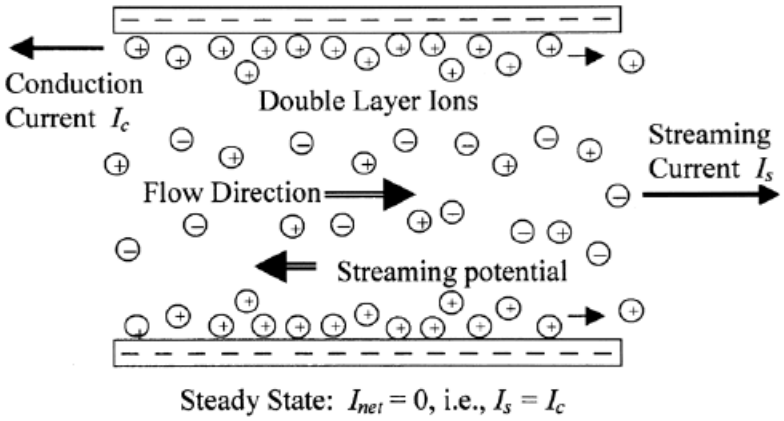
Microfluidics & Transport Processes

- Science of fluid behavior in microchannels.
- In lab-on-a-chip and μTAS devices, the following features are often seen:
  - Microchannels,
  - Microfilters,
  - Microvalves,
  - Micropumps,
  - Microneedles,
  - Microreserviors,
  - Micro-reaction chambers.

Electrokinetics

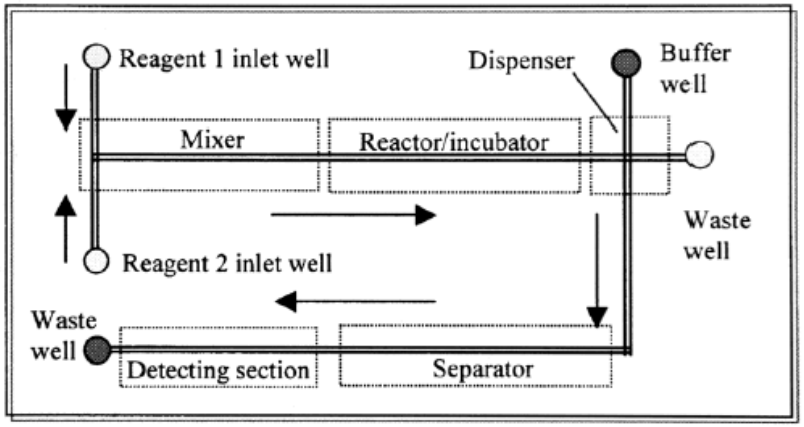
- Electrokinetic phenomenon:
  - Electro-osmosis,
  - Electrophoresis,
  - Streaming potential,
  - Dielectrophoresis.

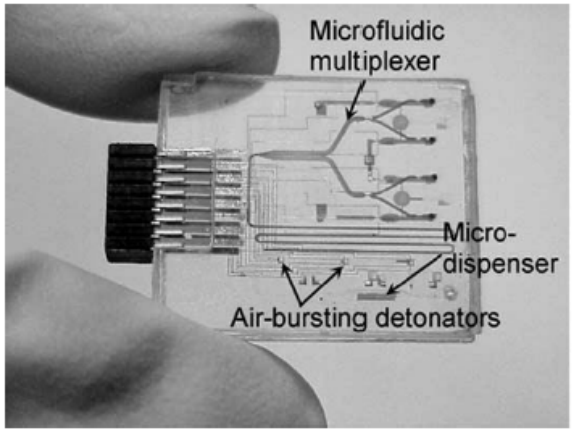


- An important tool for moving, separating and concentrating fluid and suspended particles.

