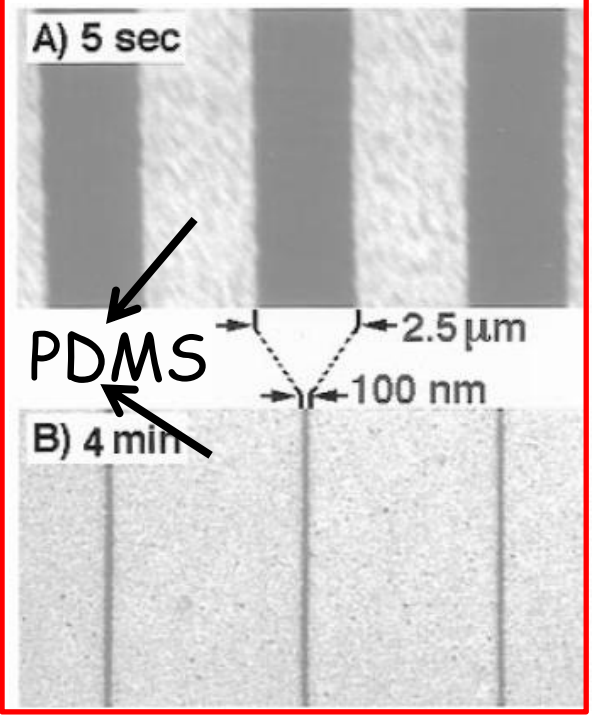
Extending Resolution of Soft Lithography

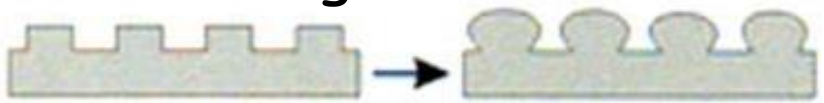
Methods to Reduce Feature Size:

Reactive Spreading

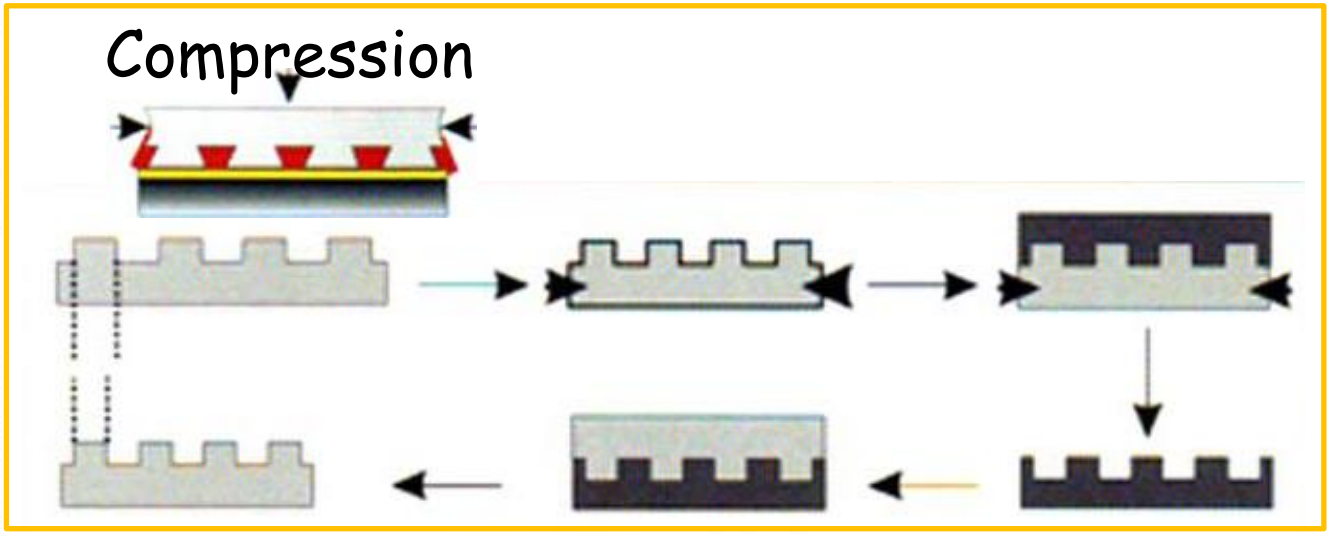


Extraction of Filler

Swelling in Solvent



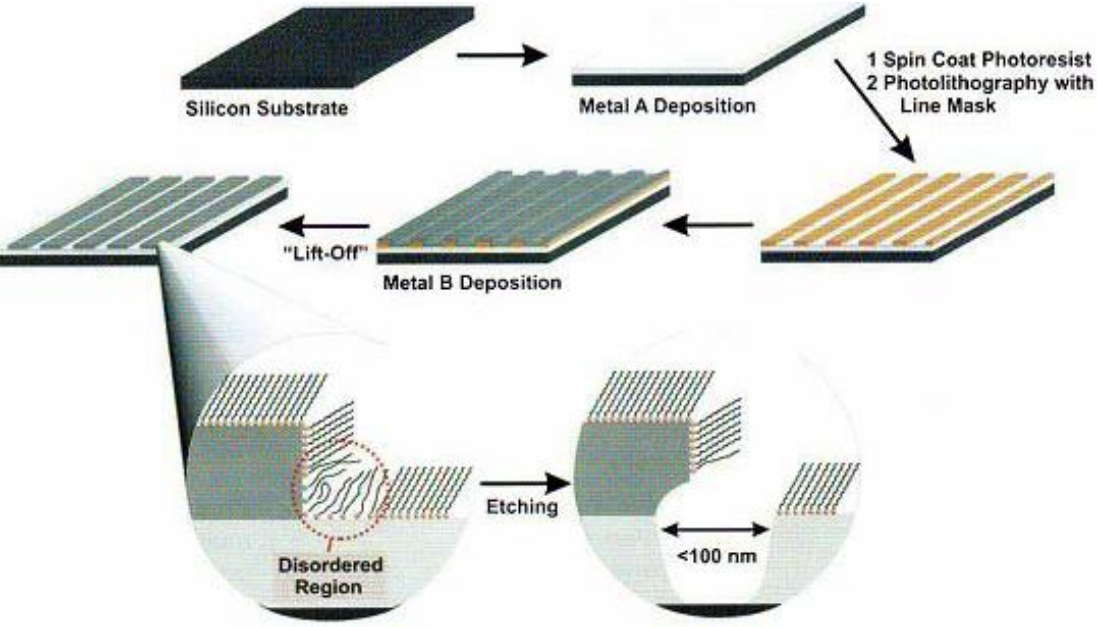
Compression

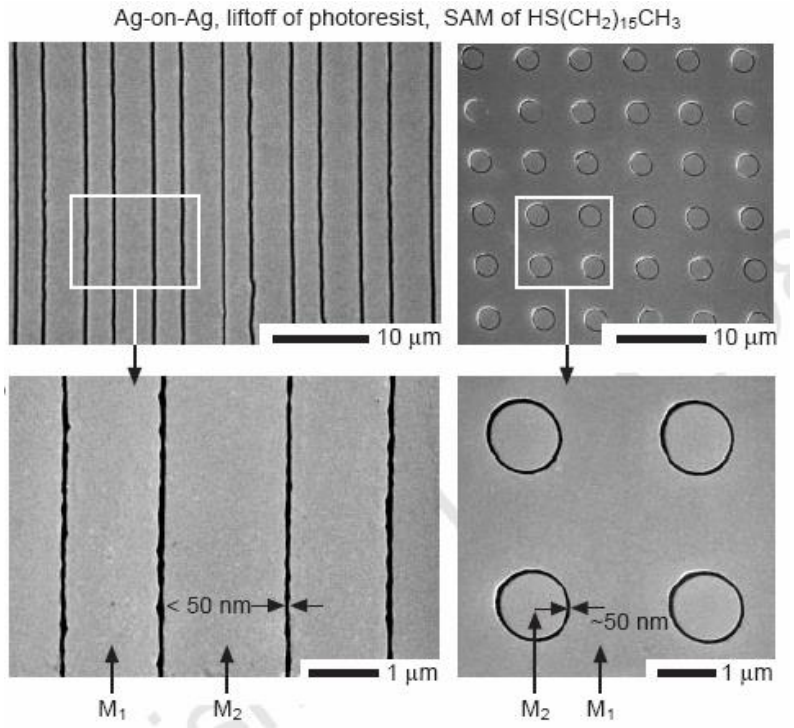


Langmuir **13**, 2059 (1997)

