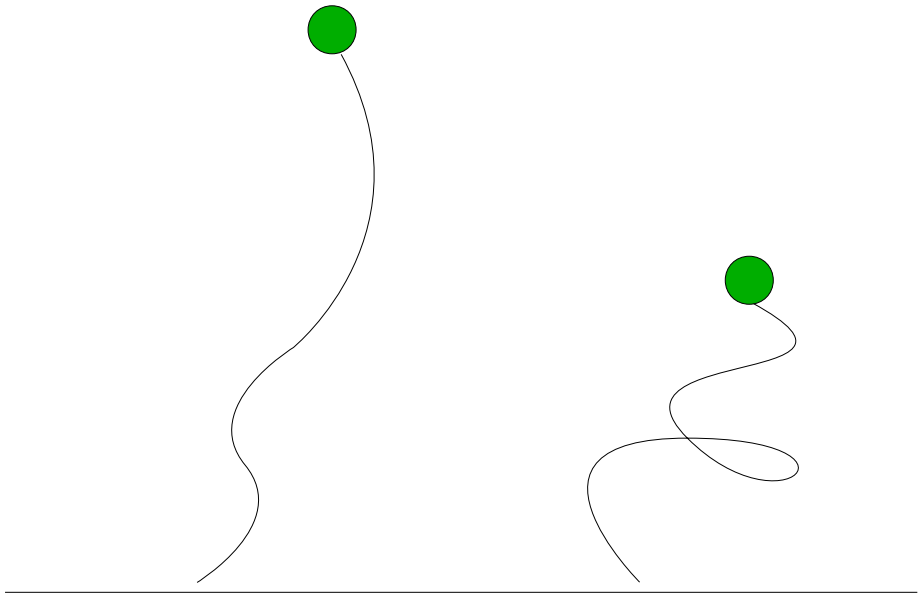
Presentation Phys 730 - Katia GASPERI

Statistical study of single DNA molecules into dynamic array

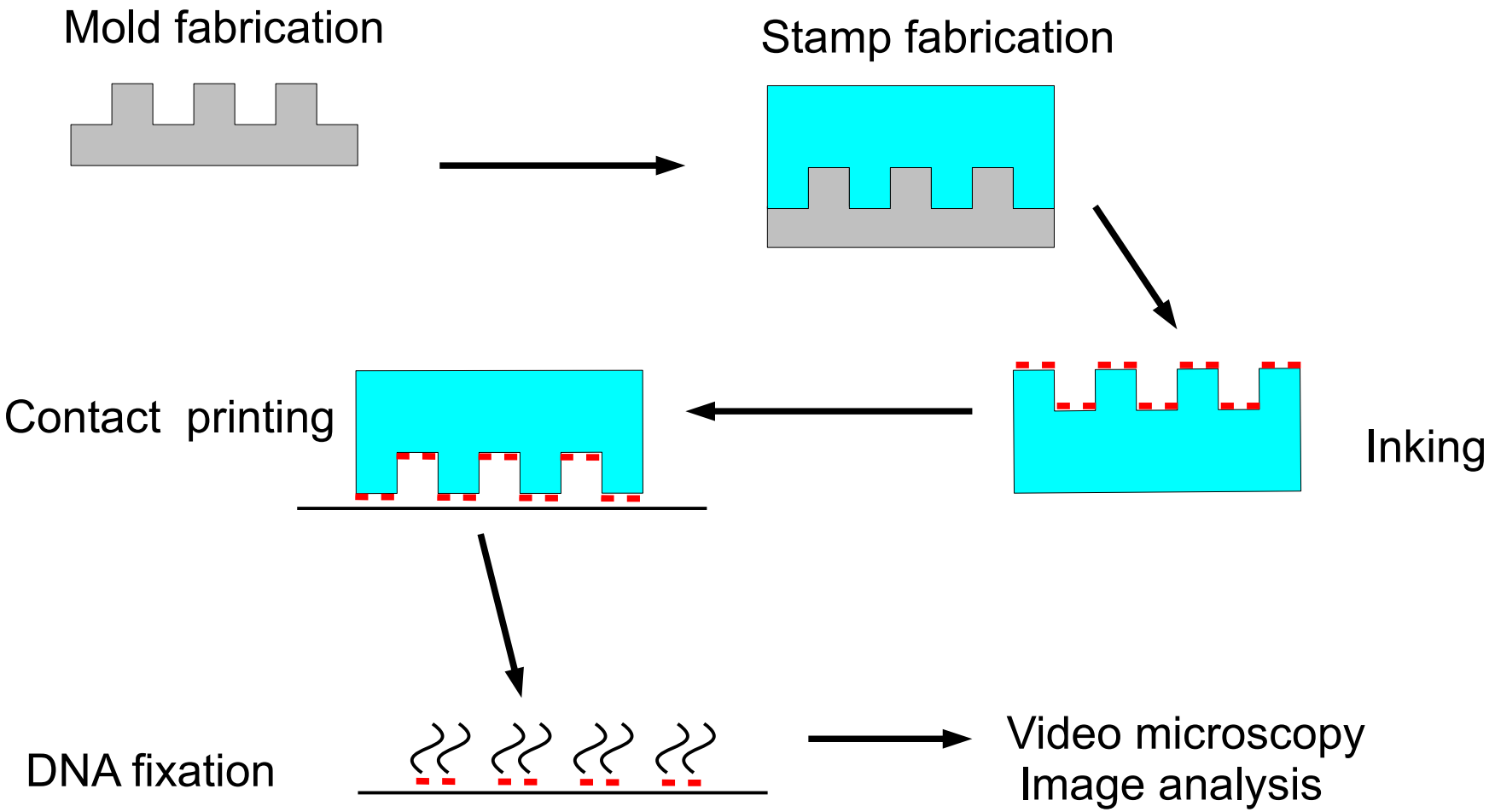


Statistical study of single DNA molecules into dynamic array

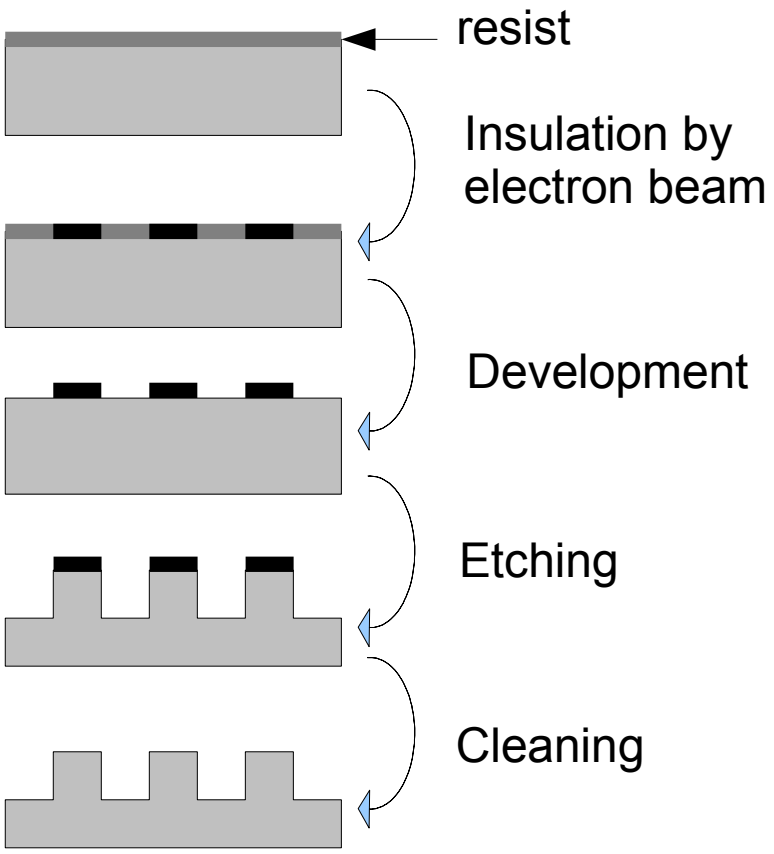
- Research project lead by Laurence SALOME and Christophe VIEU (collaboration IPBS / Laas-CNRS,Toulouse, France)

- The project initially was expected to involved 4/5 teams.

