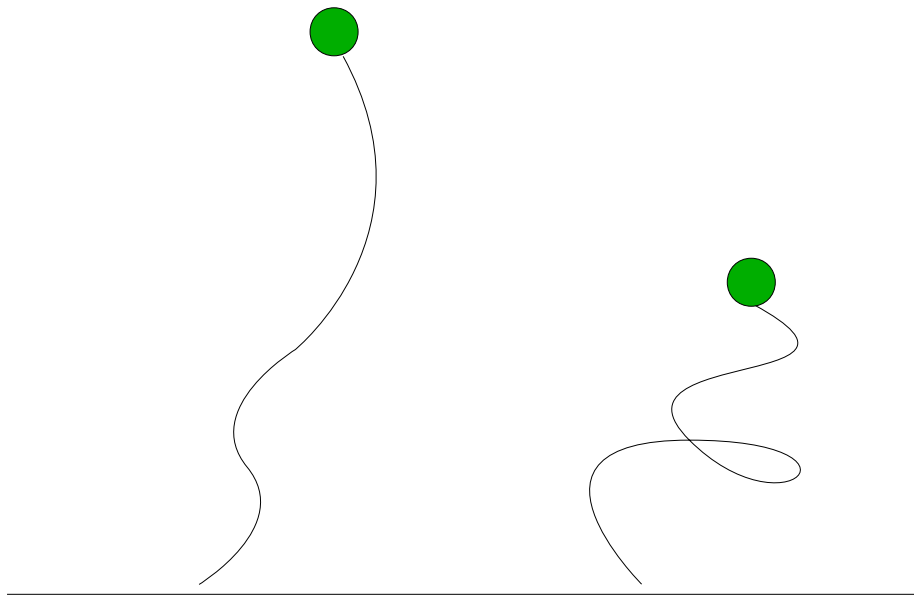


Presentation Phys 730 - Katia GASPERI

Statistical study of single DNA molecules into dynamic array



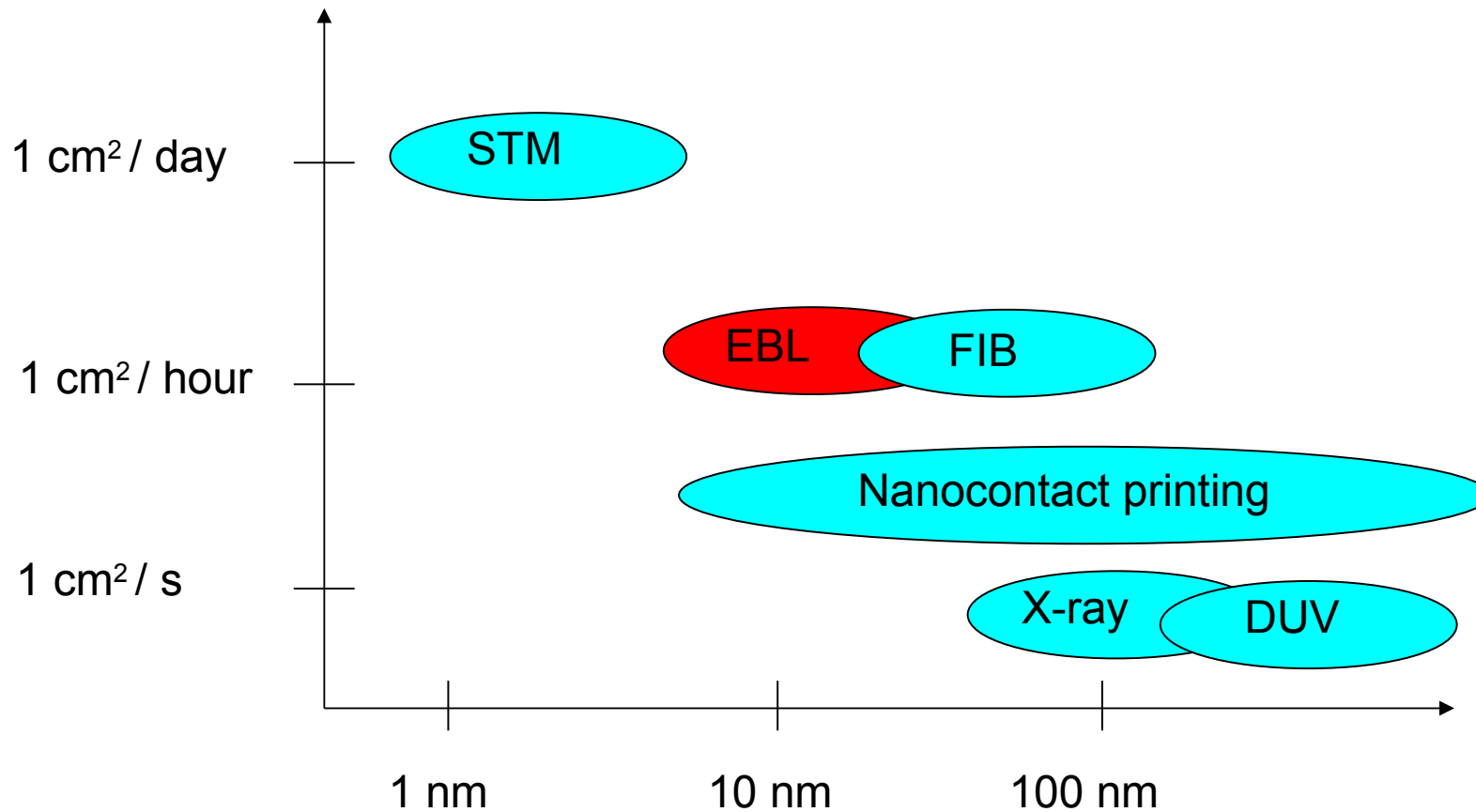
Statistical study of single DNA molecules into dynamic array