Defect Patterning

Topologically Directed Etching



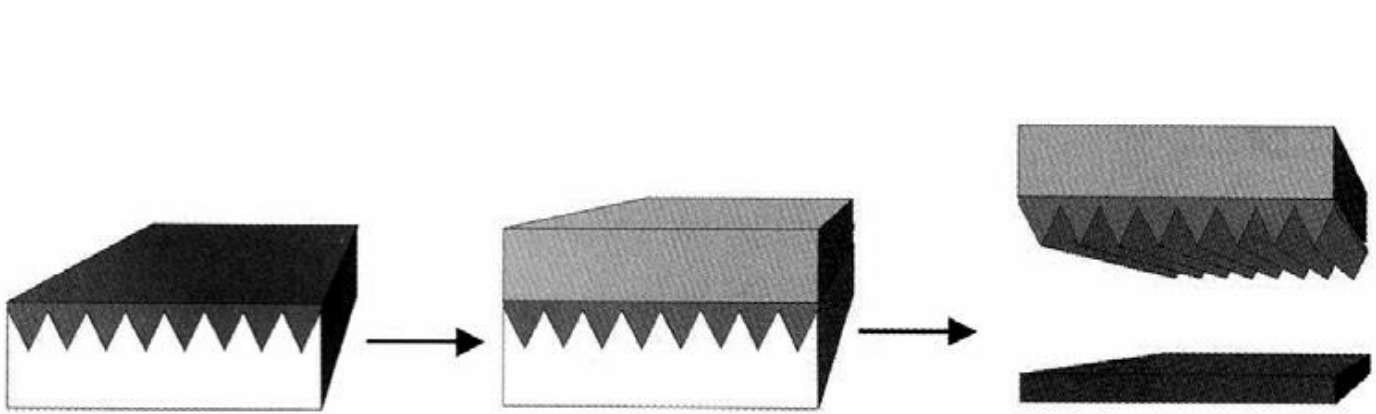


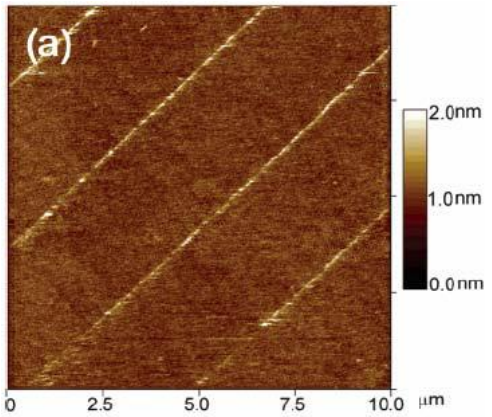
Local Disorders in SAMs:

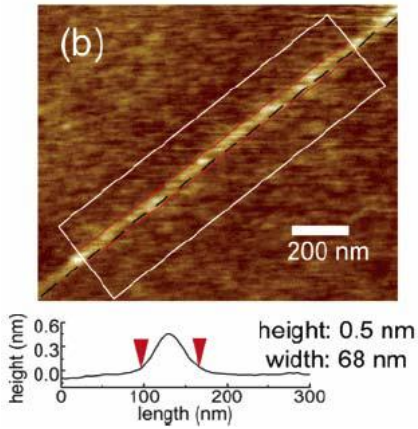
- High disorders in the transition region between two planar surfaces.
- Higher disorders lead to less etch resisting.

Nature **394**, 868 (1998)

Below 30 nm Nanocontact Printing





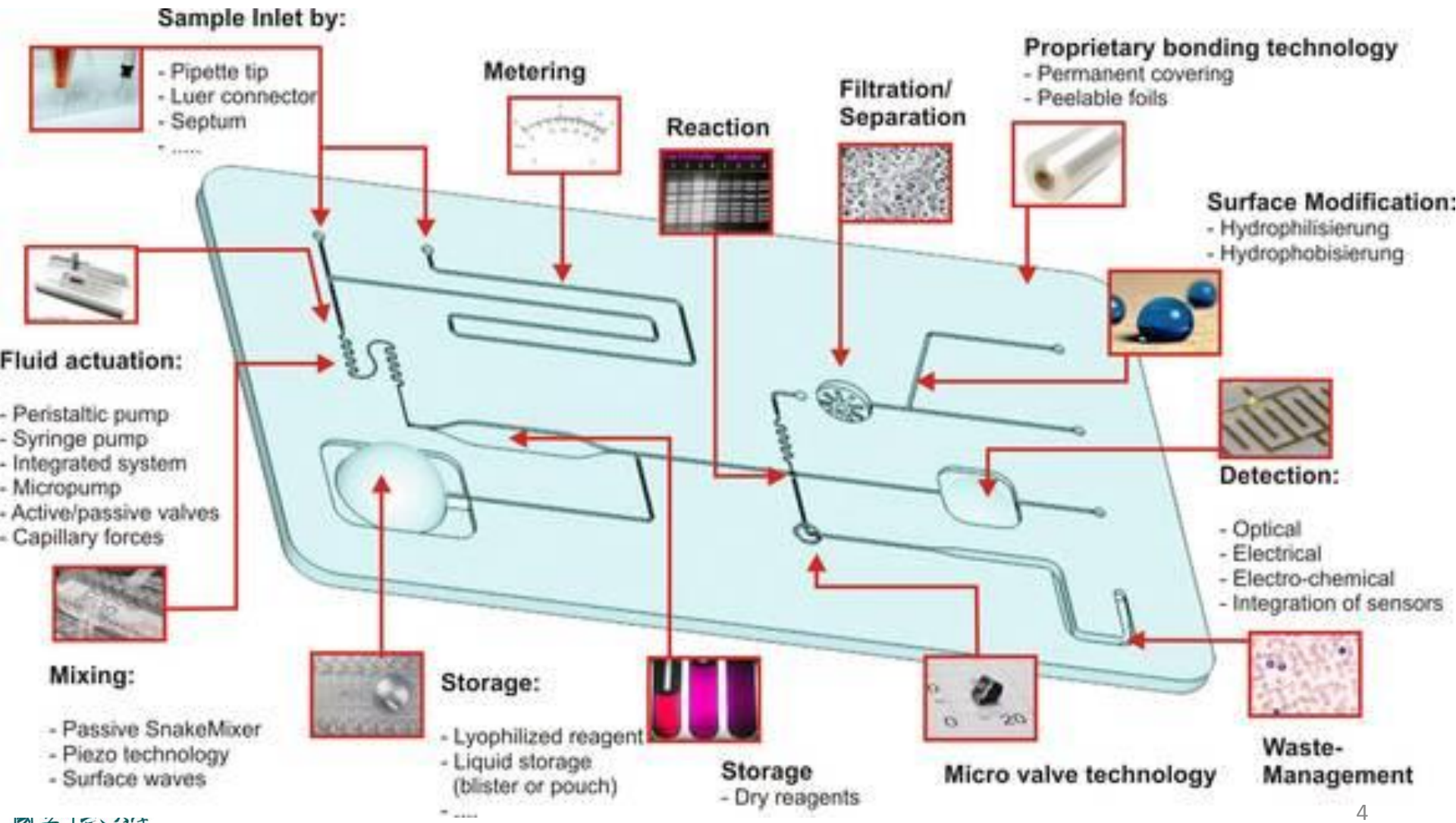


- Hard PDMS reduces deformation.
- High molecular weight inks reduce mobility and diffusive smearing.