The project step by step

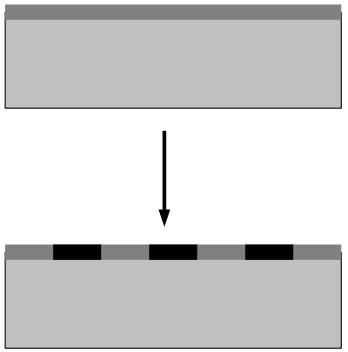


Mold fabrication



Mold fabrication : EBL

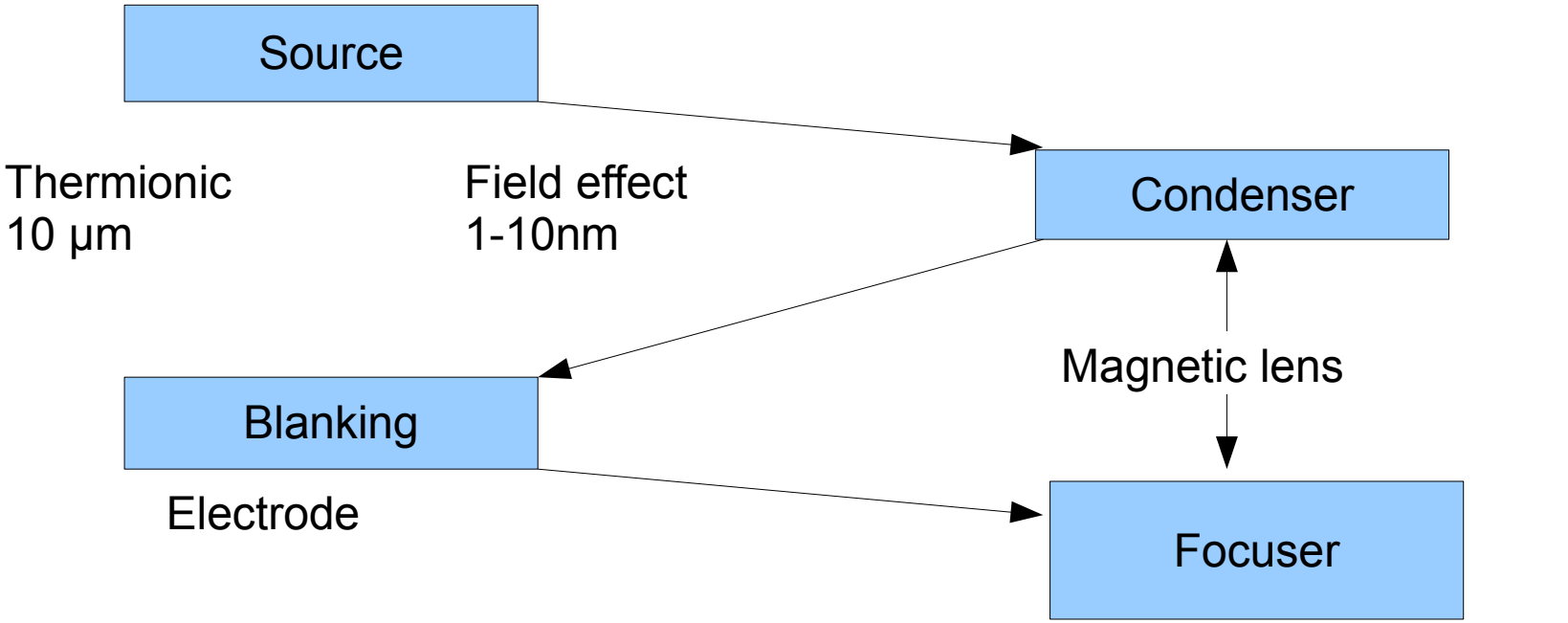
- EBL = Electron Beam Lithography

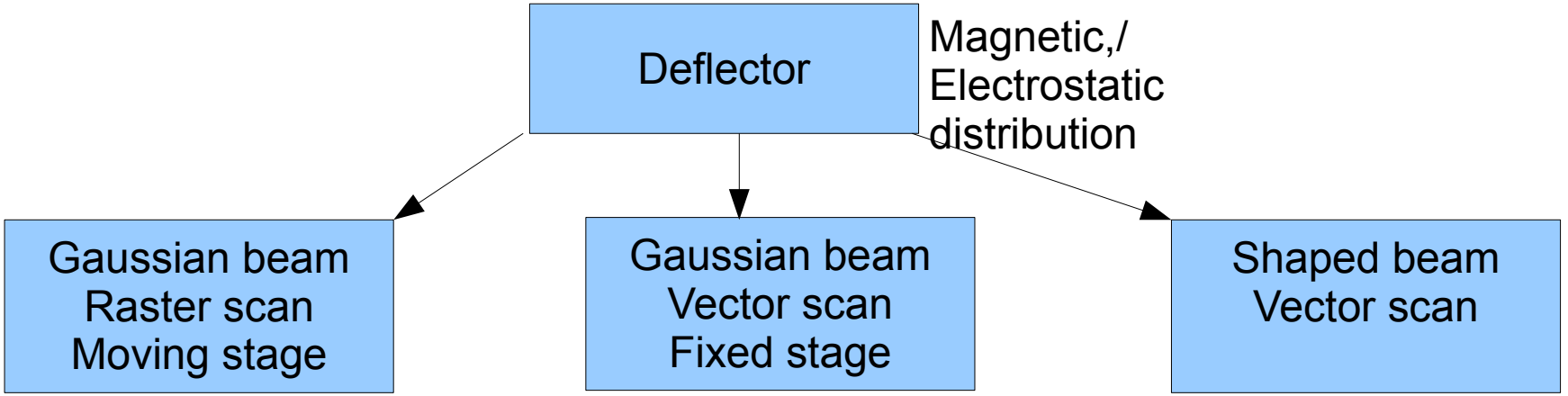


- Slow and expensive process
- High resolution

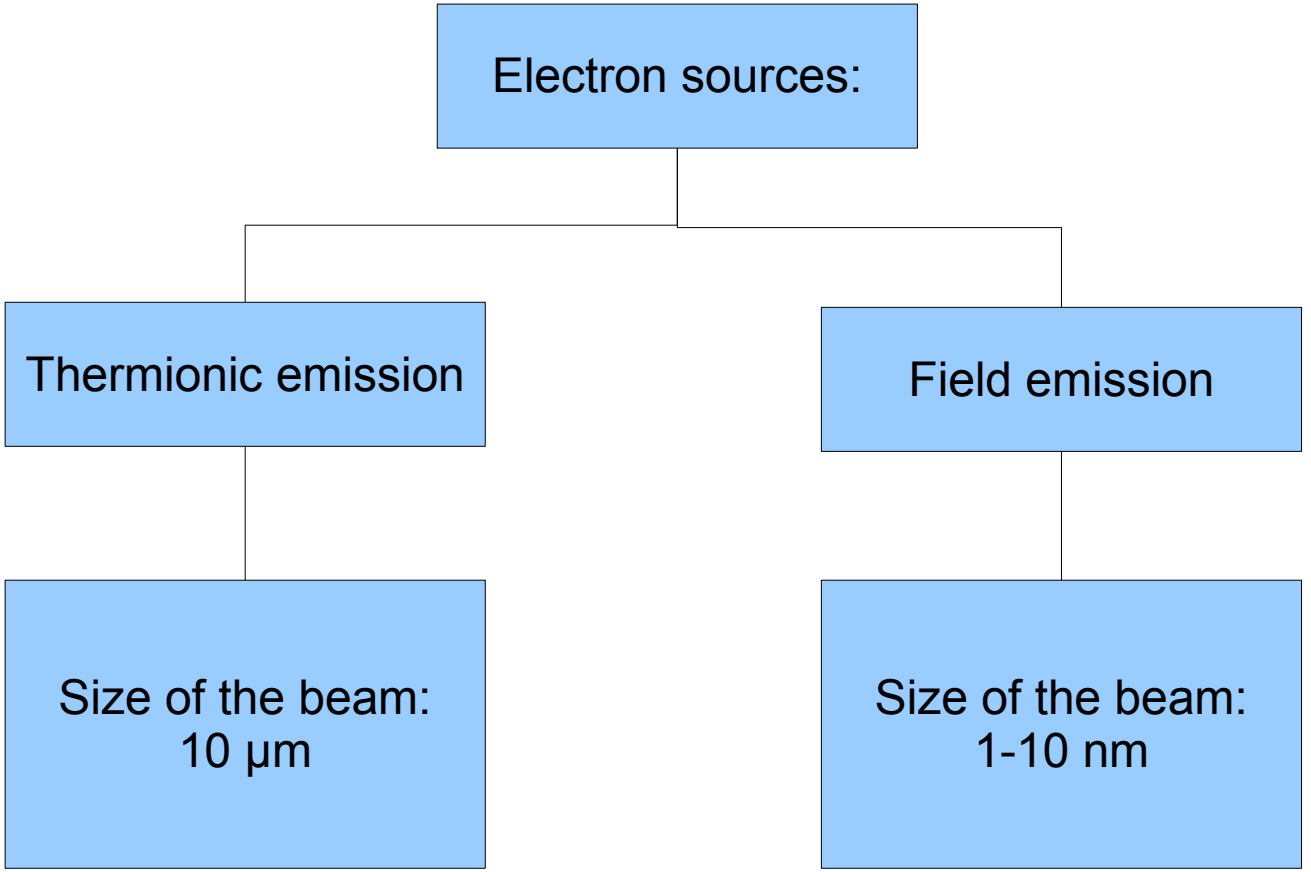
CM20
www.stevens.edu/lmsi/Instrument/Instrument.htm