- *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:
EBL / Development / Dry etching
- Stamp fabrication
- Nano contact printing / DNA fixation
- Video microscopy / Image analysis

Mold fabrication : EBL



STM = Scanning Tunneling Microscope

EBL = Electron Beam Lithography

FIB = Focused Ion Beam

Mold fabrication : EBL

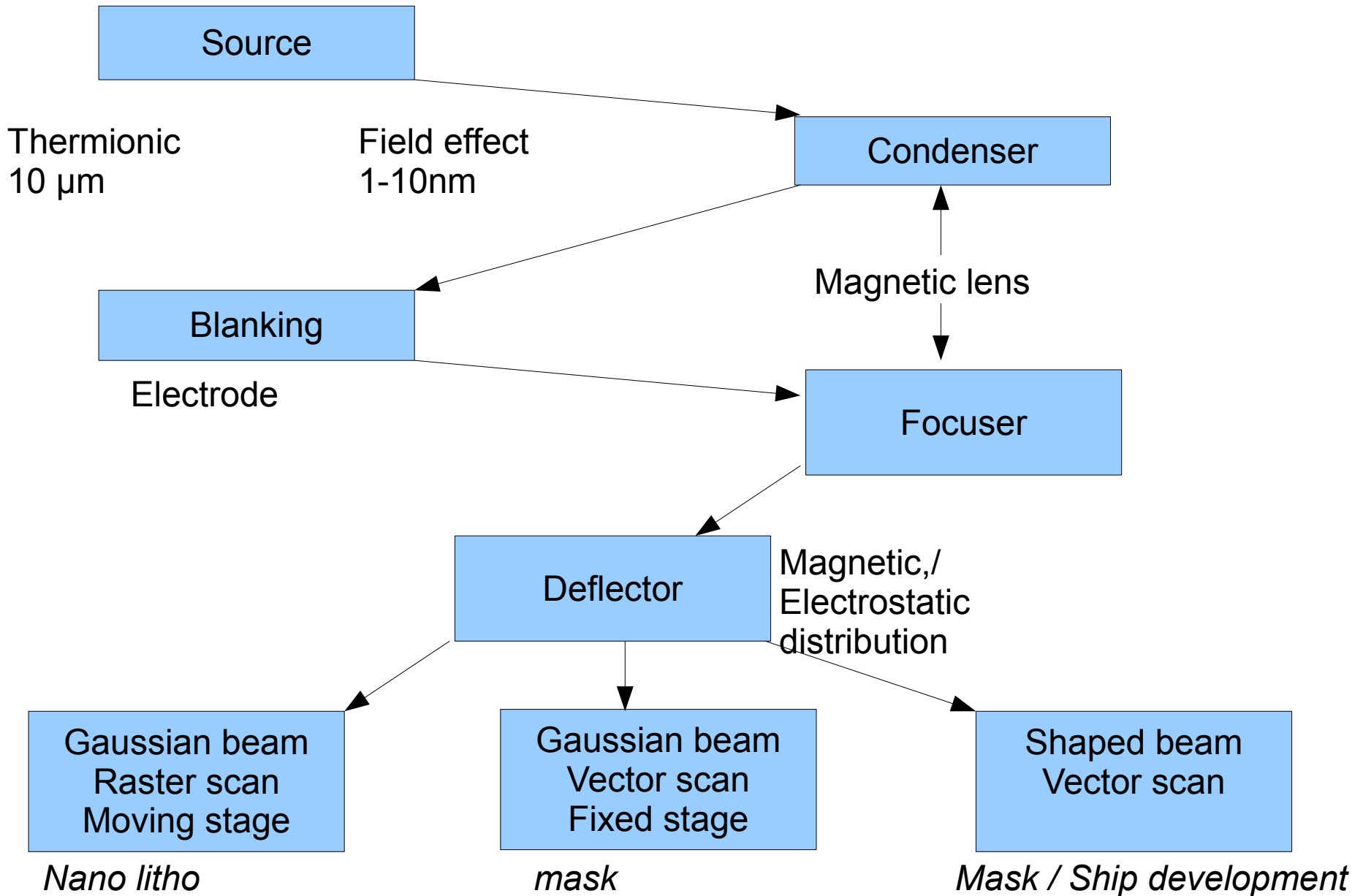
- EBL = Electron Beam Lithography
- Low and expensive process
- High resolution
- Mold reusable