Lab-on-a-Chip

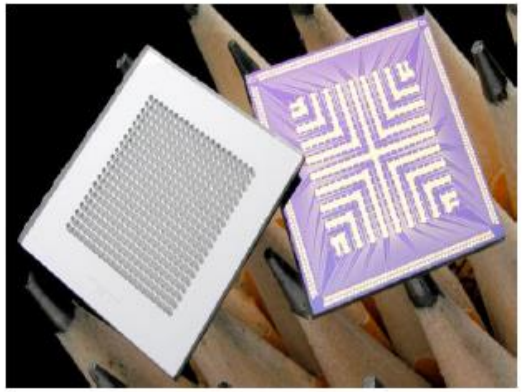
- Improved transport, efficient cell, molecular and particle separation and immobilization; smaller sample requirements and carrier volumes; and reduced reagent consumption.
- Improved throughput of analytes occurs as a consequence of miniaturization and integration.

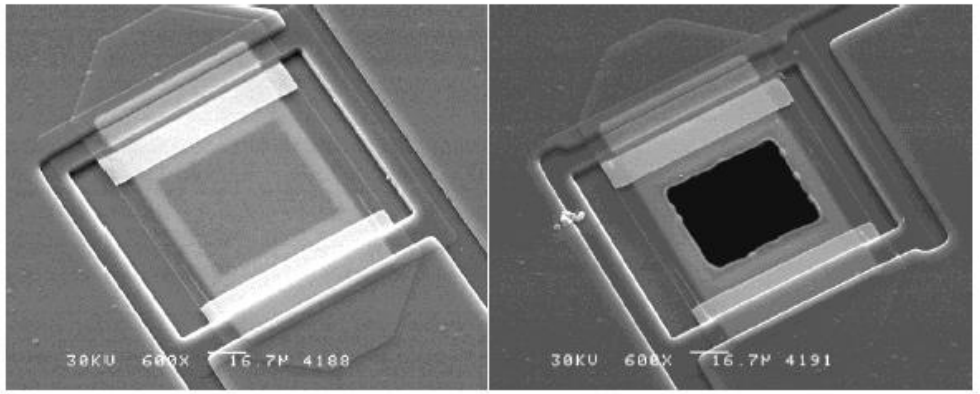




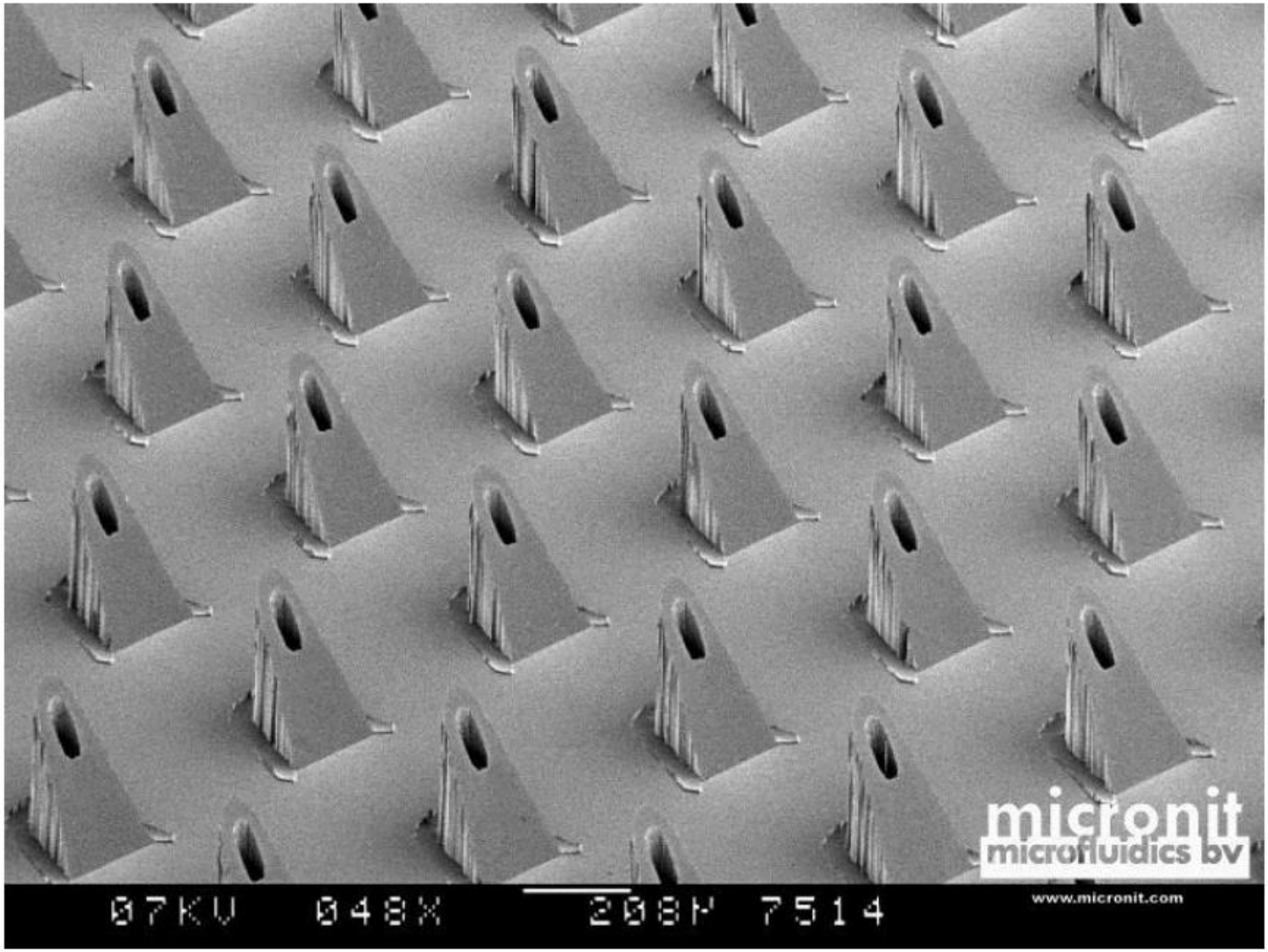
Drug Delivery Systems

- Current methods of drug delivery:
  - Topically, orally, injection, insertion, and perfusion.
- Parameters of administration:
  - Dose, frequency, duration, oscillatory behavior.
- Benefits of bioMEMS:
  - Reliable and precise release of targeted therapy.



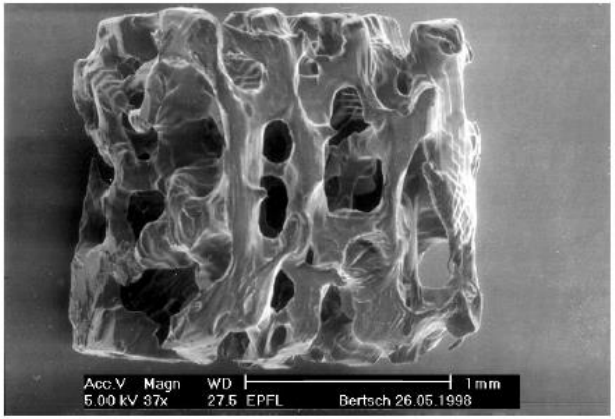


Micromachined Microneedles



Tissue Engineering

- "Application of the principles of biology and engineering to the development of viable substitutes which restore, maintain, or improve the function of human tissue."



- Tissue scaffolding devices, various sensor and stimulating electrodes and electroactive polymers as muscle substitutes are but a few of the new technologies.