Mold fabrication : EBL

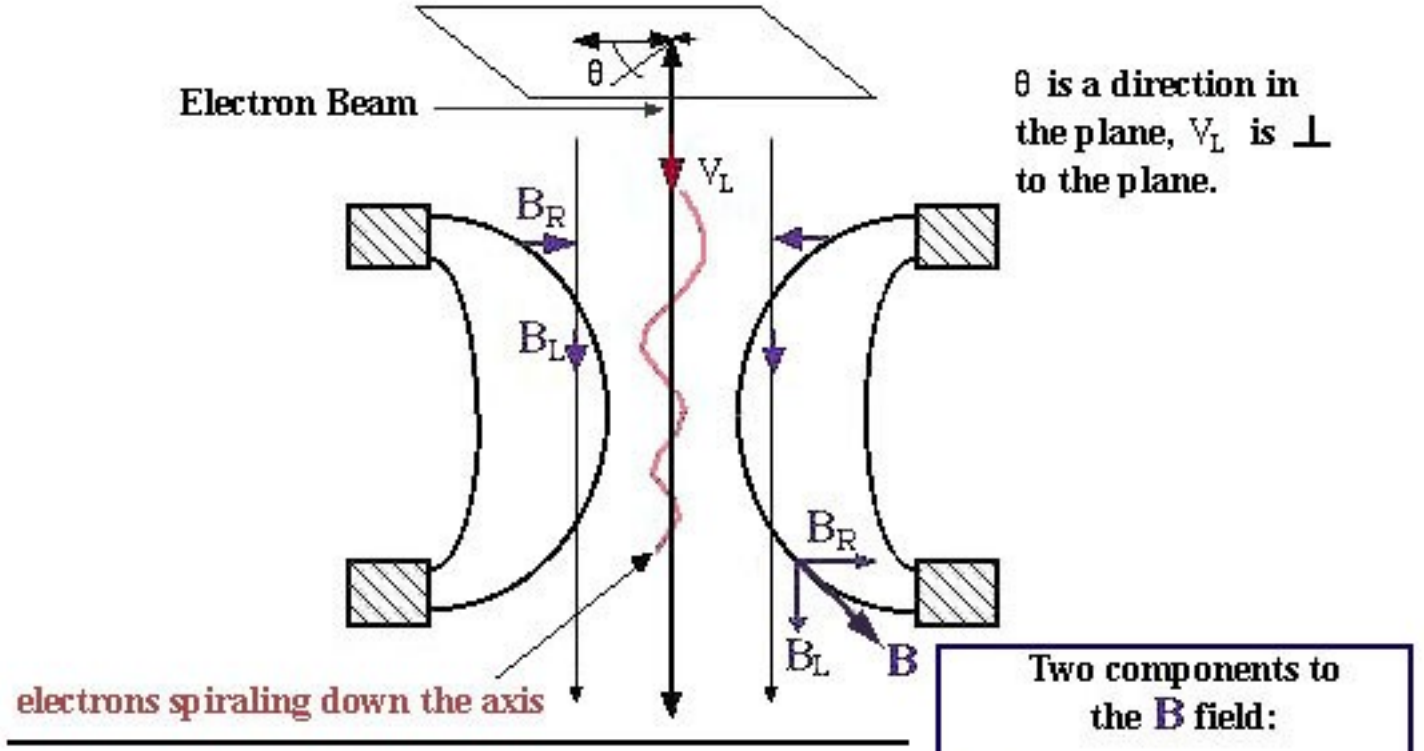




Mold fabrication : EBL Source



Mold fabrication : EBL



Magnetic Lens

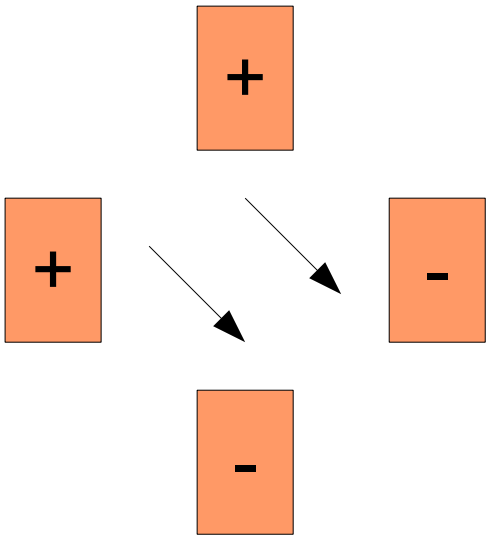
Two components to the B field:

B_L = longitudinal component (down the axis)

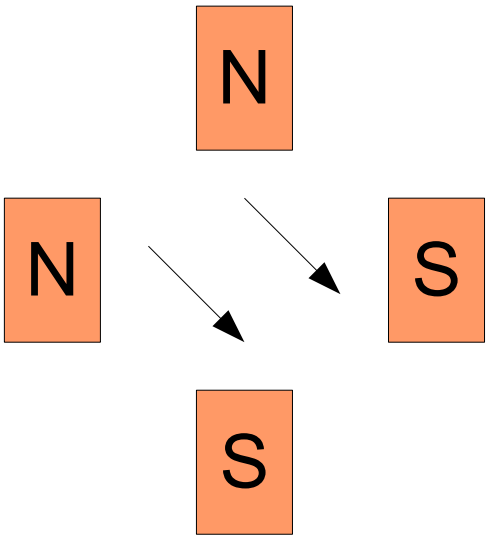
B_R = radial component (perpendicular to axis)