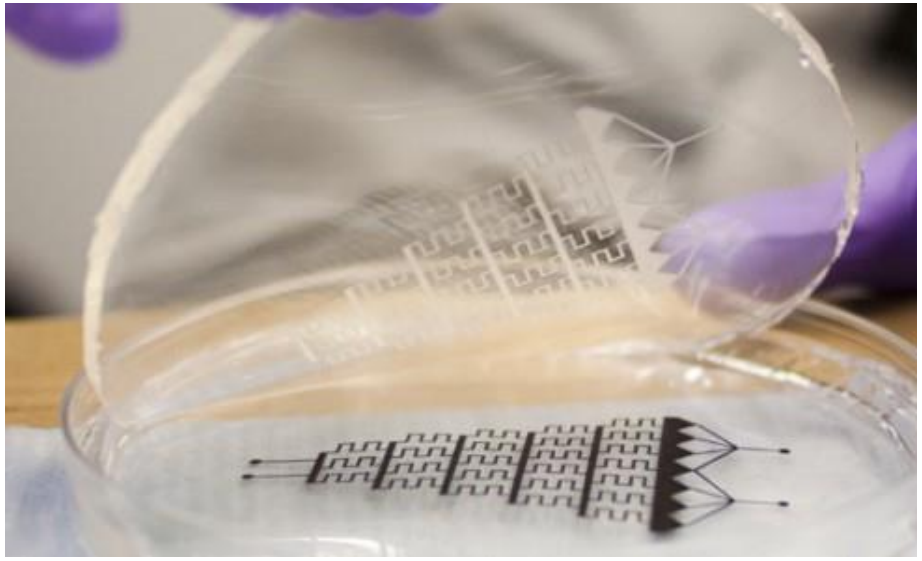
Printed titin multimer protein lines on Si

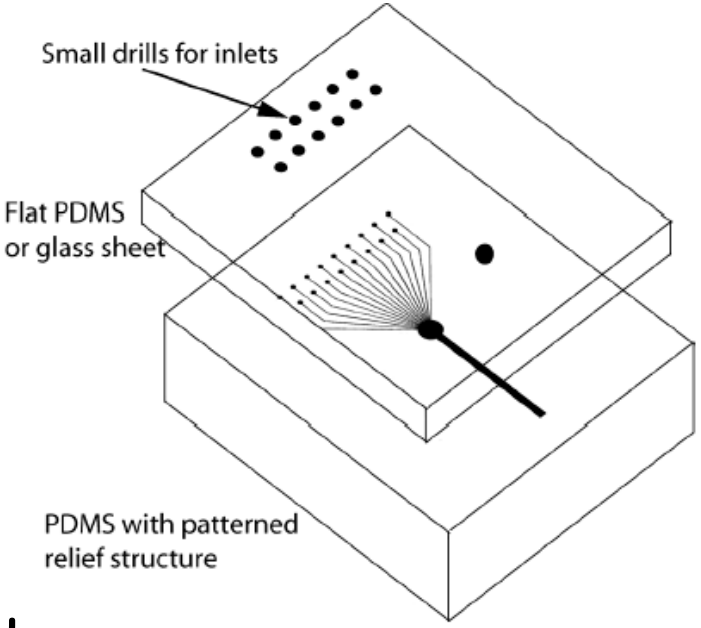
Langmuir **19**, 1963 (2003)

Soft Lithography for Microfluidics



Microfluidic Channels

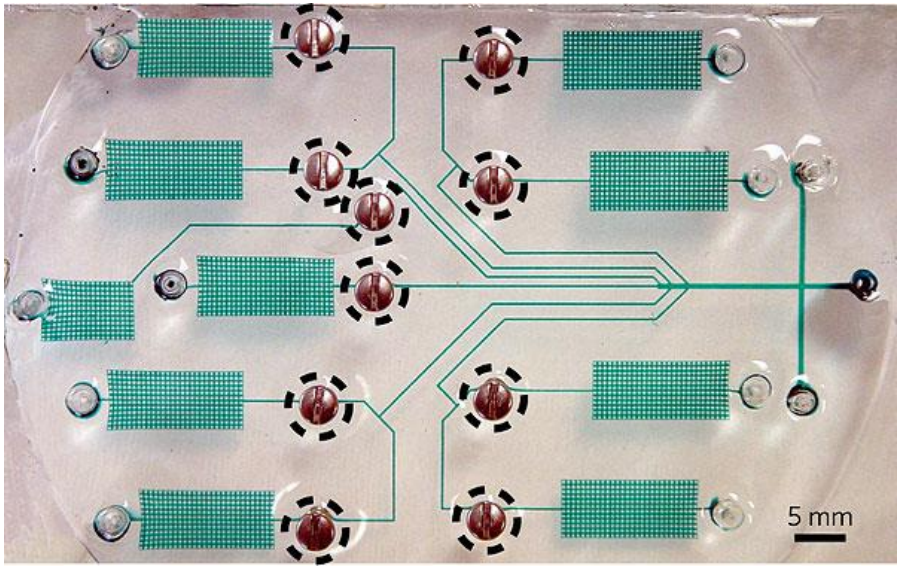


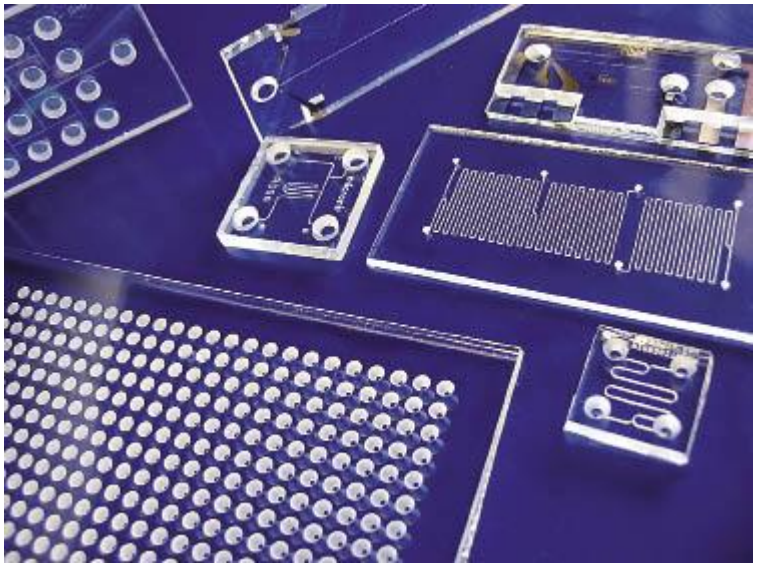


Fabrication of microfluidic channels:

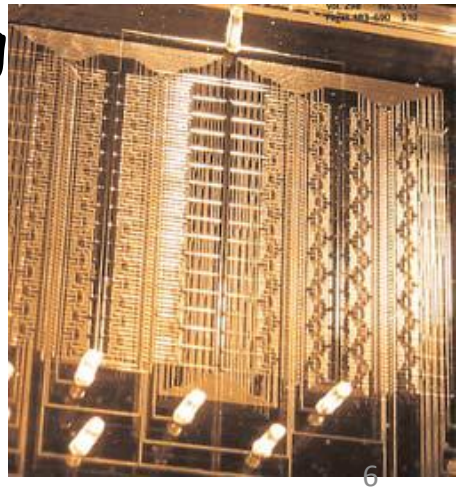
- PDMS piece is released from the master.
- Bond a standard glass slide on top of it.
- Typical microchannel width: tens of micrometers.
- The thickness of the channel is controlled by the thickness of the photoresist.