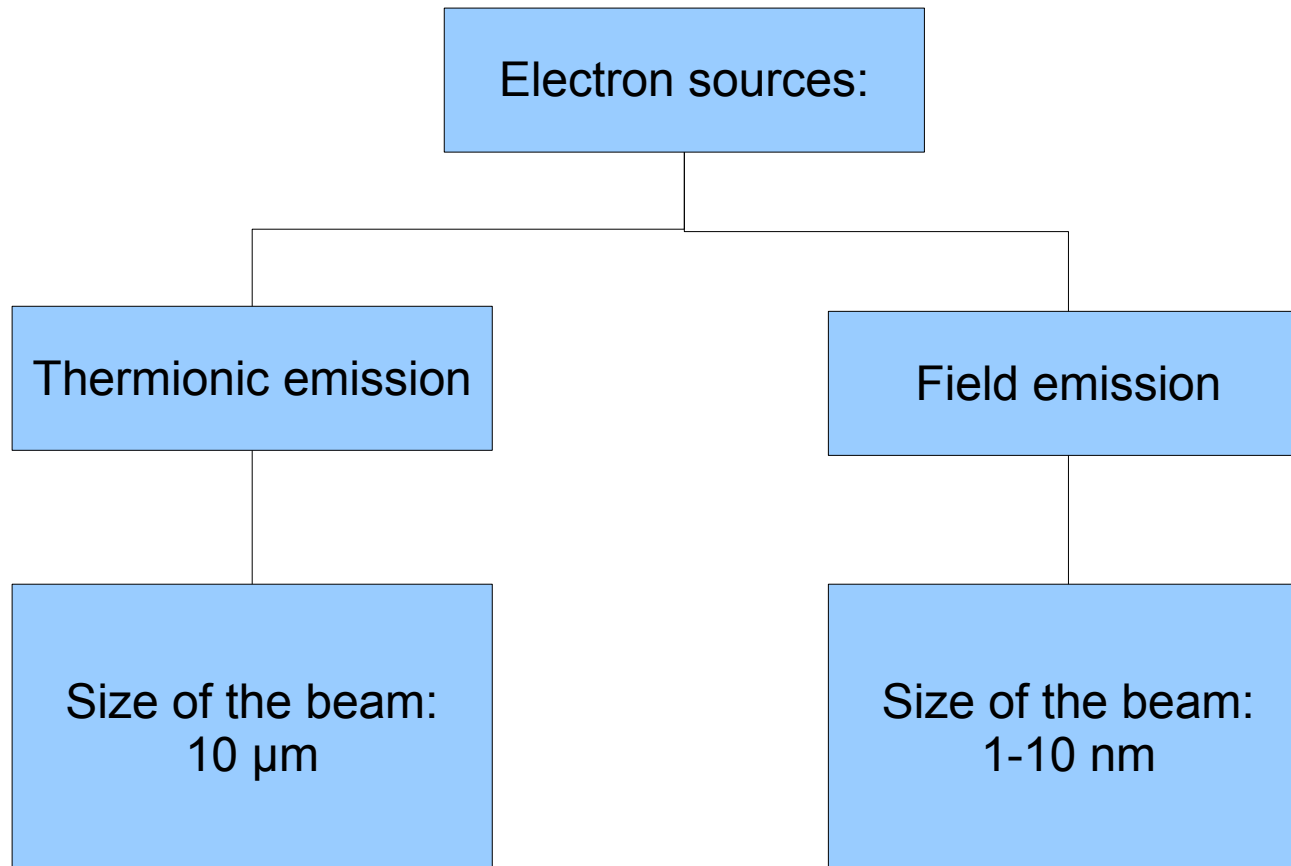
CM20

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

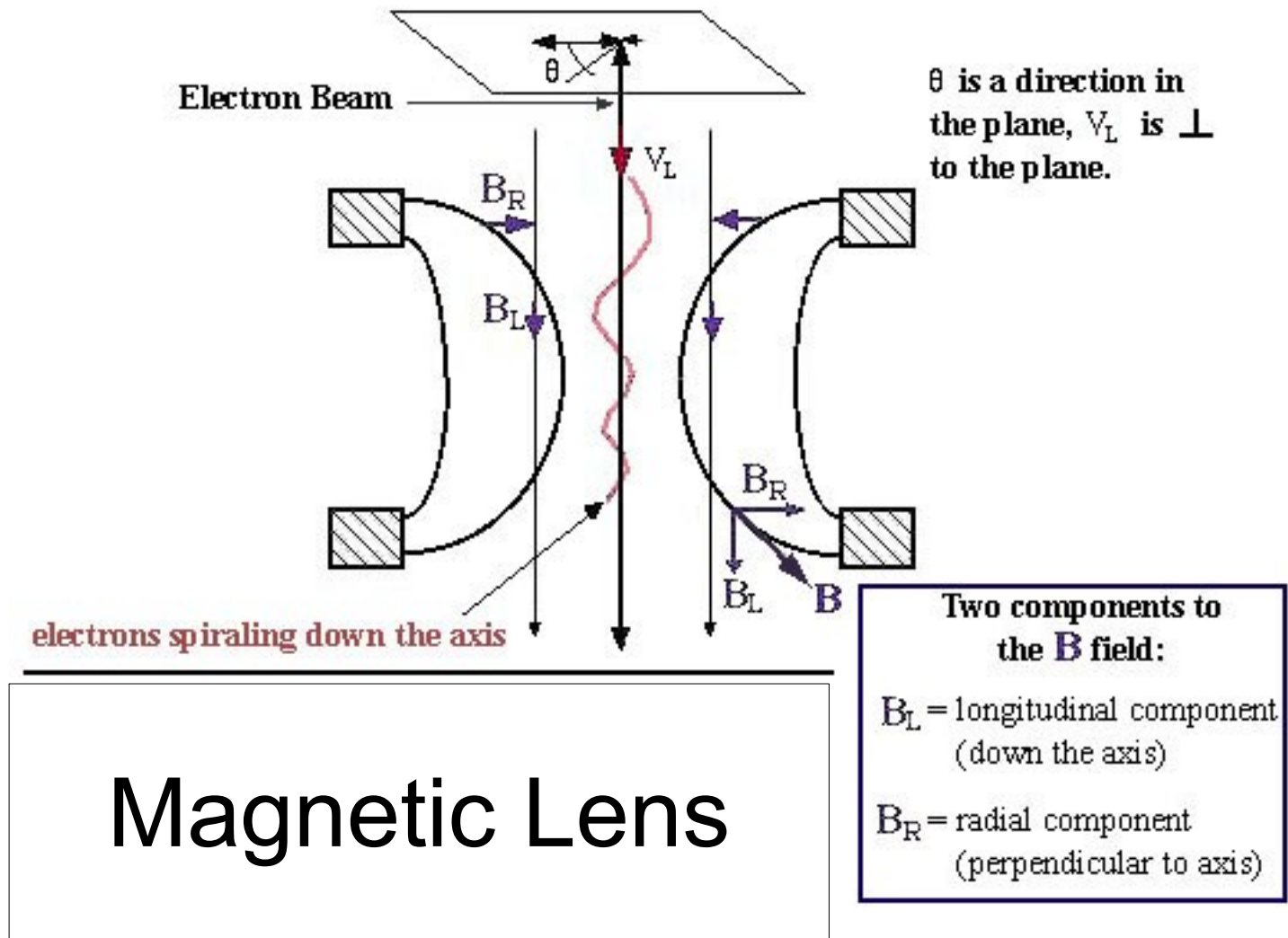
Mold fabrication : EBL



Mold fabrication : EBL Source