Mold fabrication : EBL Deflector

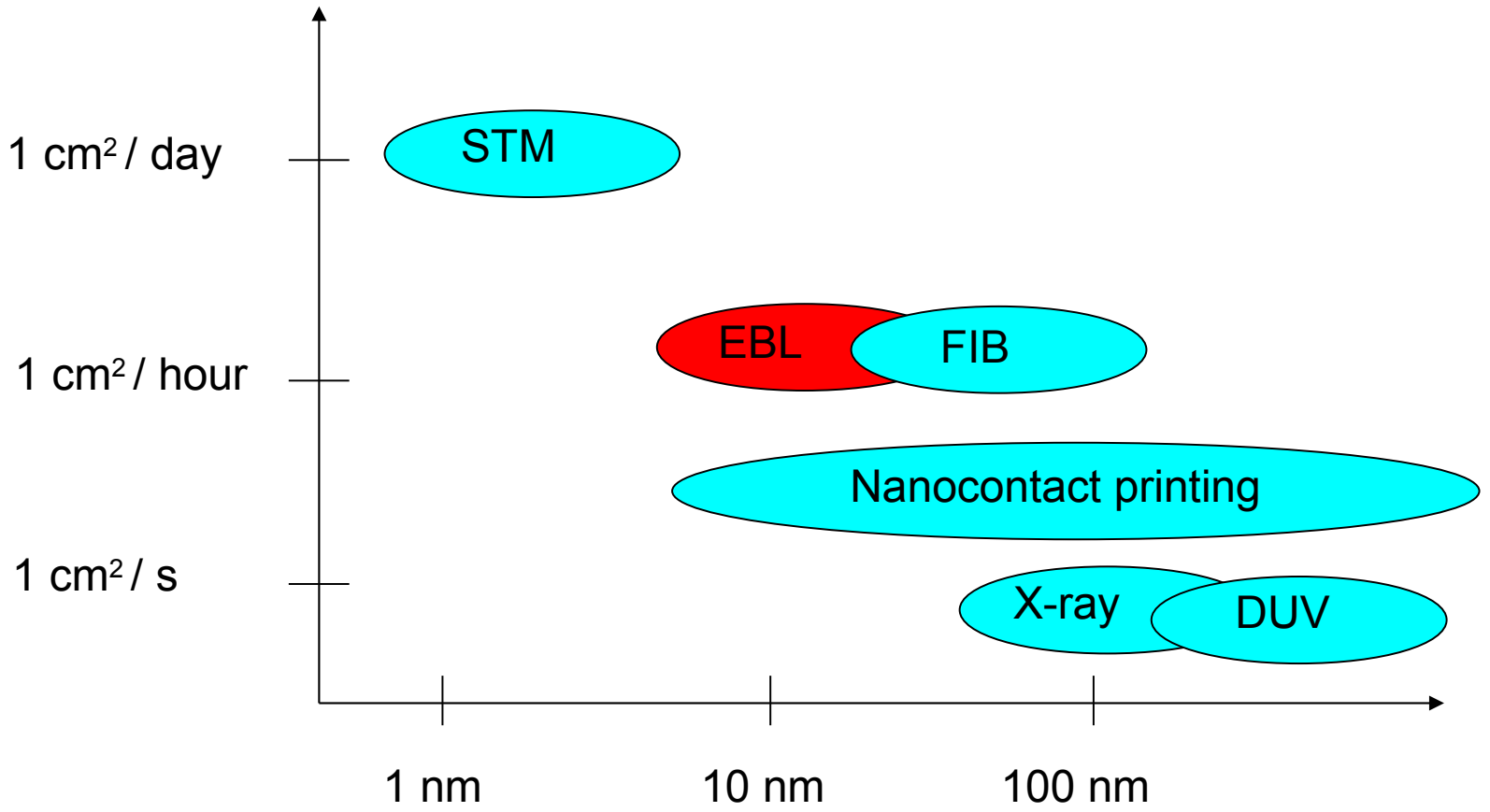
Electrostatic field



Magnetic field



Mold fabrication : EBL



STM = **S**canning **T**unneling **M**icroscope

EBL = **E**lectron **B**eam **L**ithography

FIB = **F**ocused **I**on **B**eam

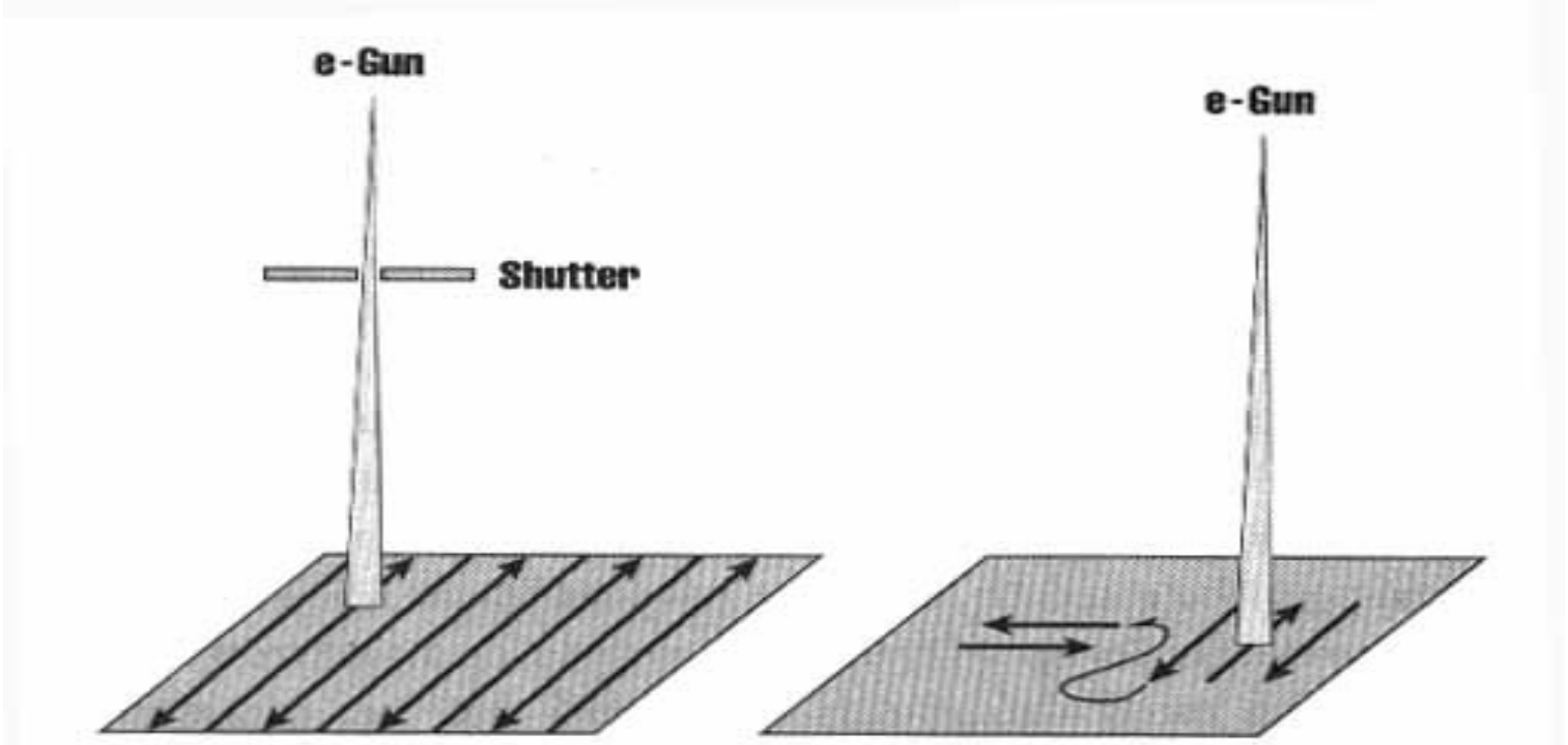
Mold fabrication : EBL Blanker

Role: turning the beam on and off

- pair of plates set up as a simple electrostatic deflector
- fast response time

To turn the beam off, a voltage is applied across the plates which sweeps the beam off axis until it is intercepted by a downstream aperture.