Soft Lithography for Microfluidics





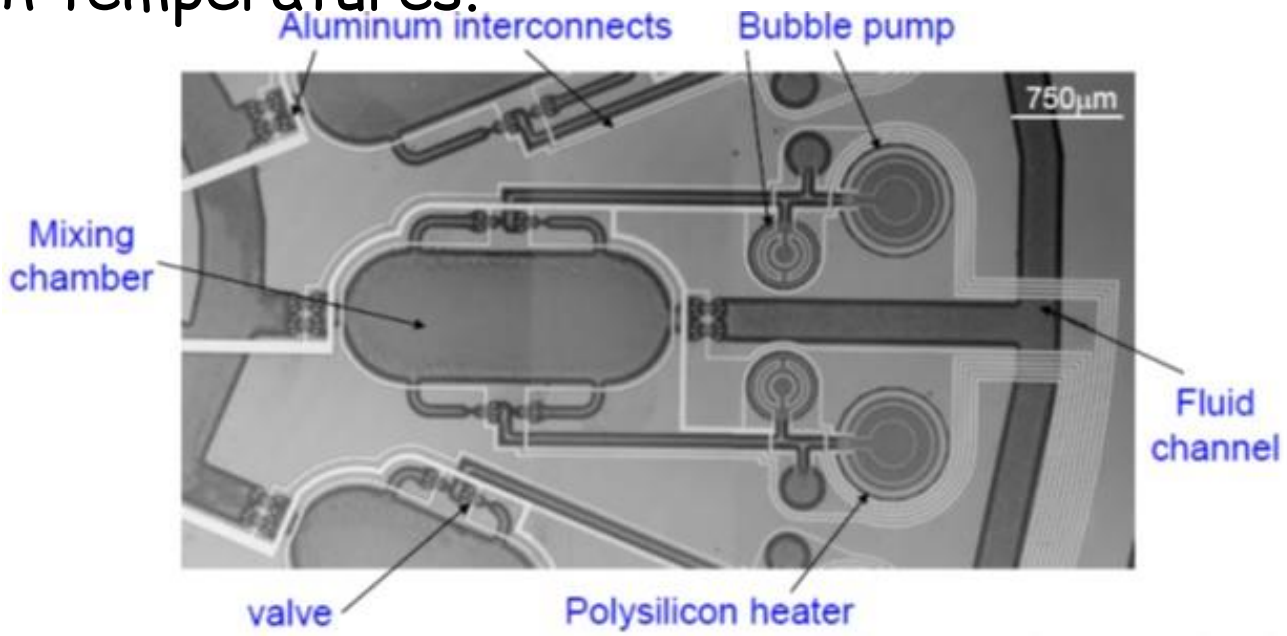
- Soft lithography is well suited for generating microfluidic channels in PDMS.
- Microfluidic channel finds applications in
  - CPU cooling
  - Lab-on-a chip devices
  - Bio-sensors



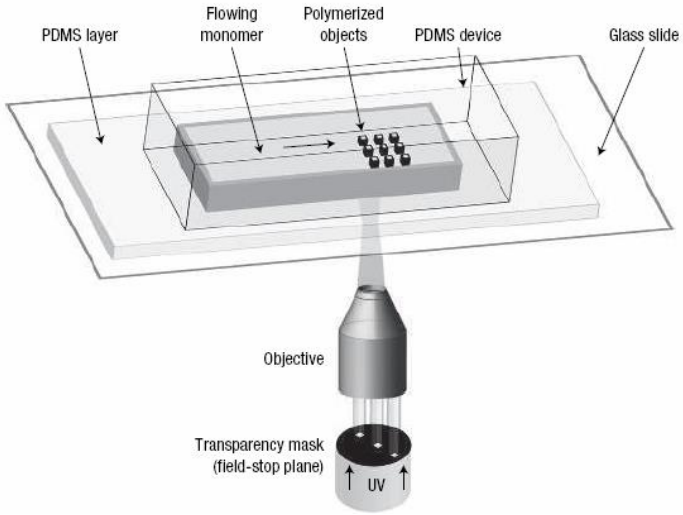
PDMS Channel Advantages

- The PDMS Channels have advantages over Si or glass channels:
  - Inexpensive
  - Flexible and durable
  - Simple to prototype

- Disadvantages: unstable in contact with some organic solvents and at high temperatures.



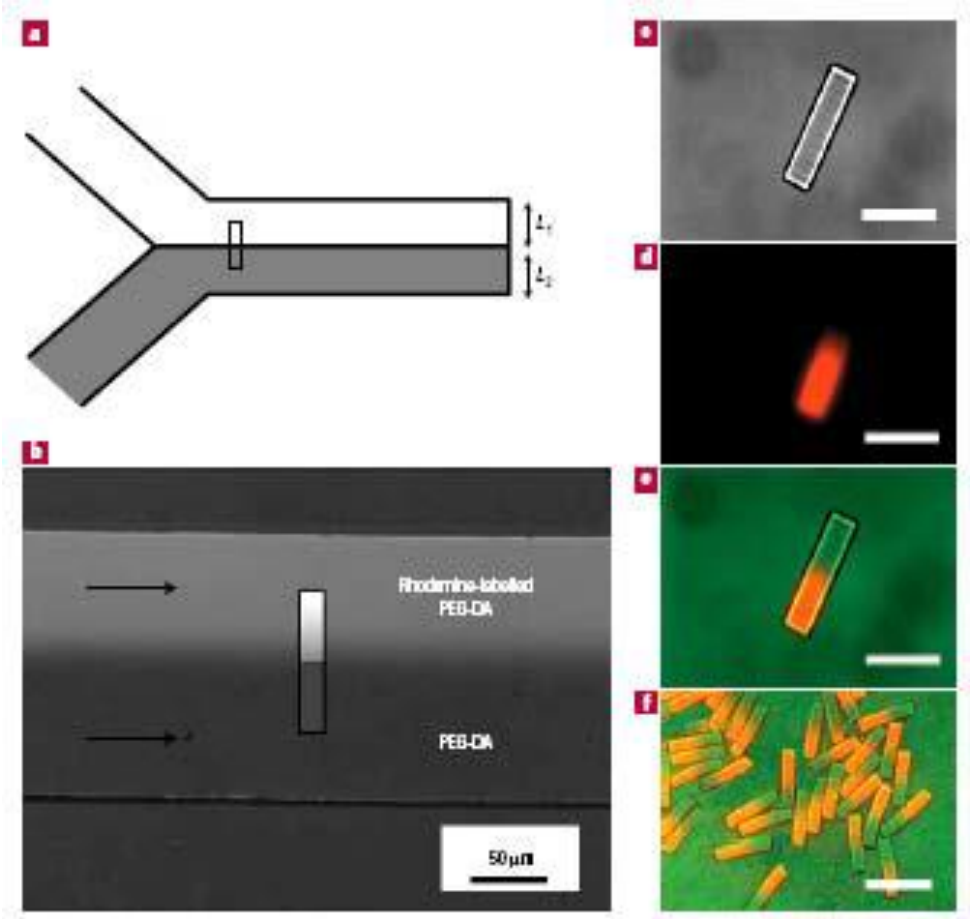
Making Janus Particles



Reynolds number (Re) – a dimensionless parameter that describes a fluid's tendency to be turbulent.

$$R_e = vl\rho/\eta \qquad R_e \sim 1 << 2000$$

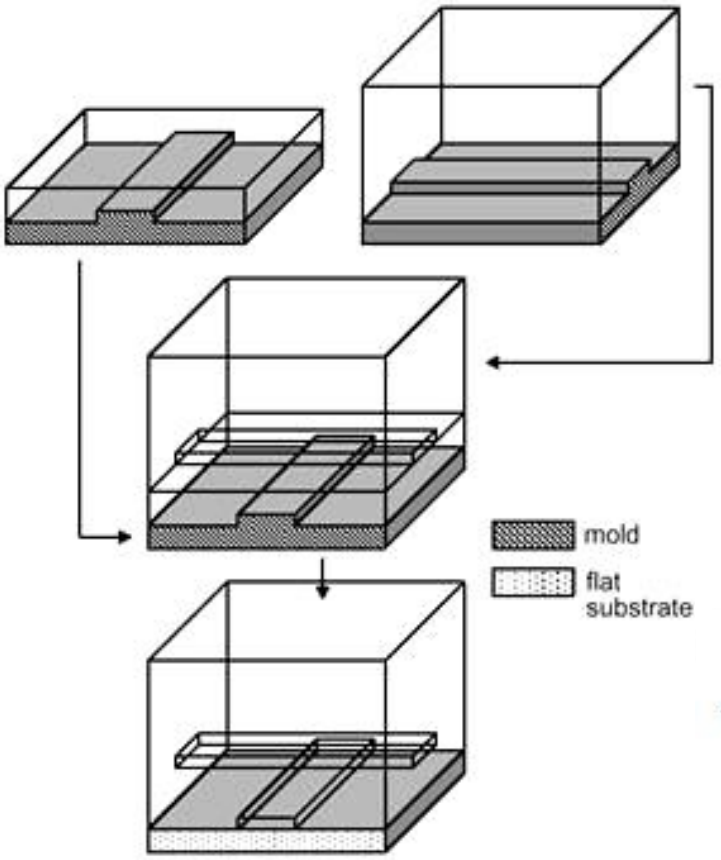
Laminar Flow!