Dario 2000

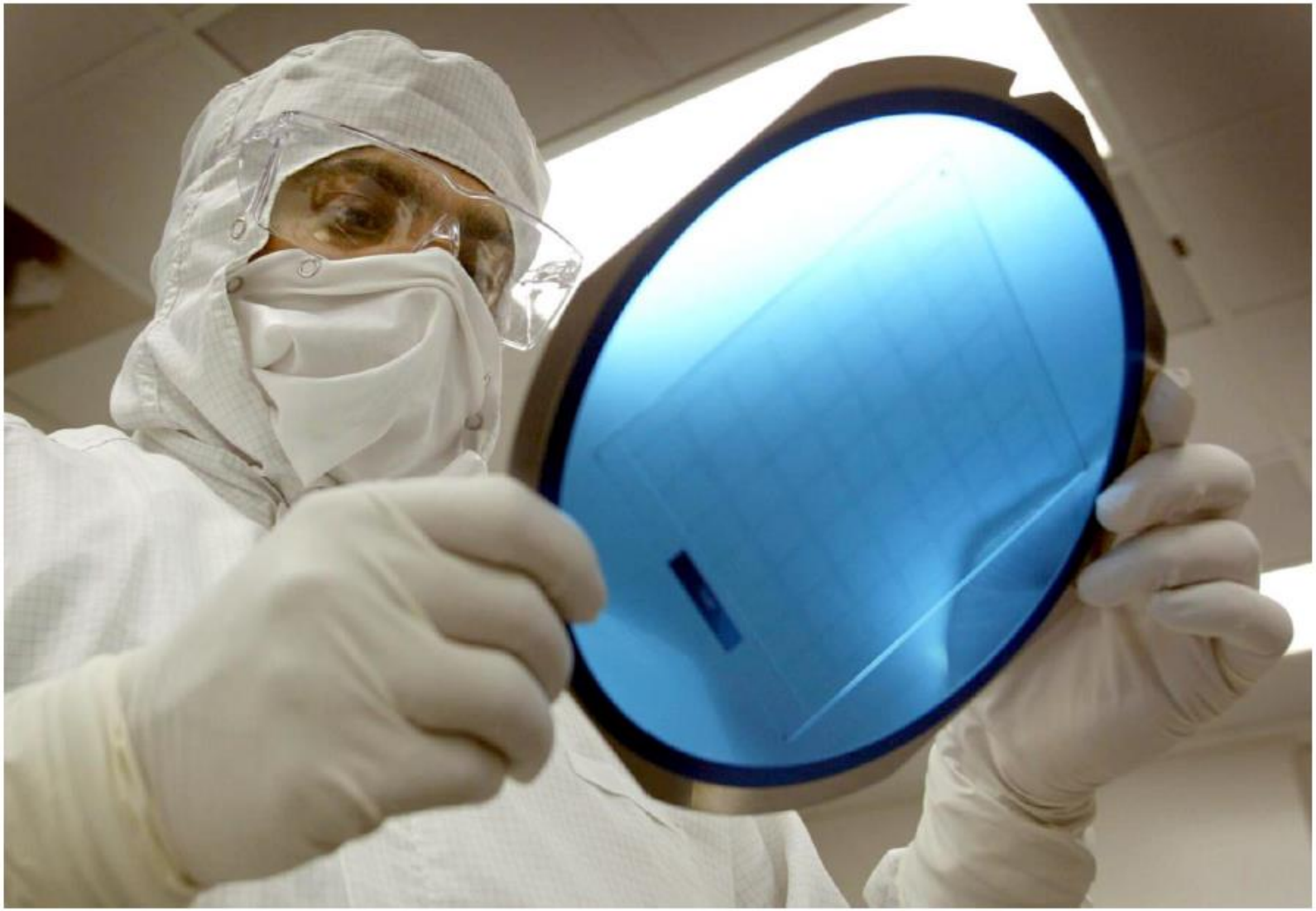
Minimally Invasive Surgery

- Onset in 1988 when Dr. J. Barry McKerman performed a laparoscopic cholecystectomy through a 1 cm incision.
- Reduced tissue damage, scarring and pain; shorter recovery time and hospitals stays.
- May use thin tubes called trocars, miniature cameras, specialized instruments and CO_2 to inflate the area.
- Opportunities for bioMEMS and MEMS devices.