Mold fabrication : EBL Scanning methodologies



Raster scan

Vector scan

Mold fabrication : EBL Aberrations

$$d = \sqrt{d_g^2 + d_s^2 + d_c^2 + d_d^2}$$

d_g : size of the source / demagnification

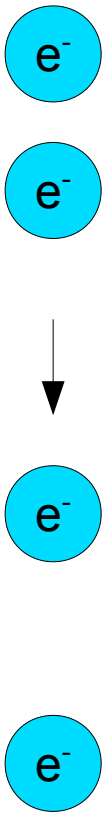
d_s : spherical aberration

d_c : chromatic aberration

d_d : diffraction limit

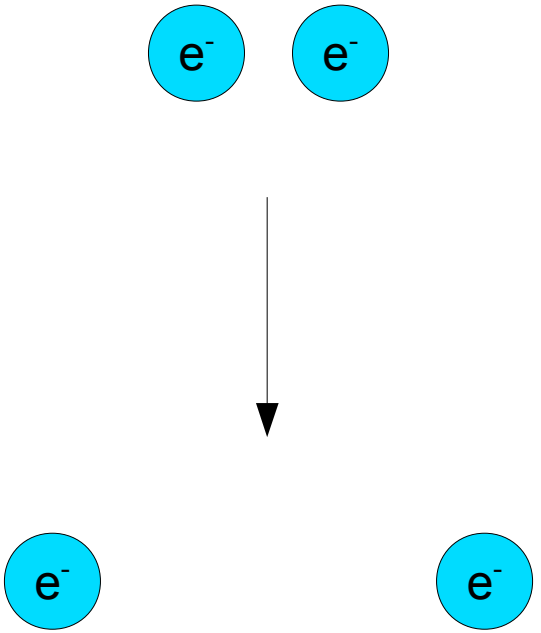
Mold fabrication :EBL and more aberrations...

Boersh effect:



Energetic dispersion
Chromatic aberration

Loeffler effect



Modification of the path
Spherical aberration

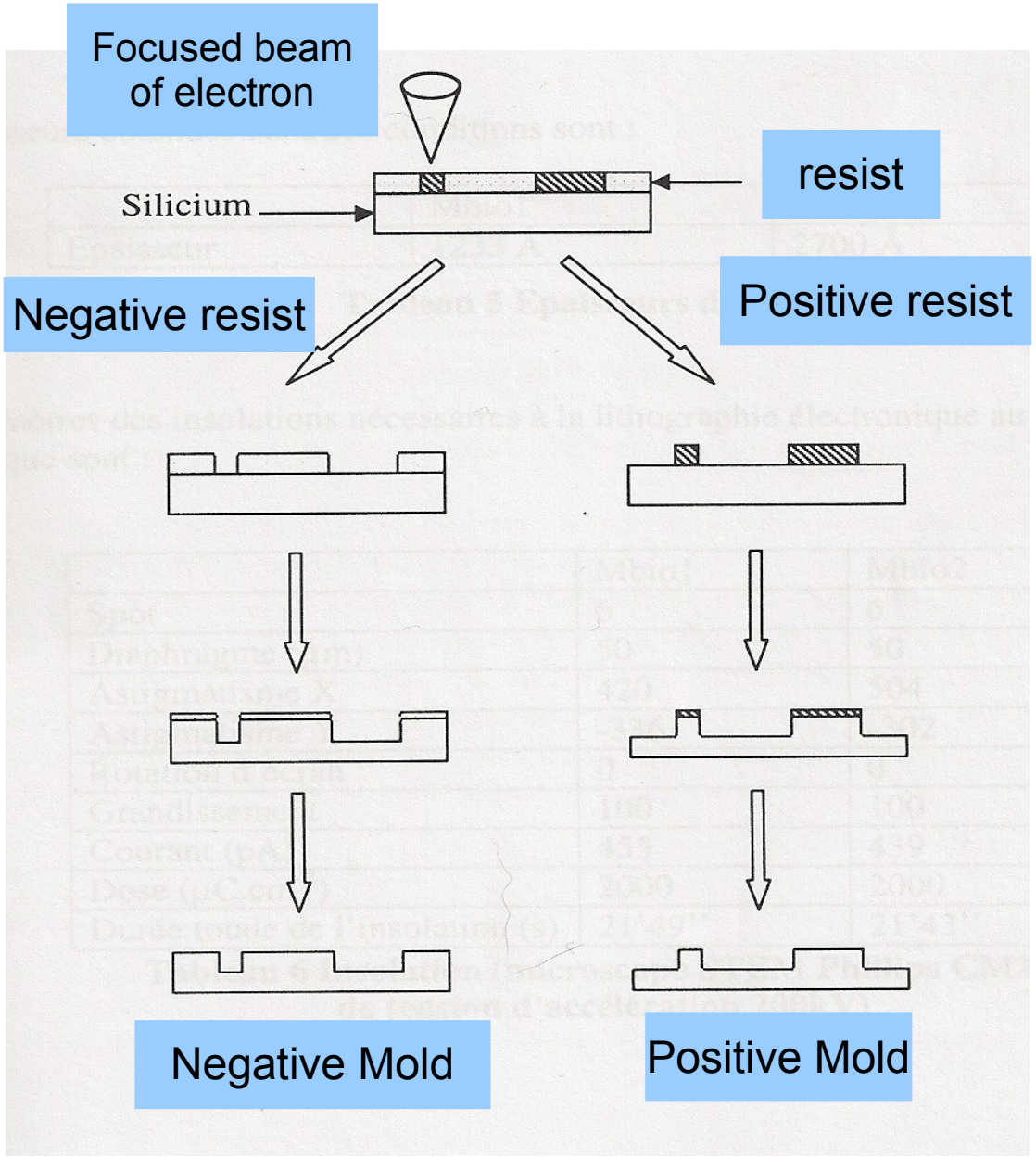
Mold fabrication : EBL Time

Dose = it/S

Example:

Current i= 450 pA
Dose = 2000 $\mu C.cm^{-2}$
Surface S = $2.8.10^{-4}$ cm
→ t = 23 minutes

