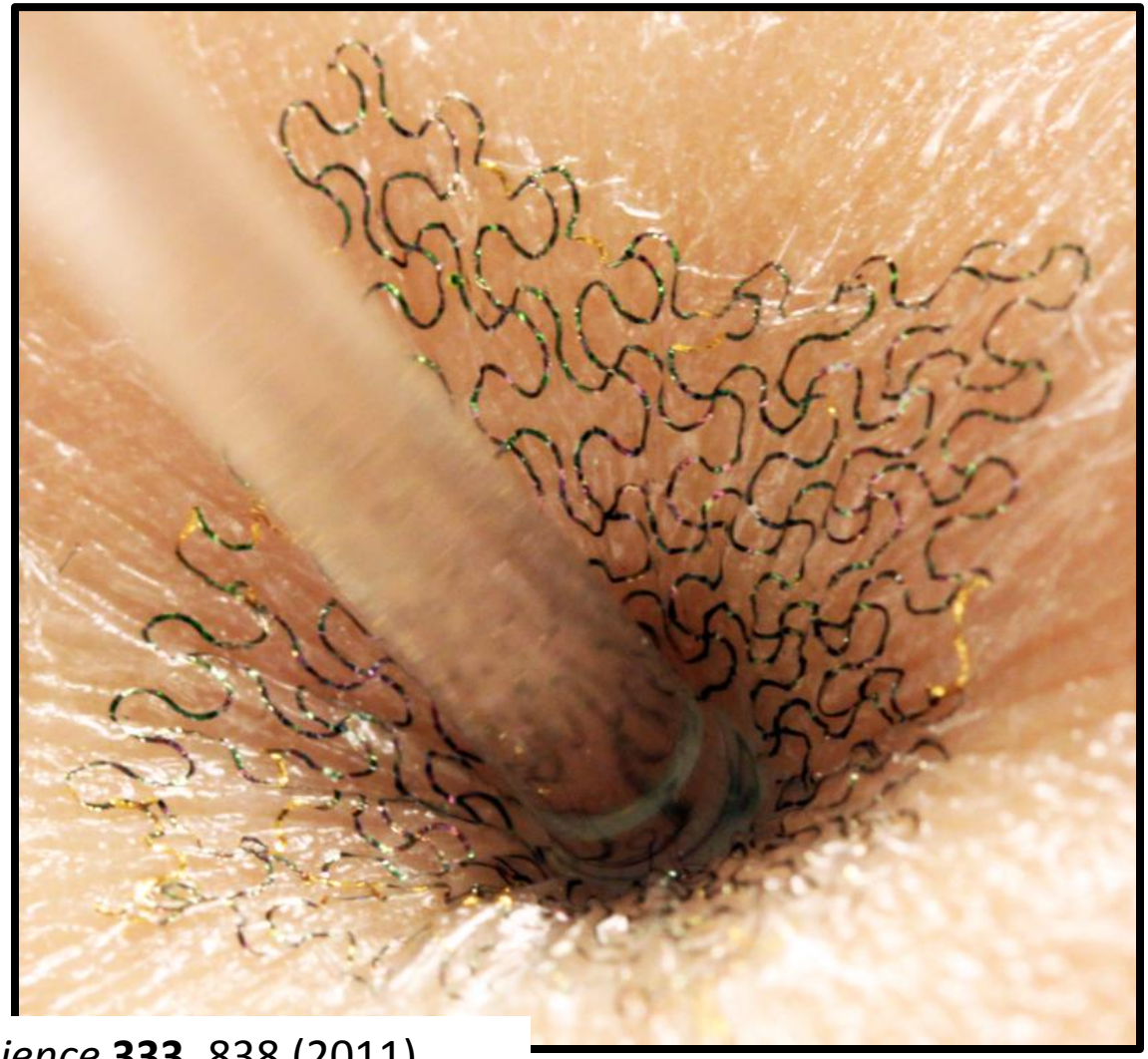




Nature **454**, 748 (2008).