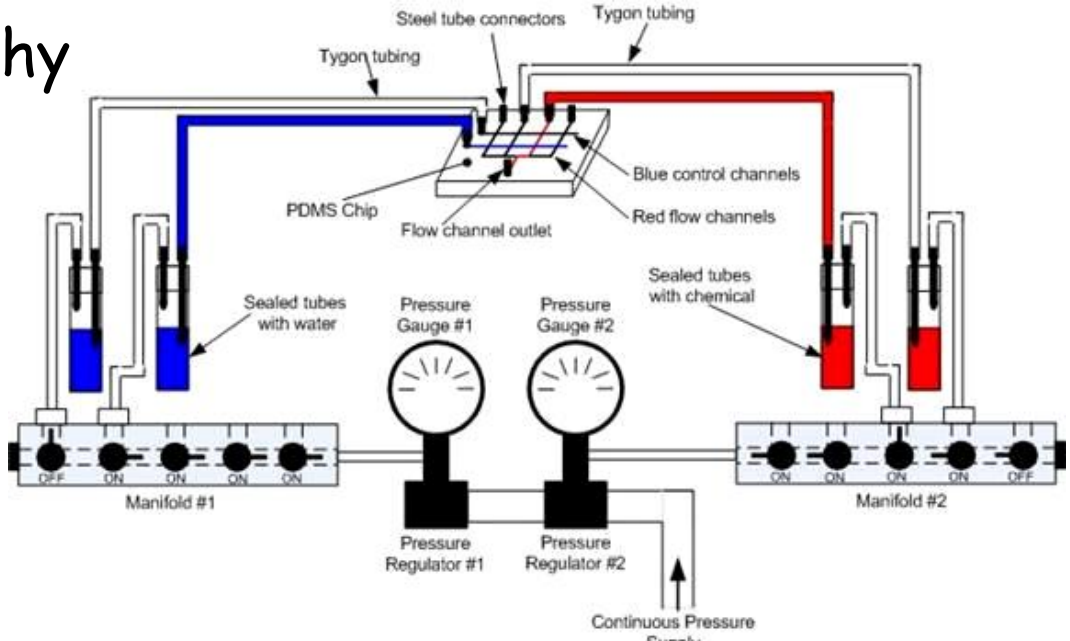


Janus particles

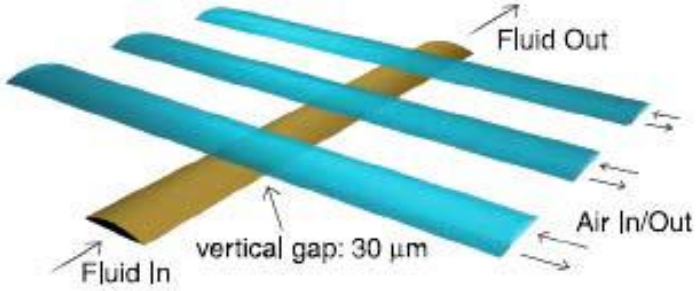
Multilayer Soft Lithography - Microvalves

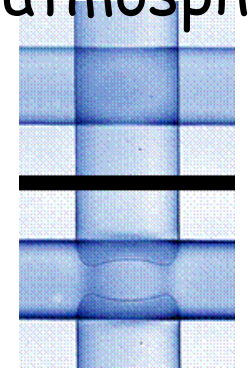
Multilayer Soft Lithography





P = atmosphere





P = 200 kPa

Science **288**, 113 (2000)

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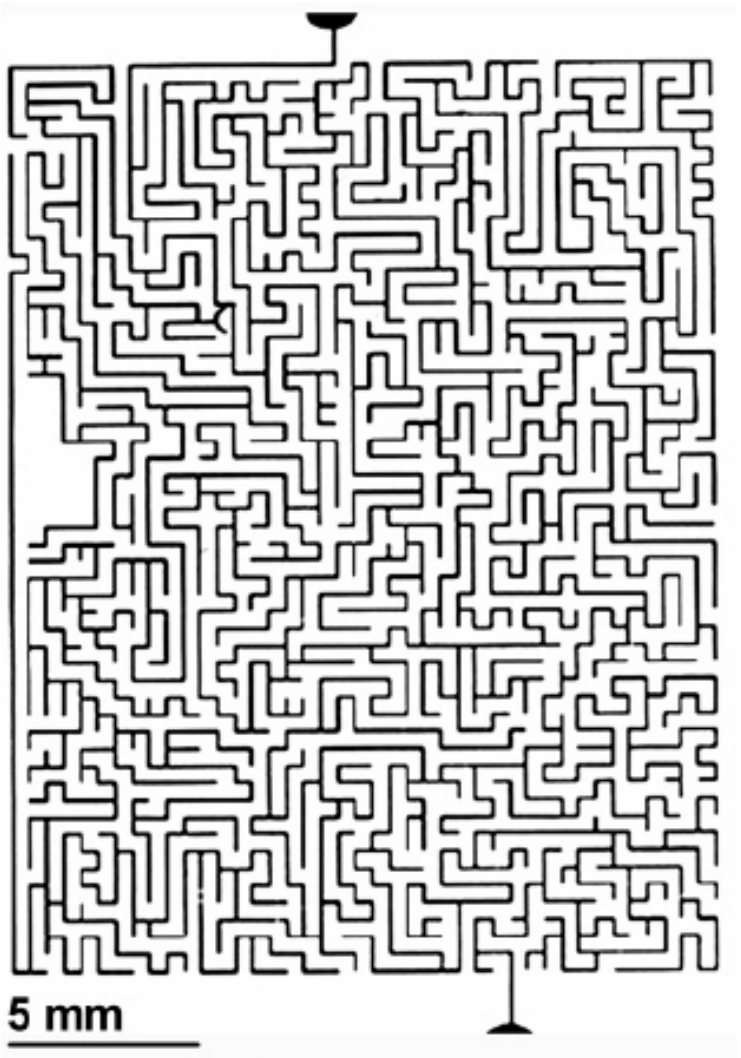
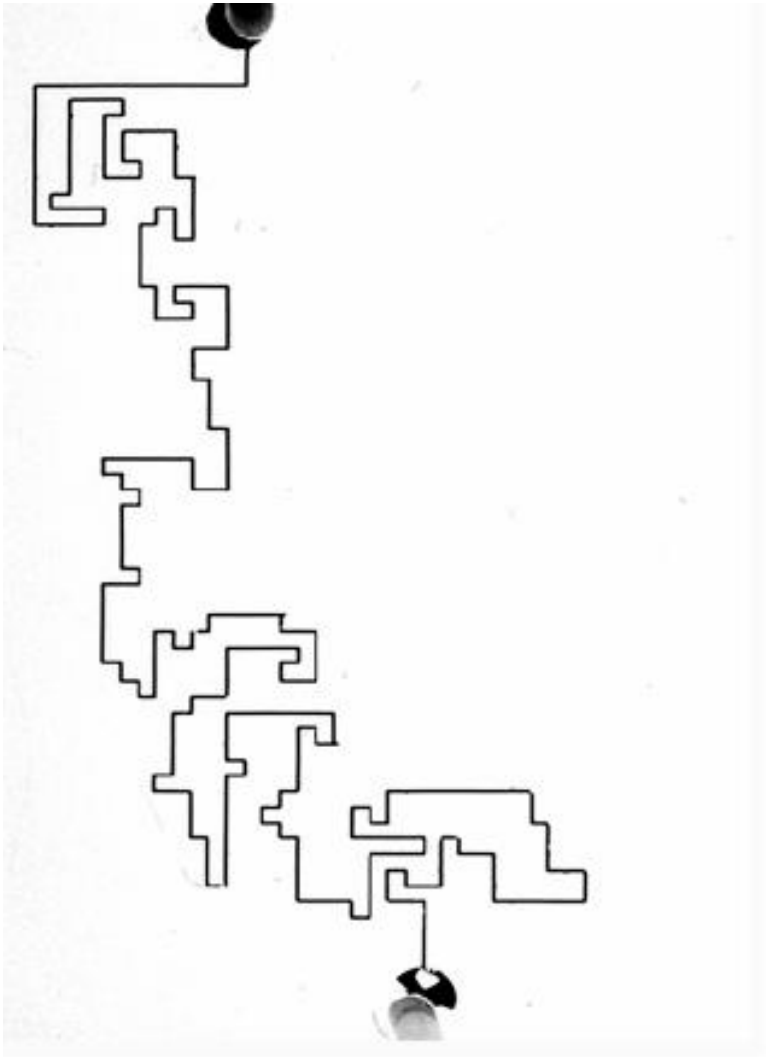
National ChungHsing University