Mold fabrication: positive/negative resist



Insulation

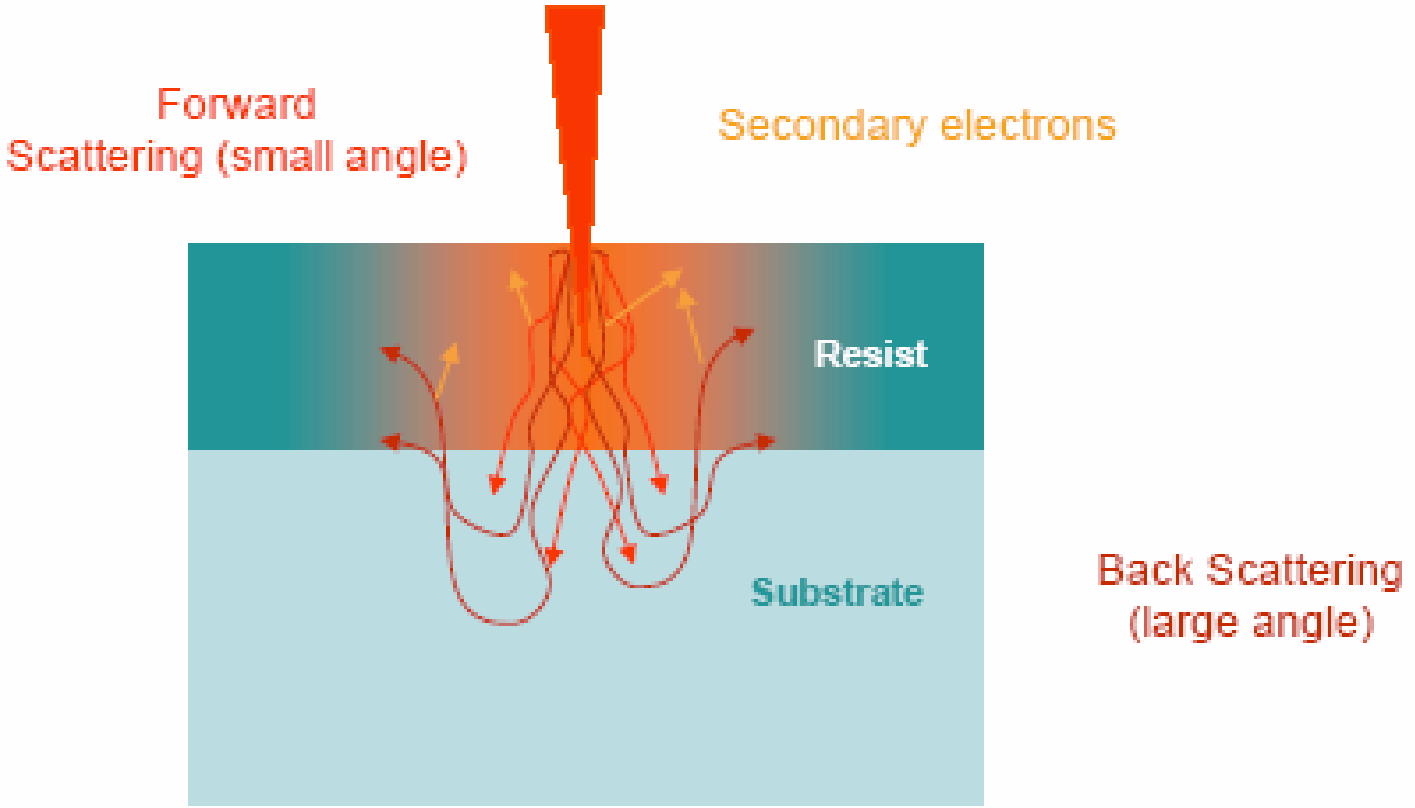
Development

Etching

Cleaning

Mold fabrication : Resist

Electron Scattering in Resist and Substrate



The scattered electrons also expose the resist!

Mold fabrication : Resist

Positive resist:

Bonds breaking

↓

Molecular Weight ↘

↓

Solubility ↗ in the developer

Negative resist:

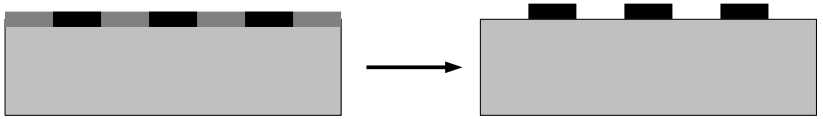
Cross linking

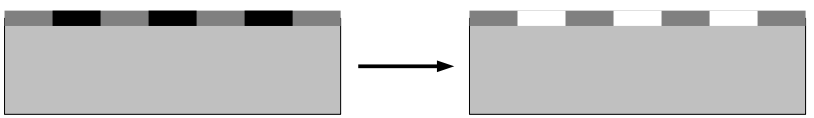
↓

Molecular Weight ↗

↓

Solubility ↘ in the developer



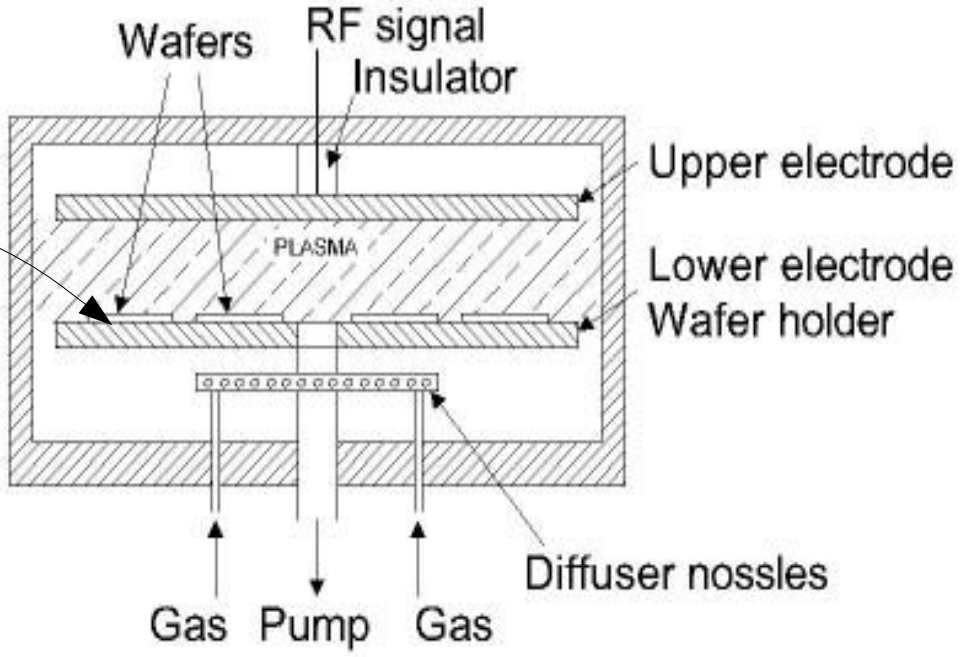


Mold fabrication : RIE

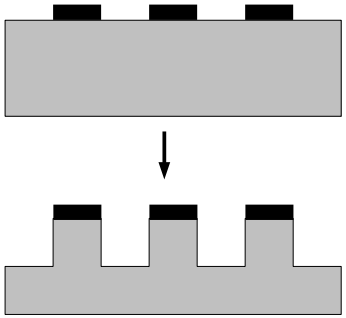
R I E = **R**eactive **I**on **E**tching

Ion bombardement + chemical reaction

- U_0 = bond energy of surface's atoms
- The neutral molecules of the plasma make U_0 decrease
- The ions accelerates when they are closed to the surface
- substrate = cathode



Interest: very anisotropic.

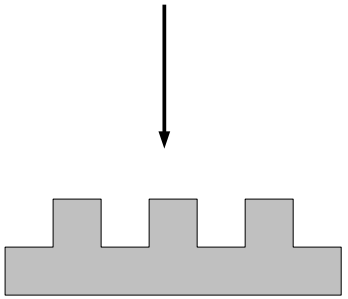


Source: www.memsnet.org

Mold fabrication: cleaning + SAM

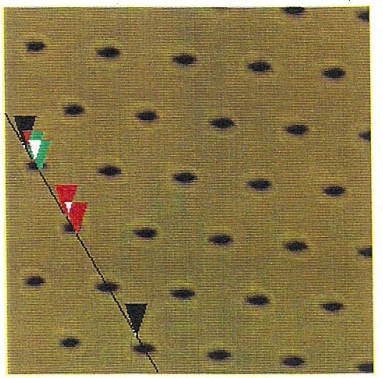
- Ultrasonic cleaning in acetone (remove the residues)
- Treatment anti-adherence

  (Self auto-assembled molecule)



The mold is ready !