Epidermal Electronics

Skin Mounted, Deformed



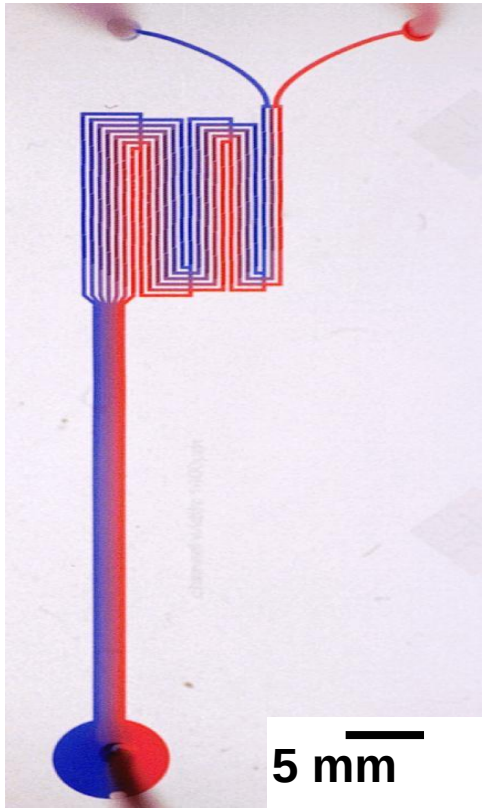
Free Standing

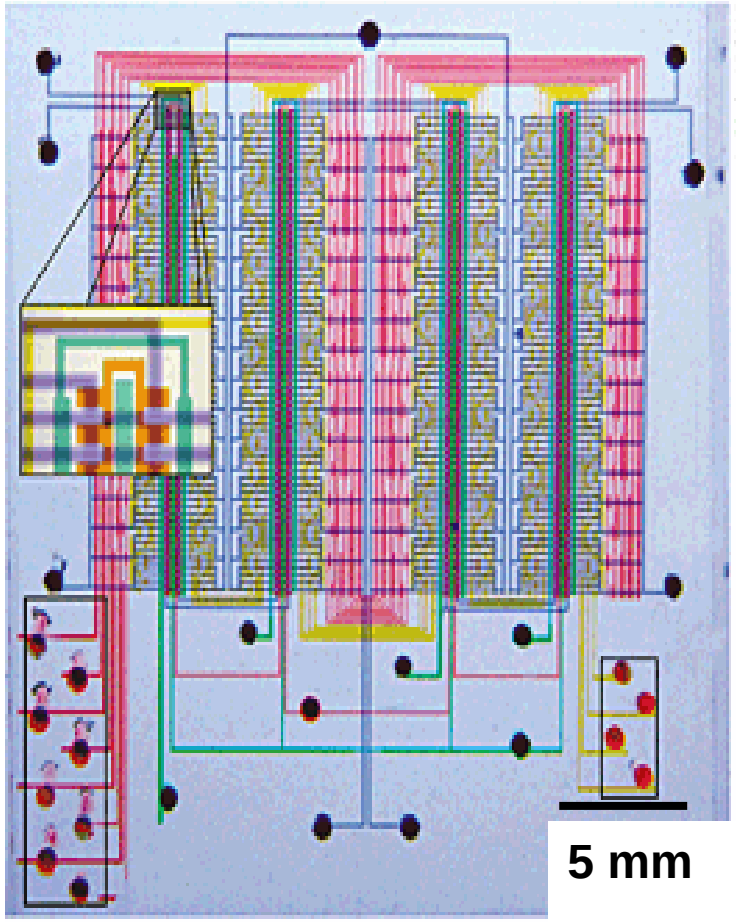
3 mm

Science **333**, 838 (2011).