Gemomics

- DNA replication, protein synthesis, gene expression and the exchange and recombination of genetic material;
- Restriction endonucleases and DNA ligases capable of cutting and rejoining DNA at sequence specific sites;
- Technical advances:
  - Polymerase chain reaction (PCR),
  - Automatic DNA sequencing.
- Bioinformatics:
  - Storing, analyzing and interpreting of data
- Functional Genomics

DNA Microarrays



DNA and Protein Microarray Chips

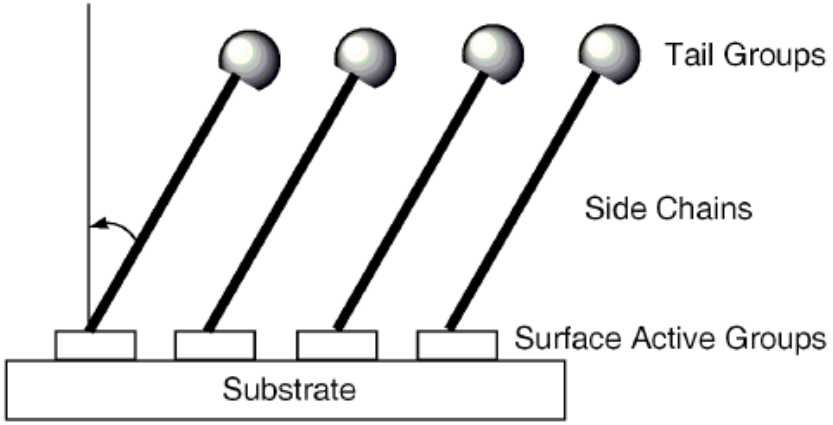
- DNA and protein microarray chips offer the ability to screen for numerous genetic traits rapidly and inexpensively:
  - Genetic screening for detection of mutations,
  - Gene expression profiling,
  - Diagnosis and prognosis of cancer,
  - Drug safety for pharmacogenetics,
  - Monitoring of pathogens and resistance in infections,
  - Stratification of patients in clinical trials.

Proteomics

- “Proteomics is the study of all proteins, including their relative abundance, distribution, posttranslational modifications, functions, and interactions with other macromolecules, in a given cell or organism within a given environment and at a specific stage in the cell cycle.”
- Lab-on-a-Chip devices for protein isolation, purification, digestion and separation.
- Microarray devices for high throughput study of protein abundance and function.