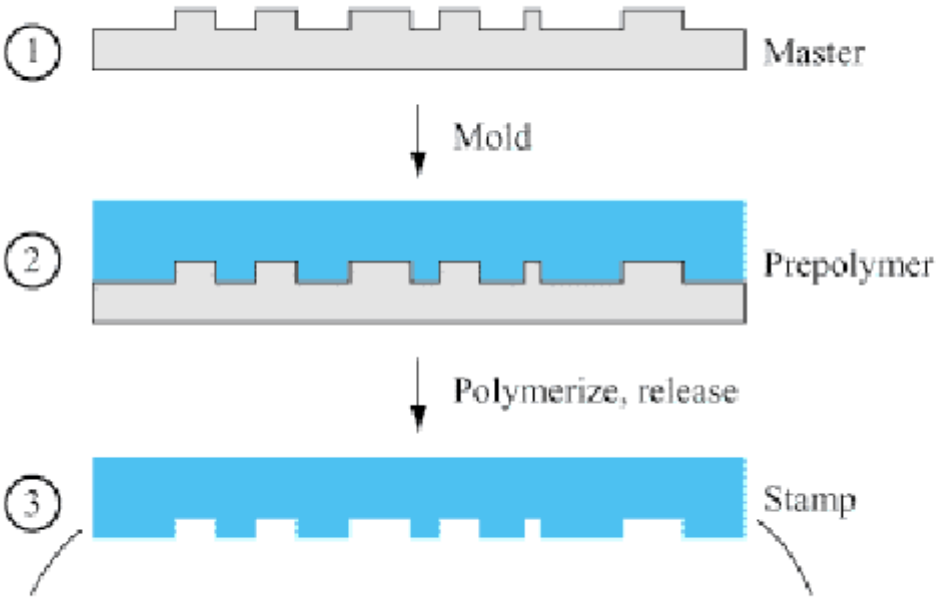
example:



AFM picture of a mold
Diameter of the holes : 200 nm
Period of the array: 500 µm

Resist: PMMA (Poly Methyl MethAcrylate)
Developer: MIBK / IPA (1:3) and IPA
(Methyl IsoButyl Ketone / IsoPropyl Alcool)

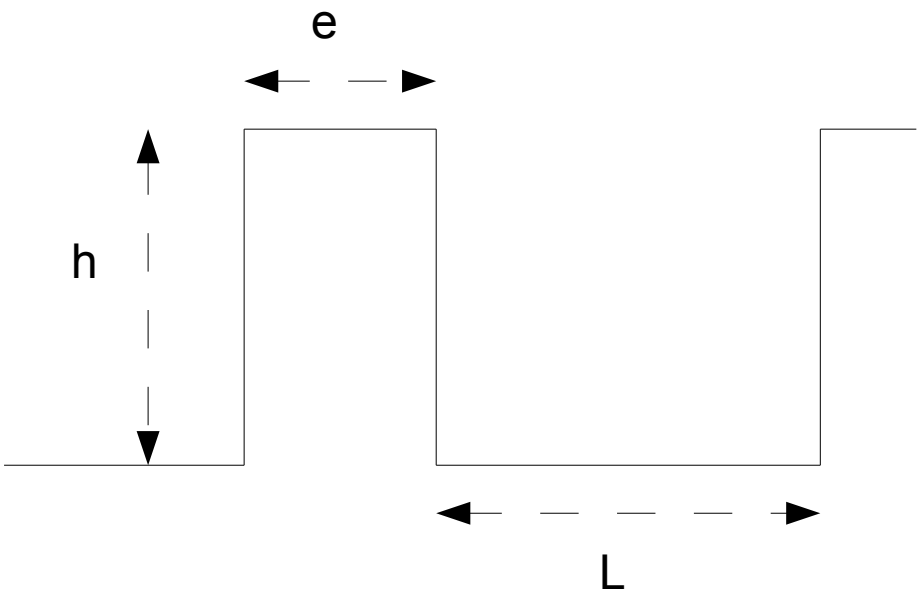
Stamp fabrication

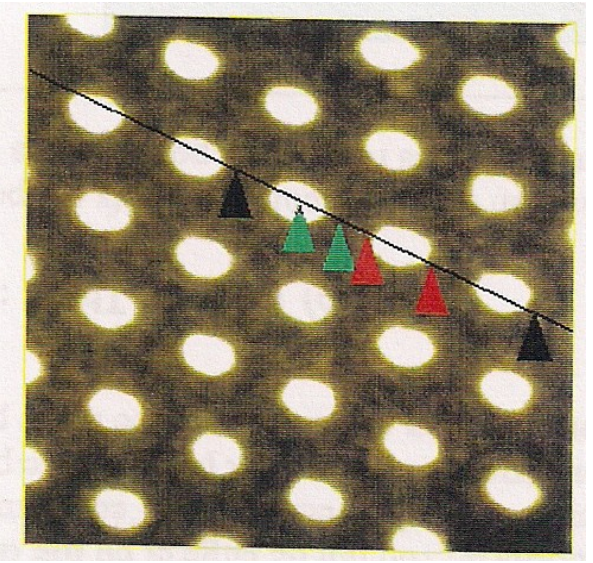


PDMS,
e.g Sylgard 184,
DOW Corning

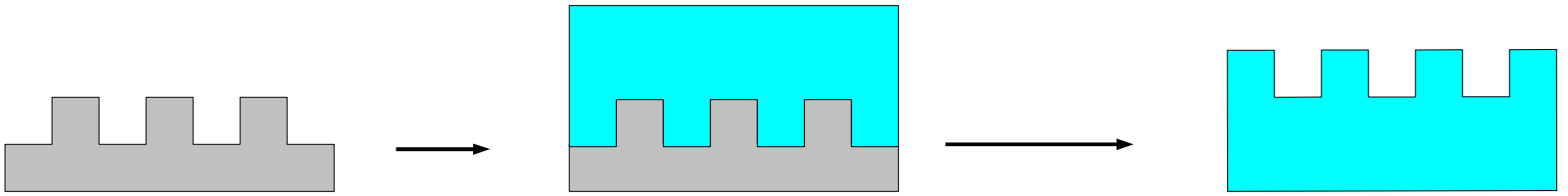
Stamp fabrication

Dimensions constraints:
L < 20h h < 2e

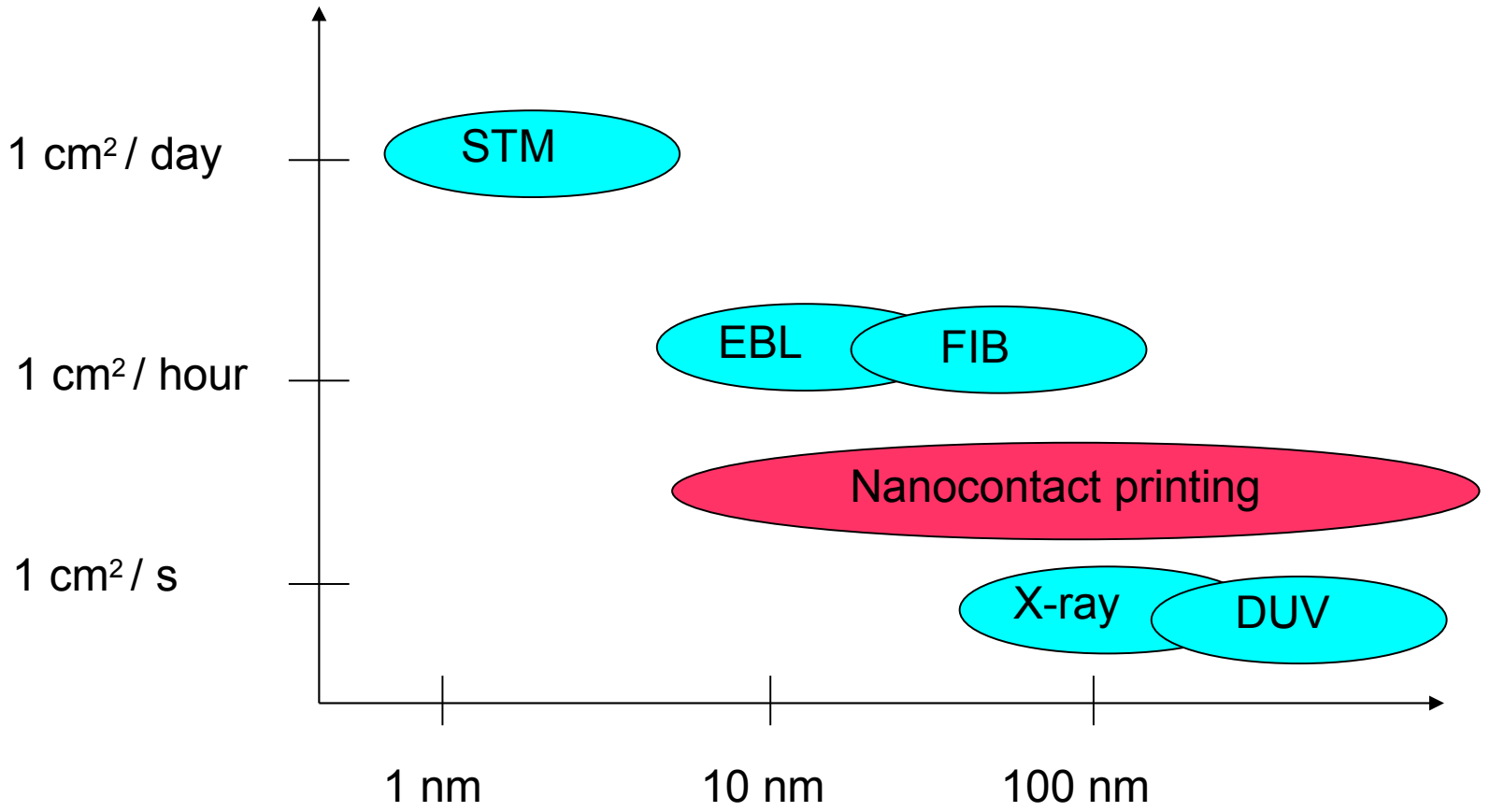




AFM picture of the stamp



Nano contact printing



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Nano contact printing / DNA fixation