John Rogers

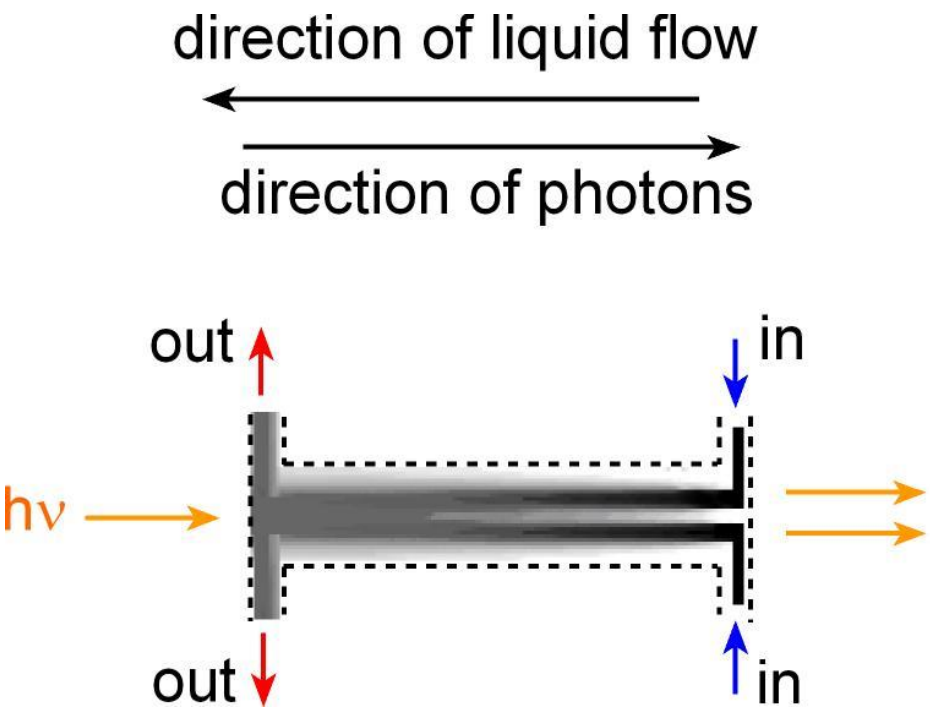
Microfluidics



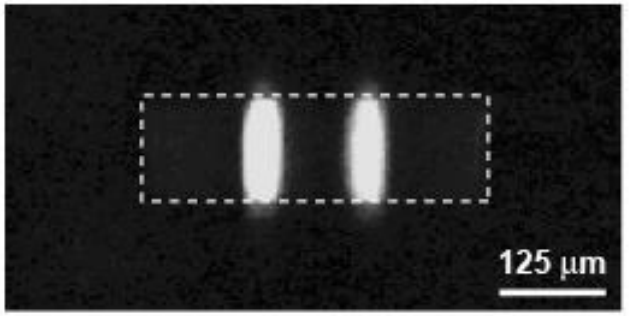


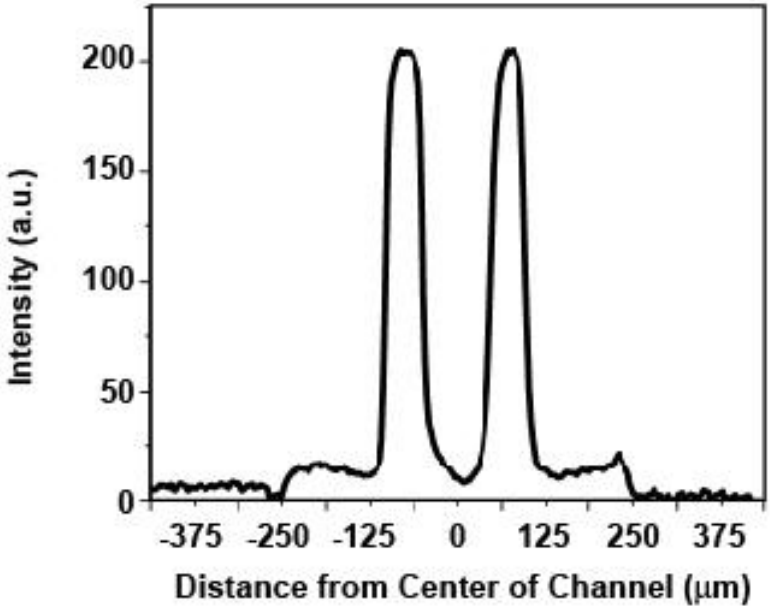
Quake/Fluidigm Inc

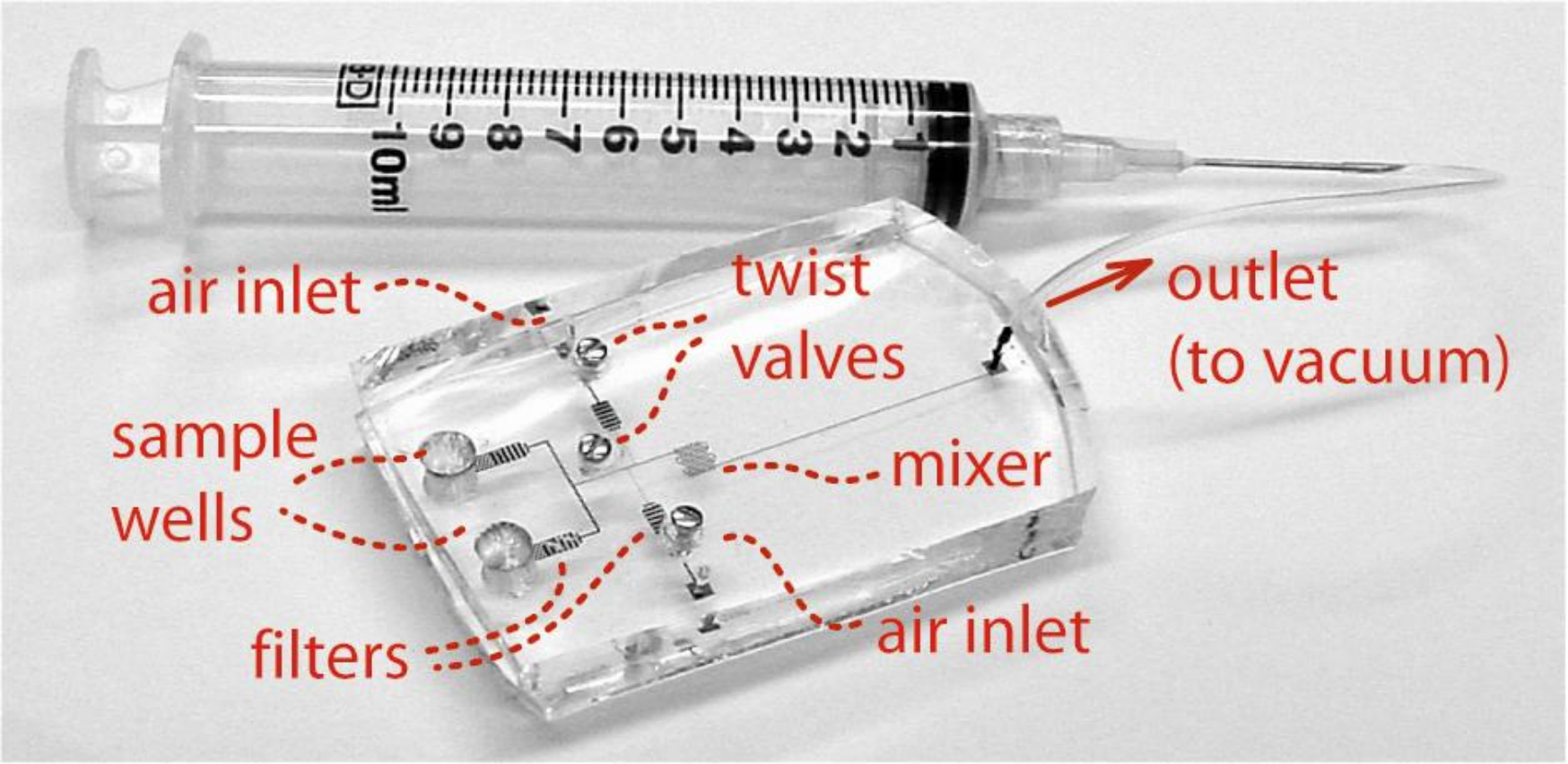
A diffusive splitter



Output

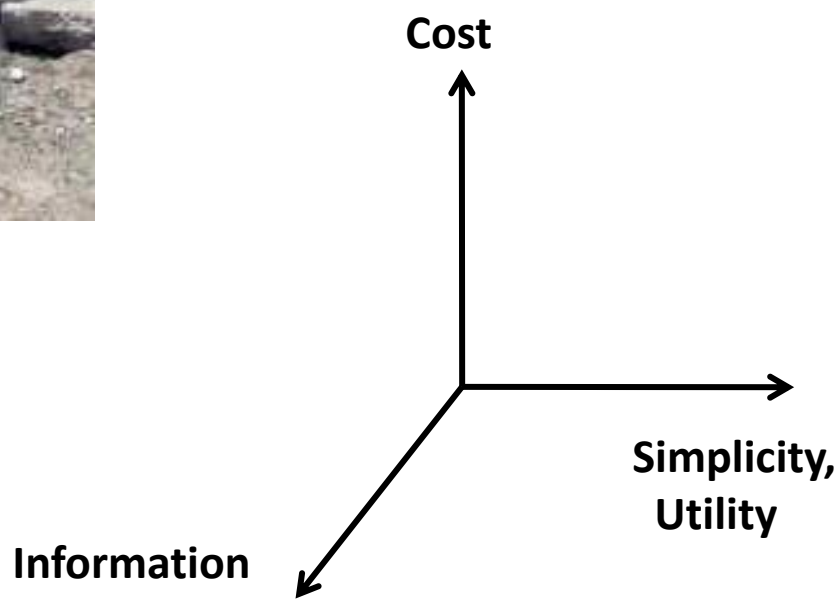