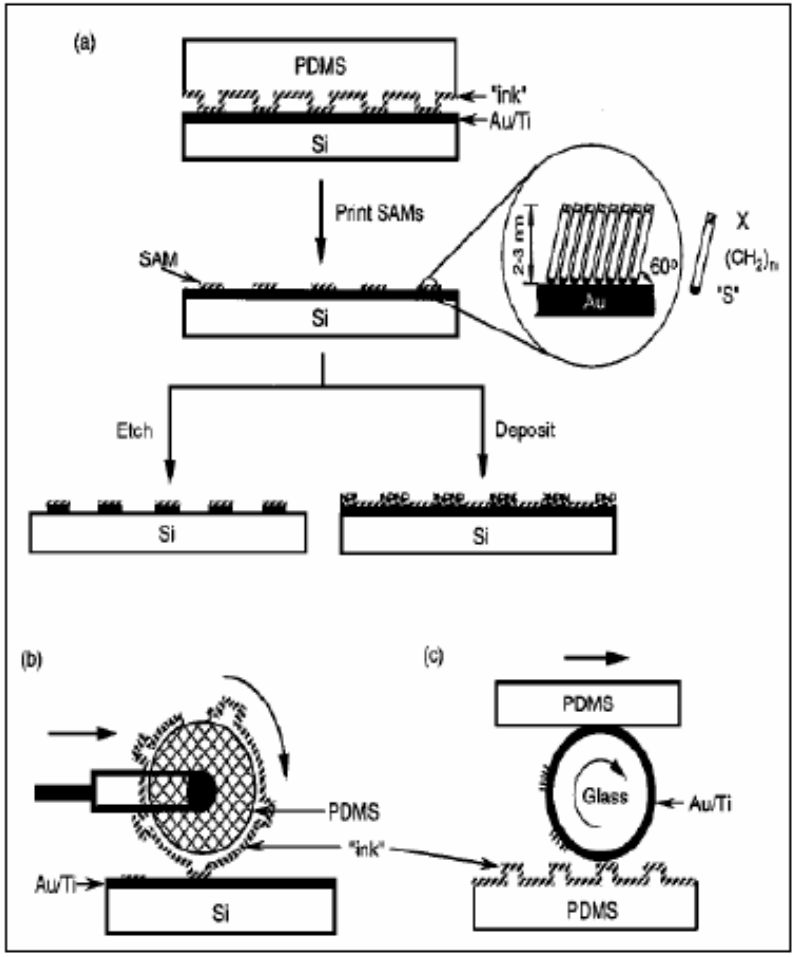
Surface Modification

- Advantages of surface modification.
- Techniques for surface modification:
  - Covalent chemical modification,
  - UV and plasma exposure,
  - SAMs,
  - Coatings.



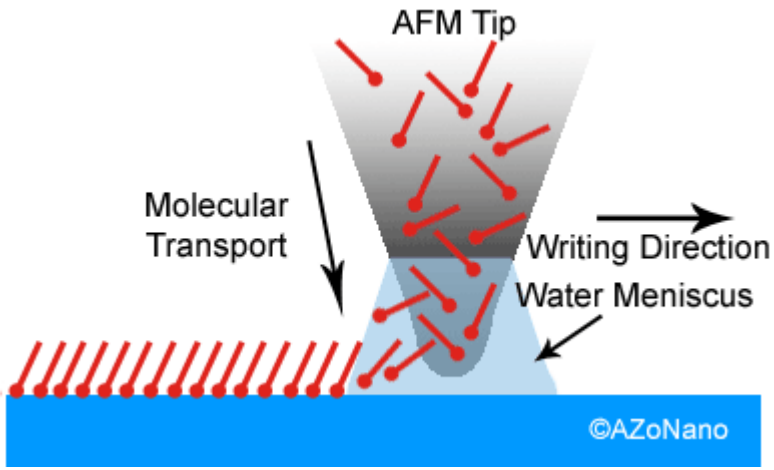
μ-Contact Printing

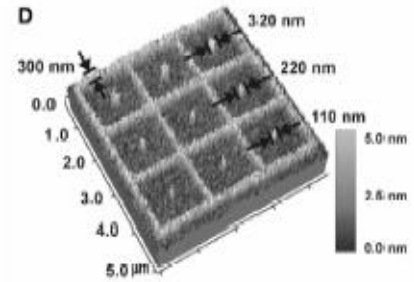
- Ink the PDMS structure with molecules (alkylthiols, proteins, DNA, etc.)
- Transfer the layer through physical contact (optimize time)
- Inking is performed via covalent binding on substrate
- Can be performed on flat surface or curved surface



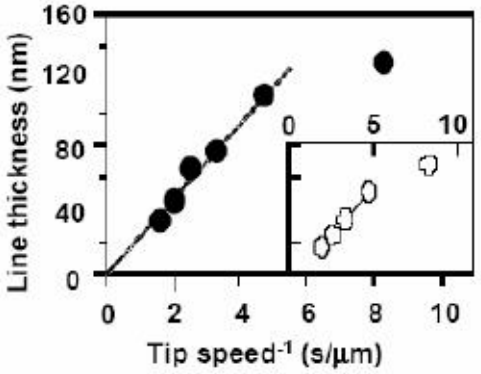
Dip Pen Lithography

- AFM Tip used to 'write' molecules
- Being commercialized by Nanoink, Inc.
- SAMs, DNA, Proteins, etc.
- Serial (need array of cantilevers for parallel writing)
- Continuous source of molecules – microfluidics !