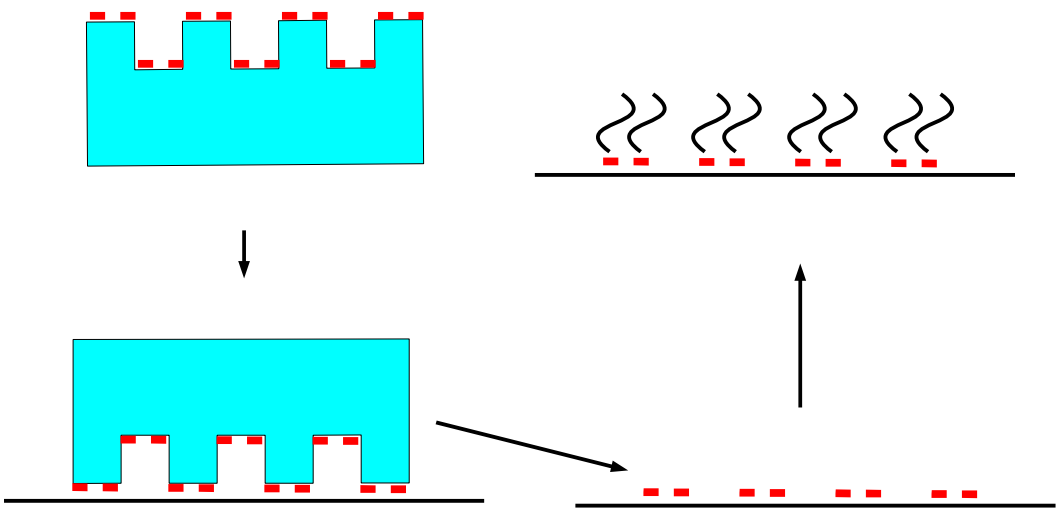
Printing of biological molecules:

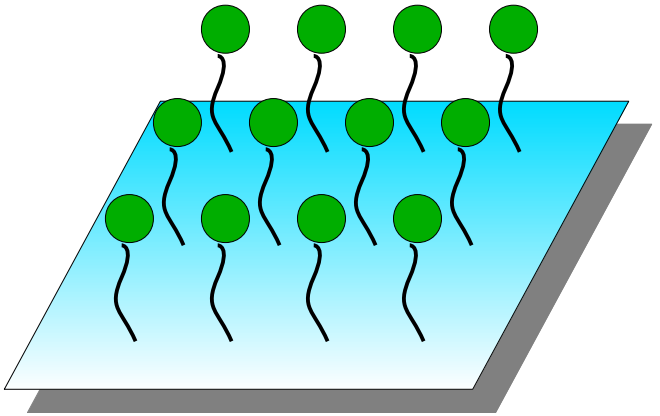
- The **dilution** well selected lead to the possibility to make arrays of single molecules.

- Important works: J.P. Renaud, A. Bernard, A. Bietsch, B. Michel, H.R. Bosshard, E. Delamarche, IBM Zurich.

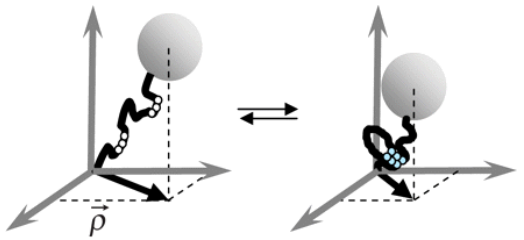
Example of application:
DNA

1. Functionalization of the surface = stamping of oligomers
2. Hybridization of DNA
3. Addition of biotine molecules





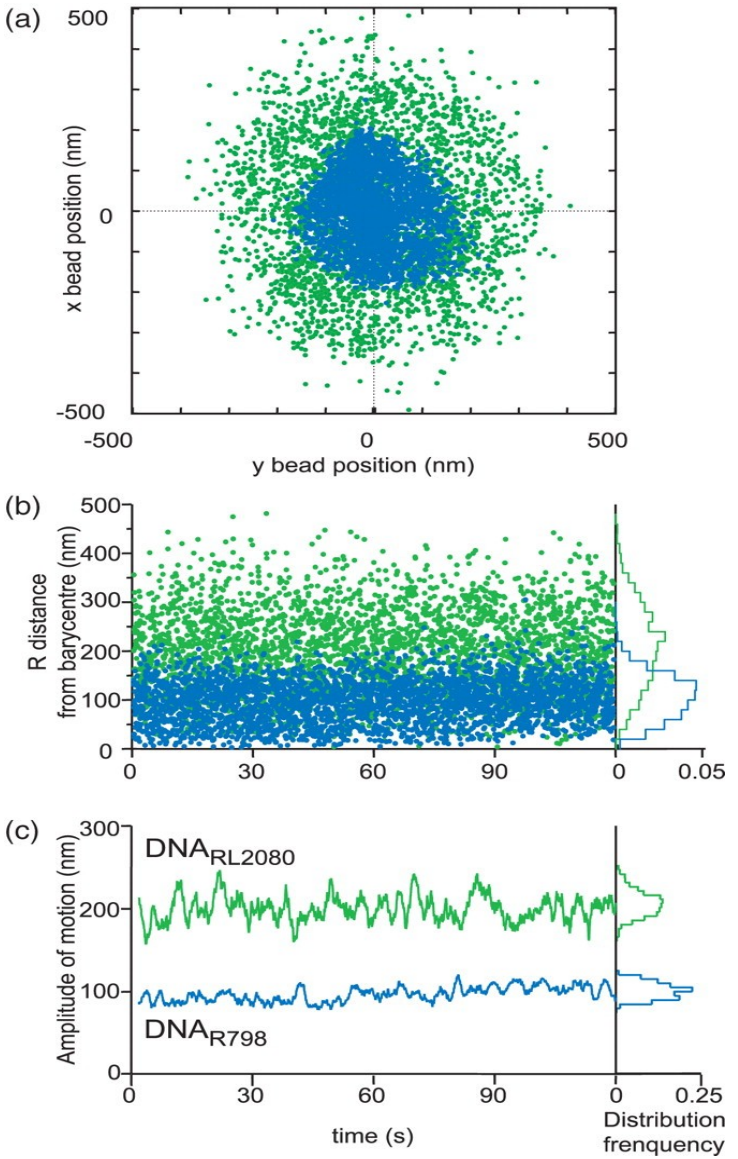
Video microscopy / Image analysis



Unlooped state Looped state

Physics Department, Cell Biology Department, Emory University, Atlanta, GA.

CNRS, Toulouse, France



To conclude...

- Through this example, we can see that the nanotechnologies are a door open to multidisciplinary project
- Each technique improvement linked to this example is a step “forward” for other applications in various fields

References

"Nanostructuration microsensor" , lecture, Christophe VIEU

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