air inlet
twist
valves
outlet
(to vacuum)
sample
wells
mixer
filters
air inlet

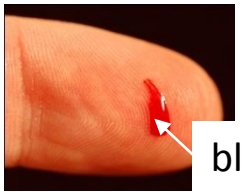
Paper Diagnostics

Dr.Gabhrani's
SPECIALITY CLINIC
FOR
SEX·SKIN
VD· & HIV

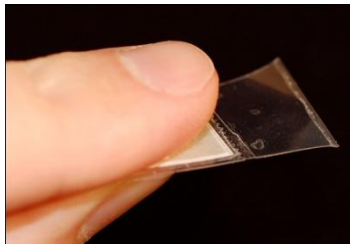

Cost
Simplicity,
Utility
Information

ALT
NEG
POS
AST
© Diagnostics For All

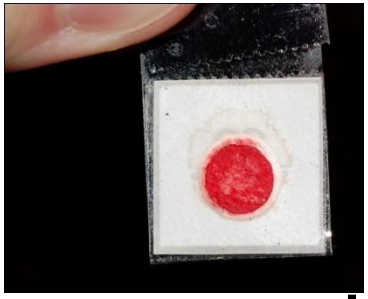
Liver Function Tests



prick finger



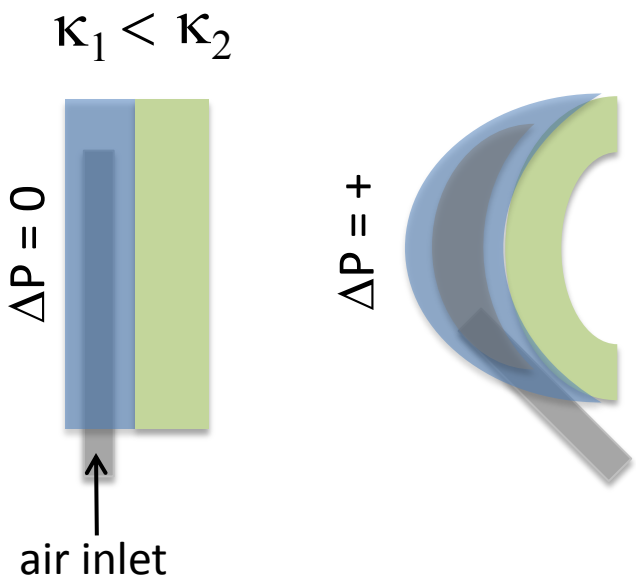
gently squeeze device



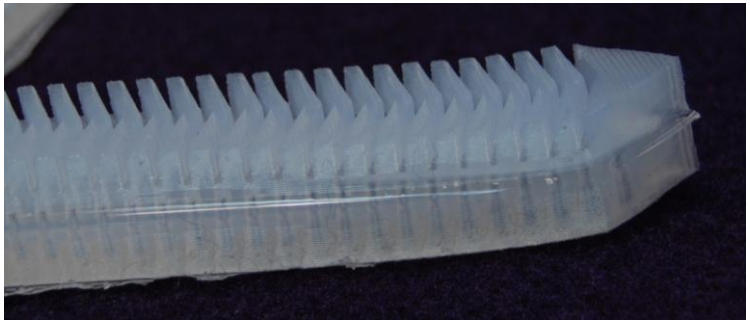
blood on filter

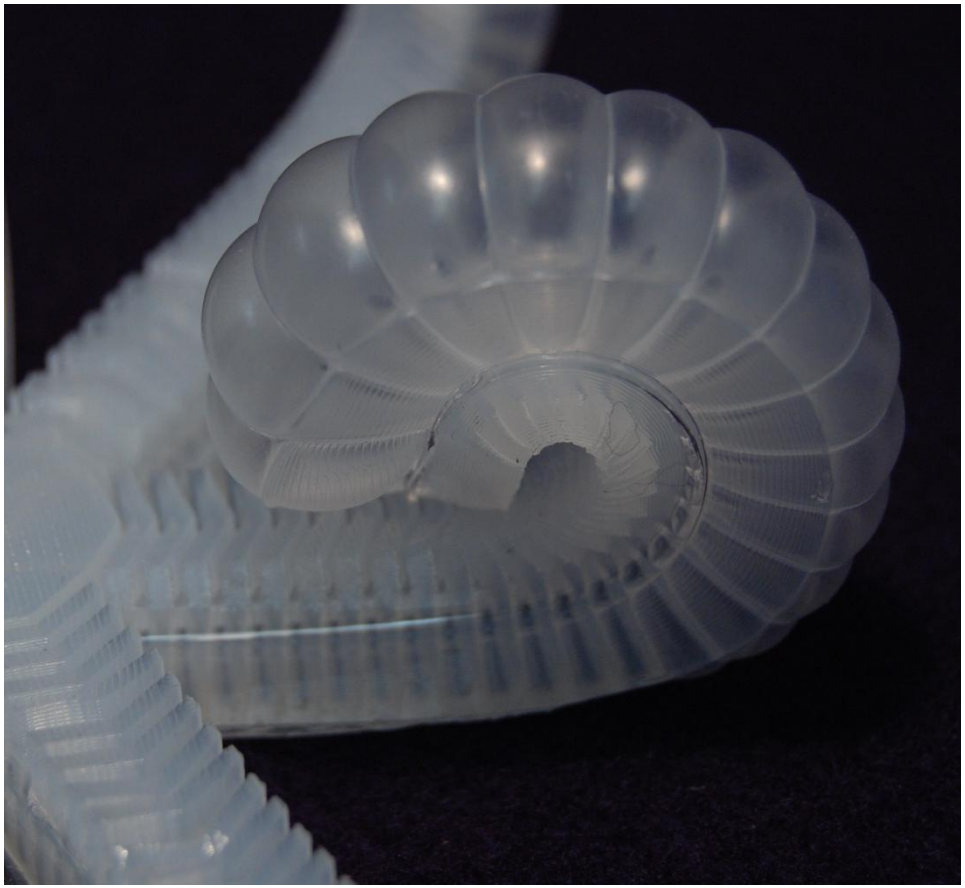
plasma (with liver function tests)