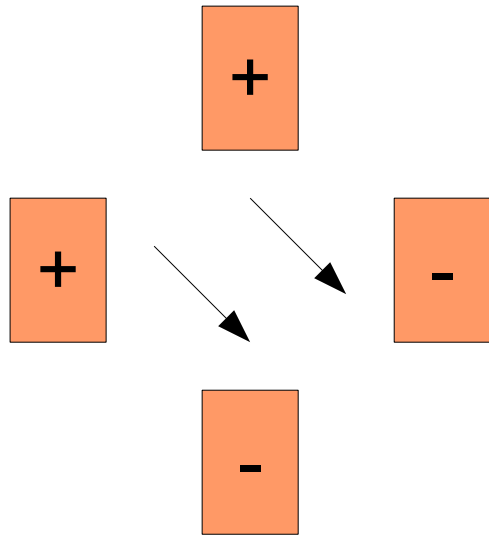


Mold fabrication : EBL

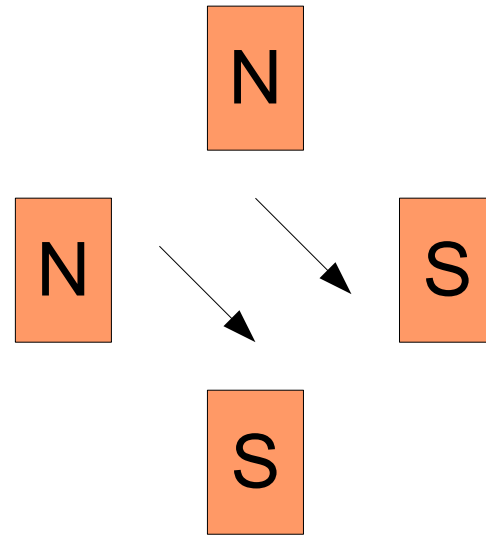


Mold fabrication : EBL Deflector

Electrostatic field



Magnetic field



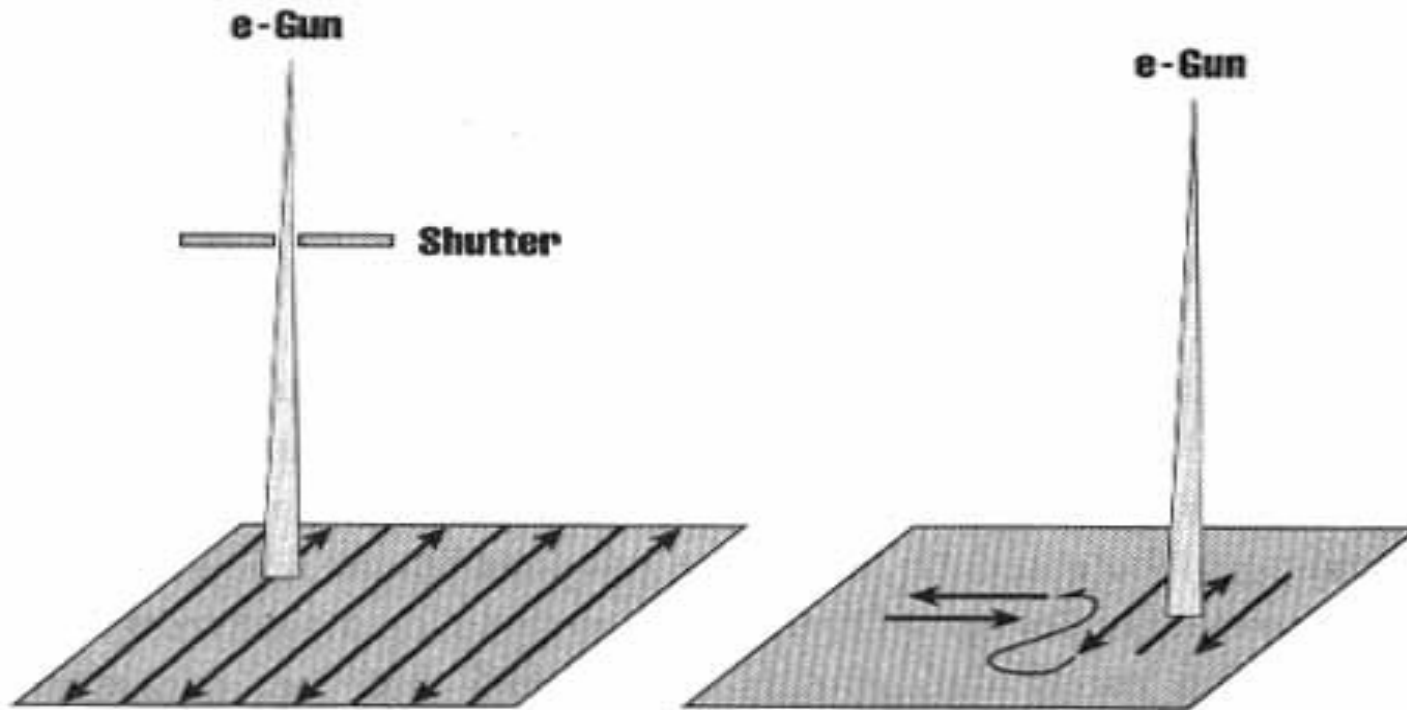