Microfluidics: Solving Mazes

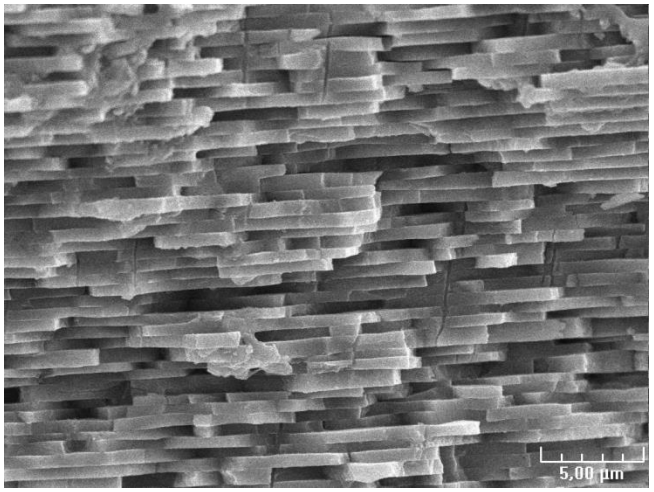


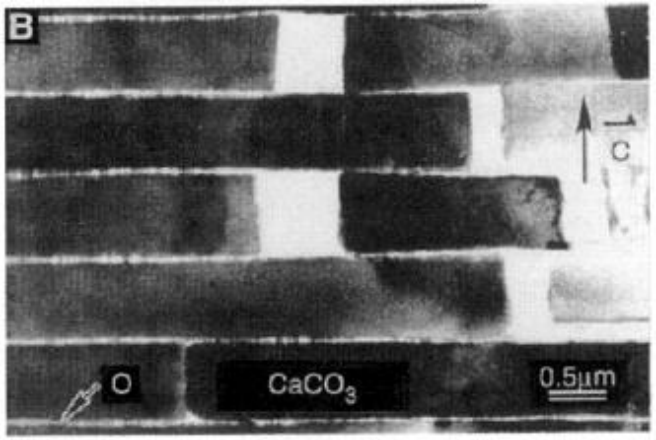


Langmuir **19**, 4714 (2003)

Nature Mazes

Iridescent Nacre Nautilus

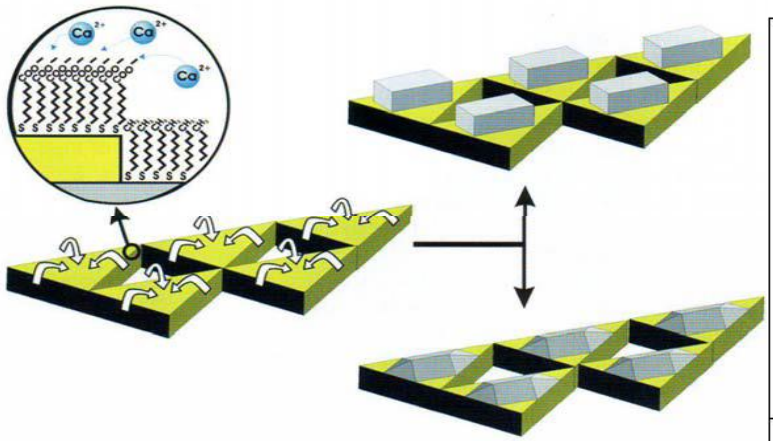


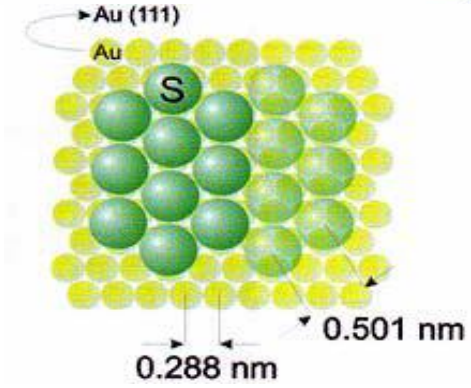


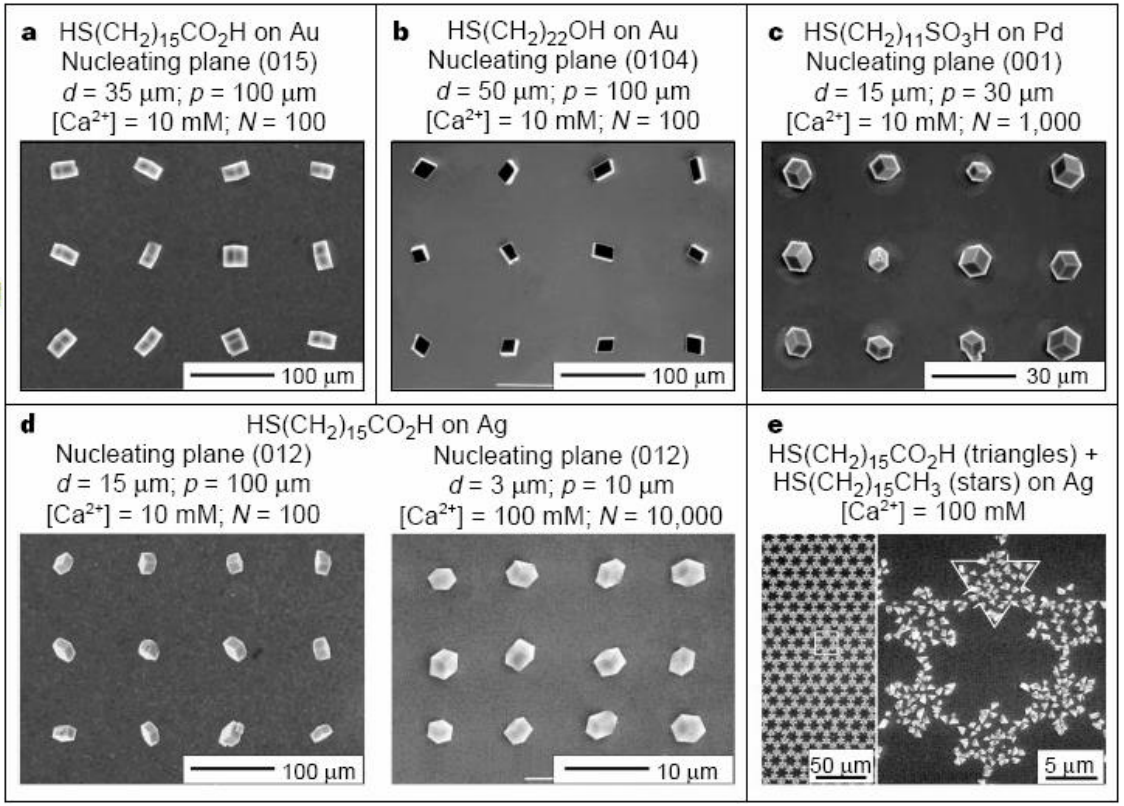
Nature **412**, 819 (2001)