Soft Robotics



- **Compressed air inflates pneumatic network, inducing strain**
- **Differential strain induces curvature**





Paper/Elastomer Actuator

Harvard University. Whitesides Group.

Paper/Elastomer Actuator

Harvard University. Whitesides Group.

Technology = Companies

- Diagnostics for All
- Nano Terra
- MC 10
- Semprius
- Cool Edge
- Liquidia
- NanoInk
- Surface Logix
- Claros
- Cellectricon
- Fluidigm
- Raindance
- Biacore (chips)
- Molecular Imprints
- Minerva
- GeneOhm

As we are doing it, it is taking 10-20 years to go from “idea” to “manufactured product”.

Curiosity, or Problem

Science

"Amorphous Technology"

Product Prototype

Manufacturing Prototype

Manufactured Product

Essential

MURI
DURIP
DARPA
Gates Foundation

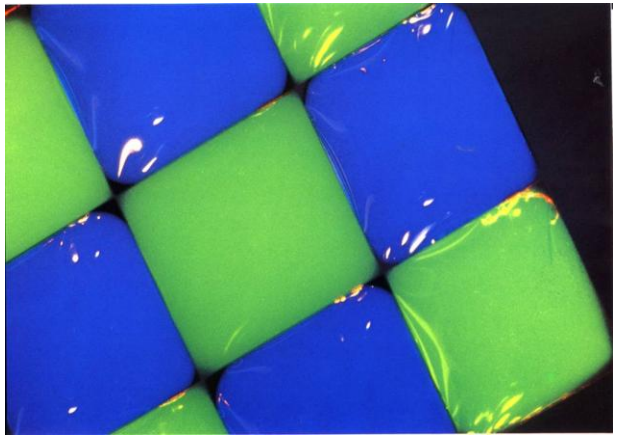
Absent

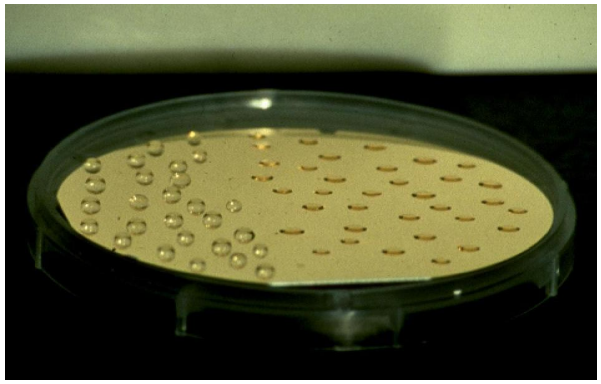
NSF
NIH
DoE

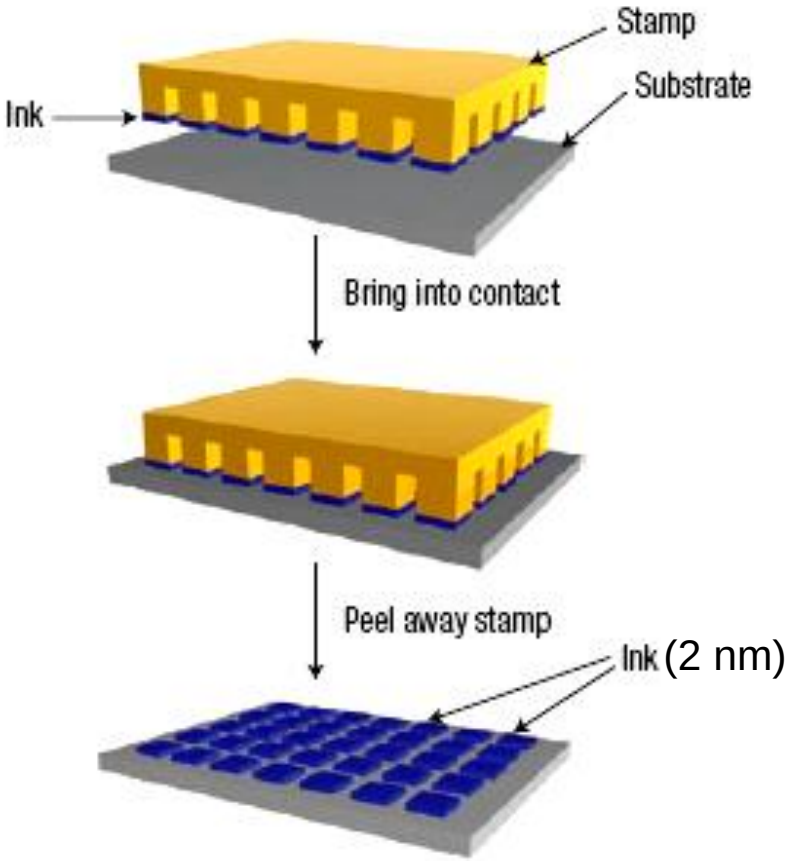
New Participants

BASF
Reliance
Wyss
CSIR (India)