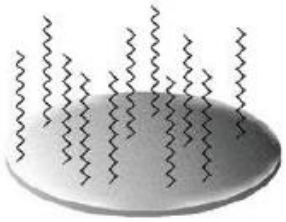


Lee, K.B.; Park, S.J.; Mirkin , C.A. ; Smith, J.C.; Mrksich, M.
Protein nanoarrays generated by dip-pen nanolithography



C. S. Mirkin, et. al, Science, **283**, 661 (1999); Science **286**, 523 (1999); **288**, 1808 (2000).

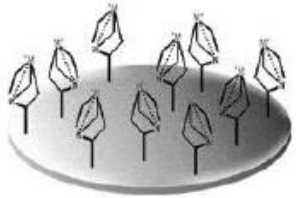
Protein Chip Surface Interactions



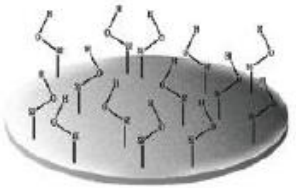
Hydrophobic

Cation exchange

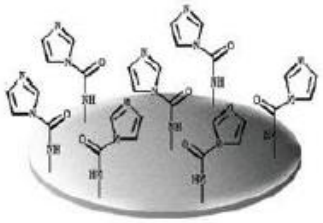
Anion exchange



Metal affinity

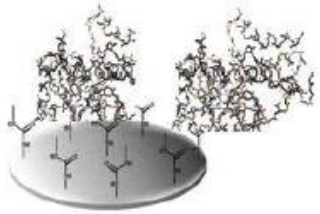


Normal phase



PS-10 or PS-20

Antibody–antigen

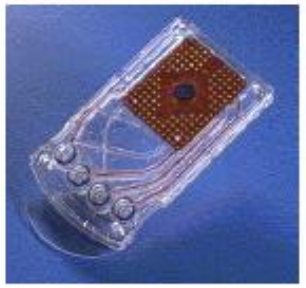


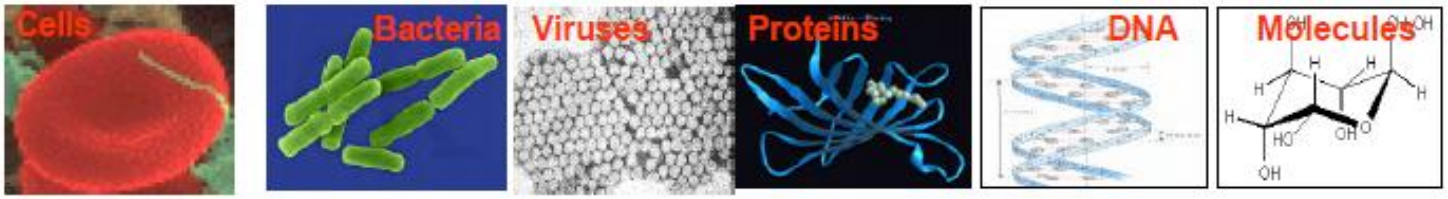
Receptor–ligand

DNA–protein

Biochips for Detection

- Applications
  - Medicine
  - Pharmaceuticals
  - Food Safety
  - Homeland Security, etc.
- Integrated, Sensitive, Rapid, Cost x Performance
- Commercialized; Nanogen, Affymetrix, Caliper, Others….





Individualized Treatment

1. Molecular diagnostics, particularly single nucleotide polymorphism (SNP) genotyping.
2. Integration of diagnostics with therapy.
3. Monitoring of therapy.
4. Pharmacogenomics.
5. Pharmacogenetics.
6. Pharmacoproteomics.