Nanocontact Printing

SAMs Controlled Mineralization

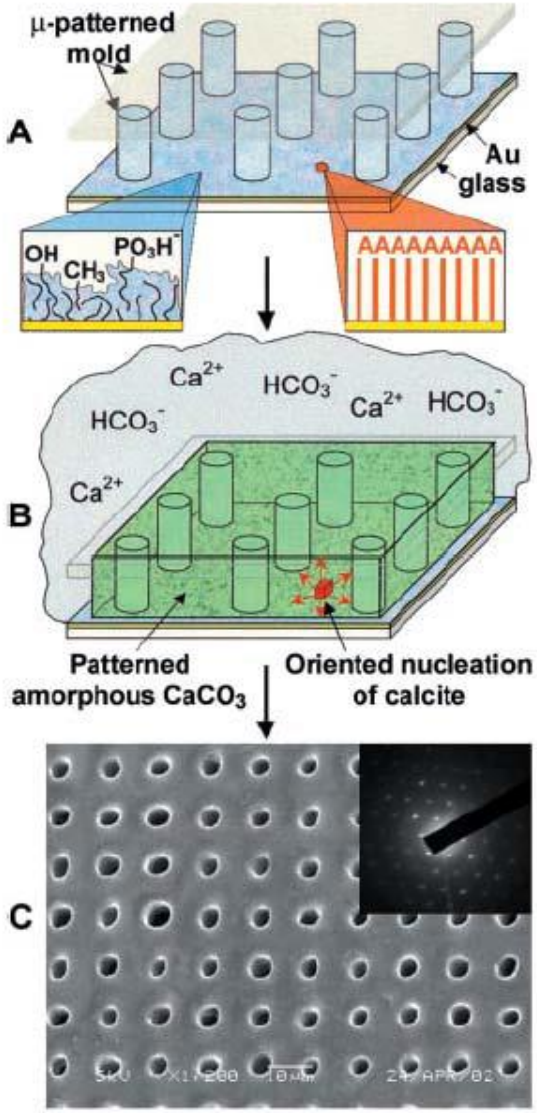


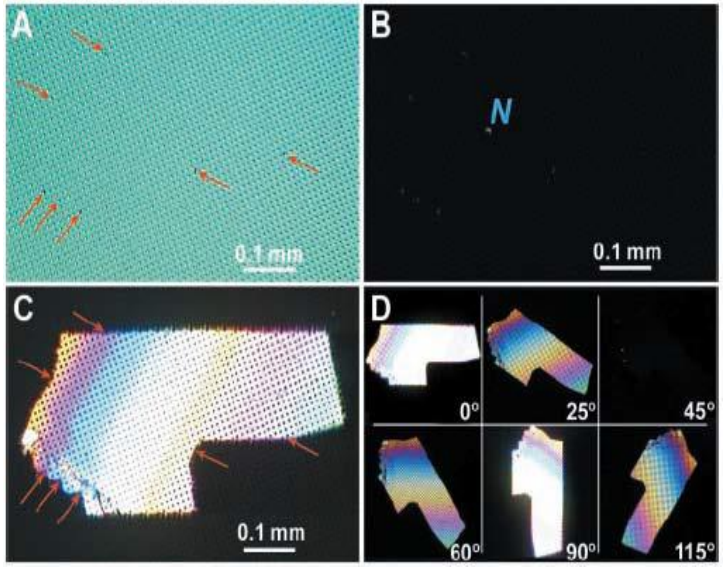




- The densities of nucleation, uniform sizes and crystallographic orientation are controlled by the micropatterned SAMs.
- Nucleation stems form a match between the pattern and orientation of ions adsorbed on the organic surface.

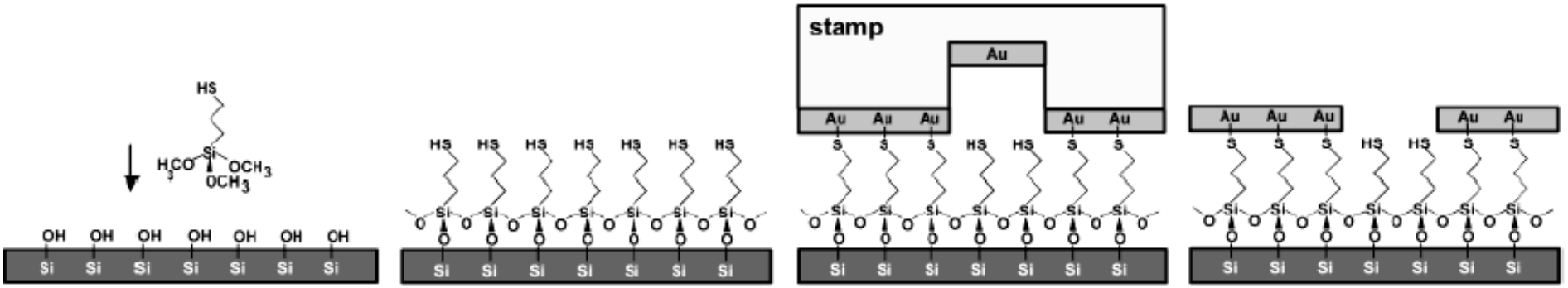
SAMs Directed Growth of Large Single Calcite Crystals

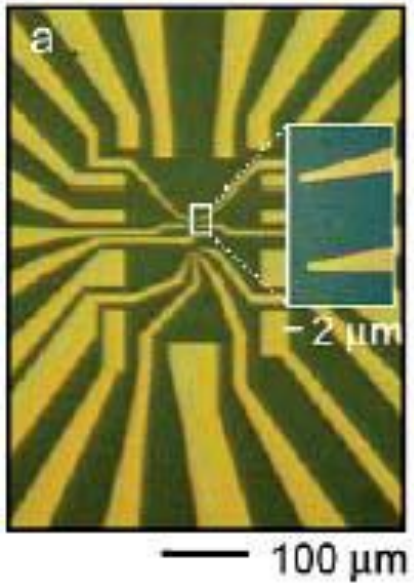




- A = OH, CO_2H, SO_3H.
- Site-specific nucleation of a nascent calcite crystal occurred at the imprinted SAM nanoregion.
- Micropatterned frameworks act as sites for stress release.