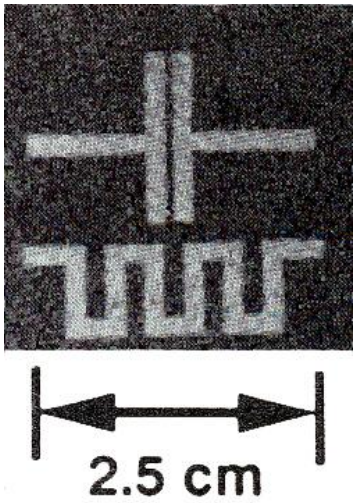
SAM → Micro contact printing



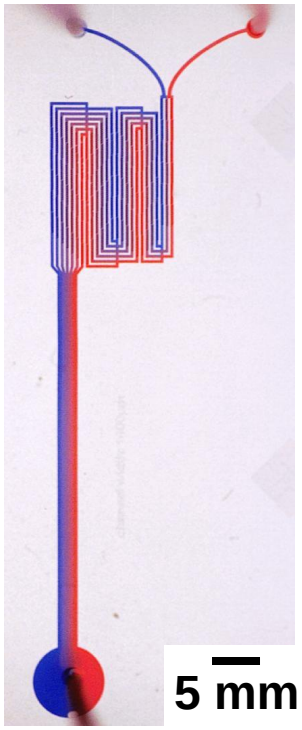


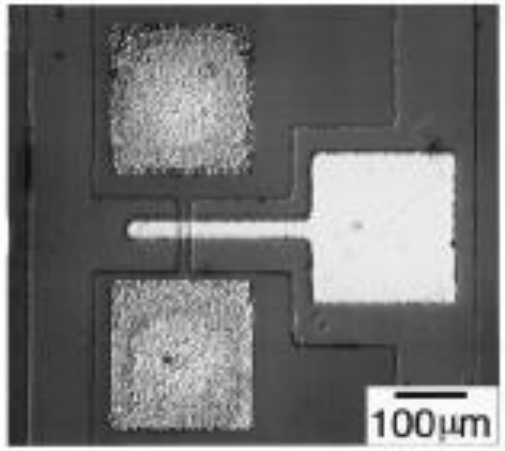


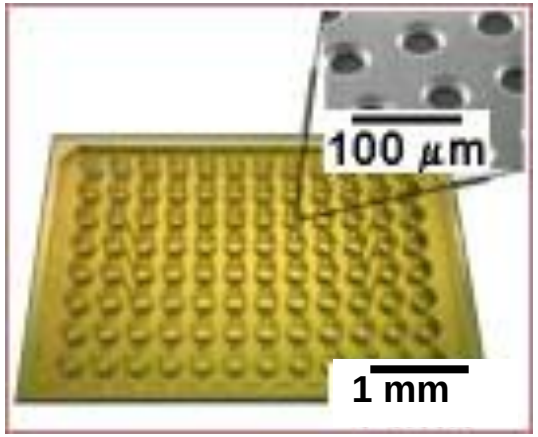