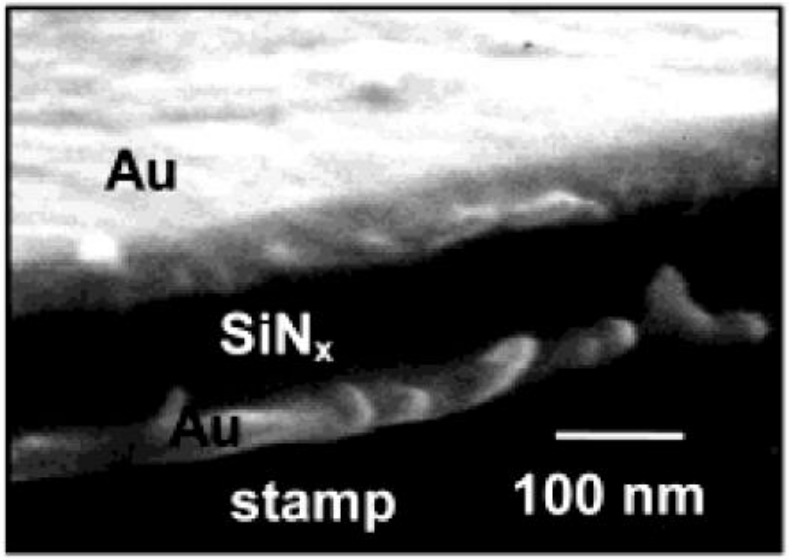
Transfer Printing of Thin Films





On Si

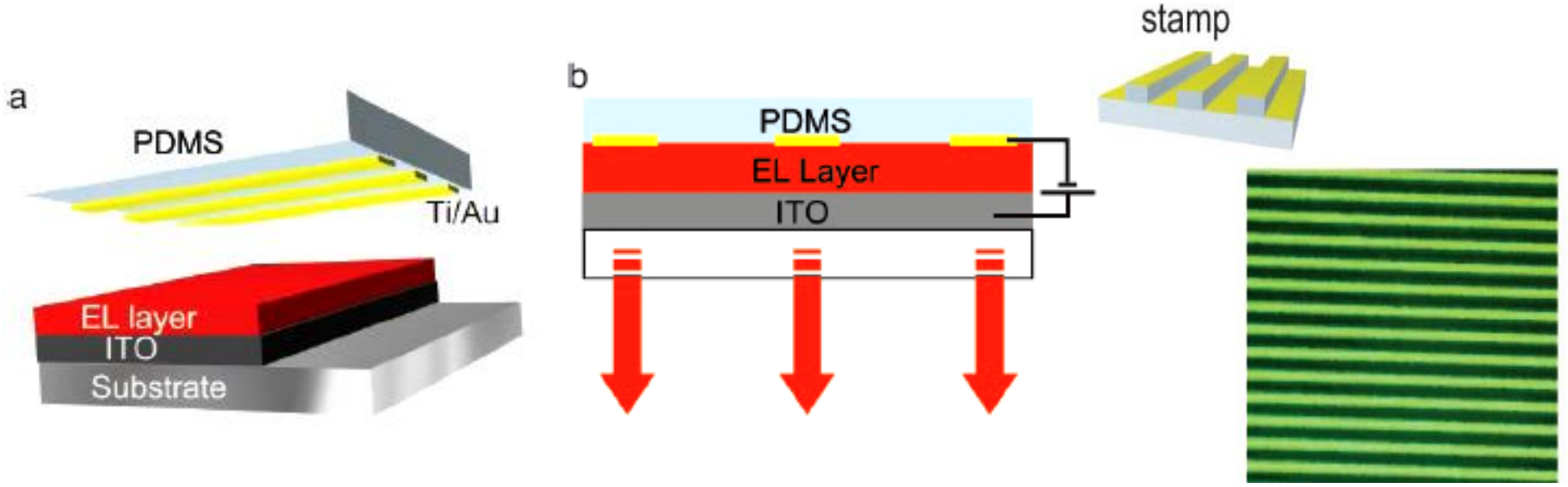
On PET



Printed capacitor on PET

JACS **124**, 7655 (2002)

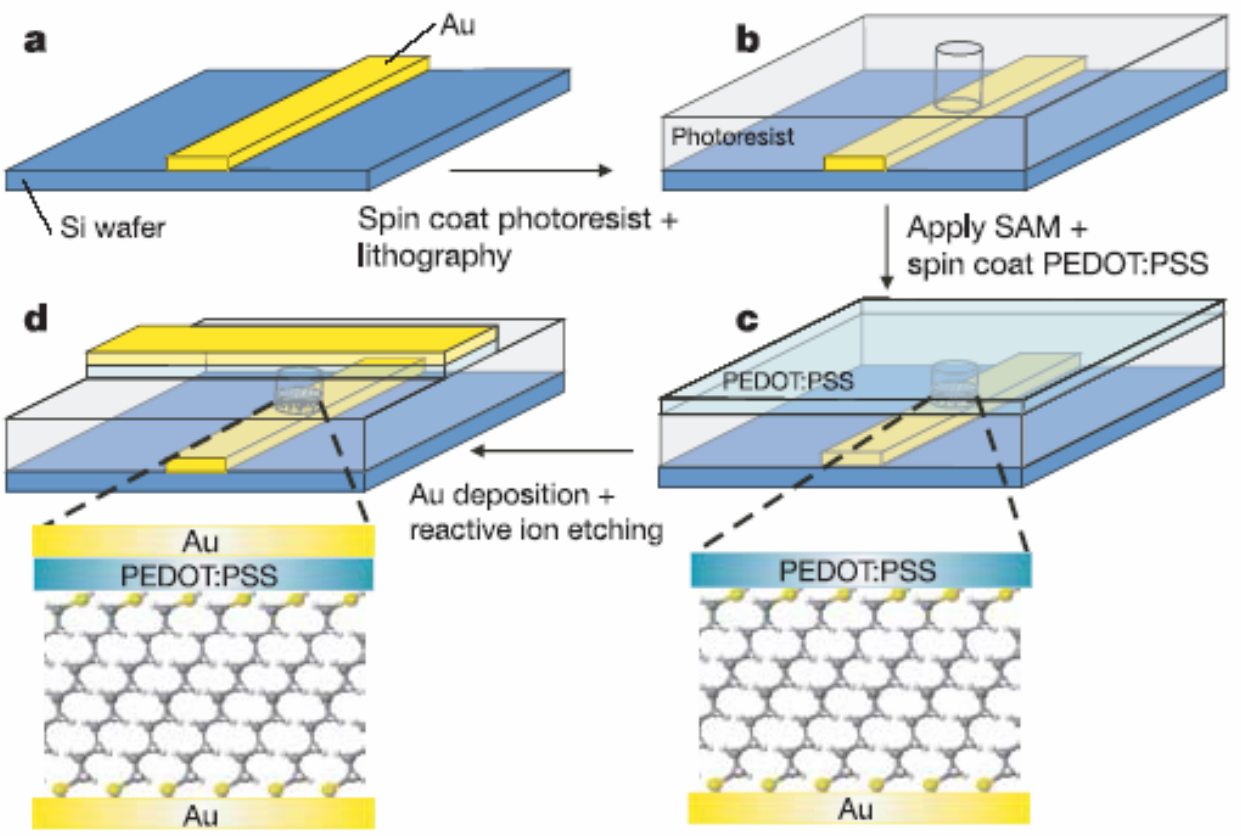
Soft Lithography for Organic Light-Emitting Diodes (OLEDs)

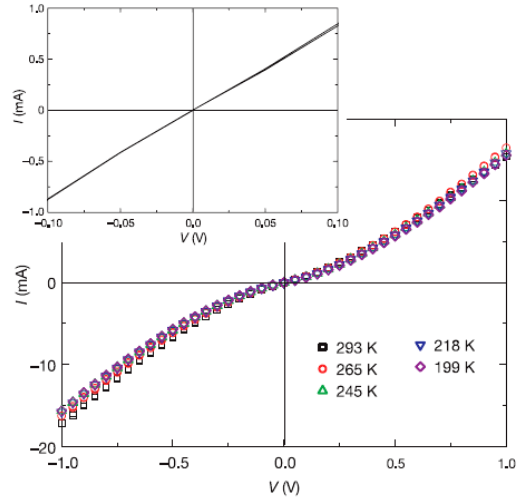


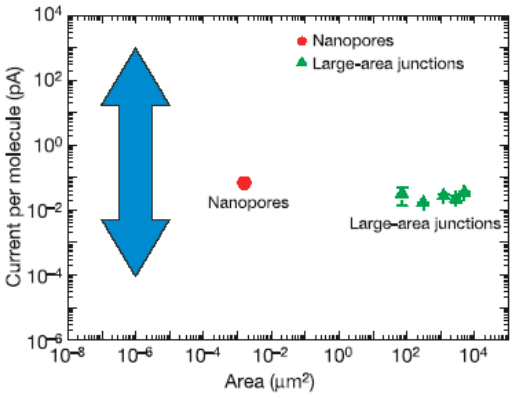
- Lamination of thin metal electrodes on an electroluminescent organic.
- van der Waals interactions establish intimate contacts.
- Reduced sensitivity to pinhole defects.
- Patterned OLEDs with sub-100 nm features.
- High performance displays and memory.

PNAS **101**, 429 (2004)

SAMs Molecular Junctions for Molecular Electronics







Nature **441**, 69 (2006)

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SAMs Molecular Junctions for Molecular Electronics