Abbott, Xia, Rogers, Aizenberg



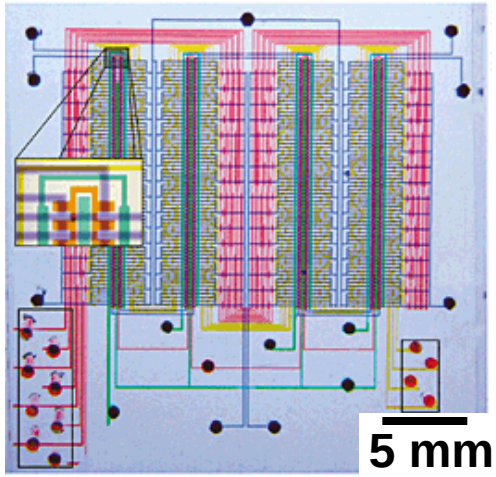
Kumar, Whitesides
Appl. Phys. Lett.
(1993) 63, 2002



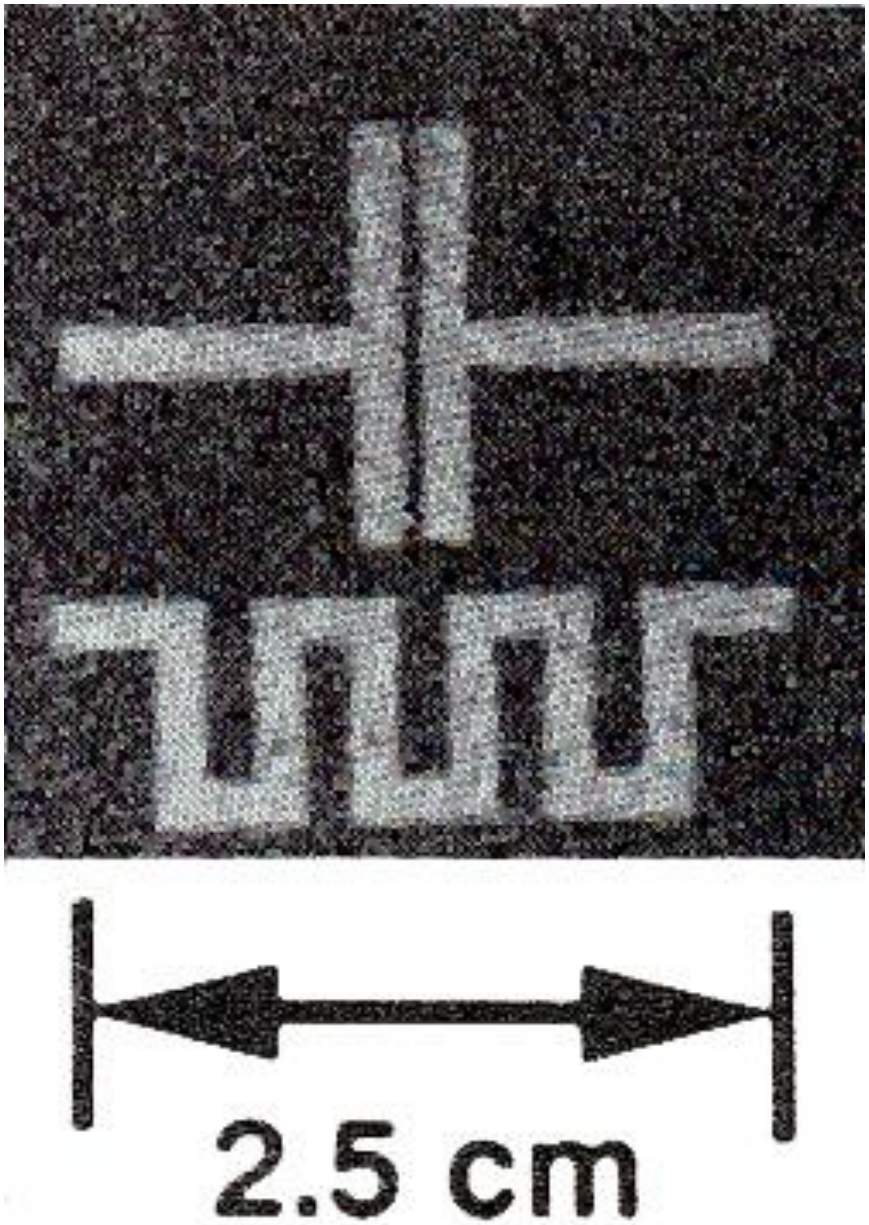




Whitesides/Surface Logix Inc



Quake/Fluidigm Inc


2.5 cm