Mold fabrication : EBL Blanker

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

Time & Dose

$$\text{Dose} = it/S$$

Example:

Current = 450 pA

Dose = 2000 $\mu\text{C}\cdot\text{cm}^{-2}$

S = Surface insulated

Dose = it/S

t = 20 minutes

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

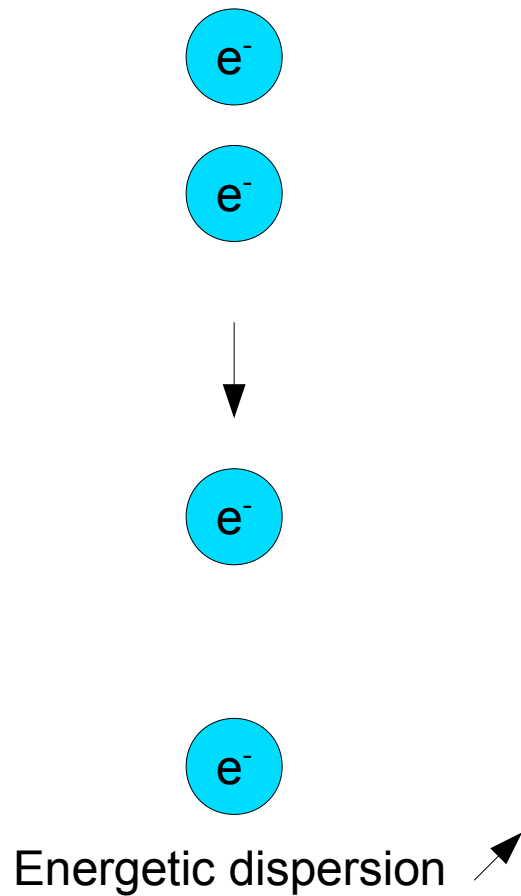
d_s : spherical aberration

d_c : chromatic aberration

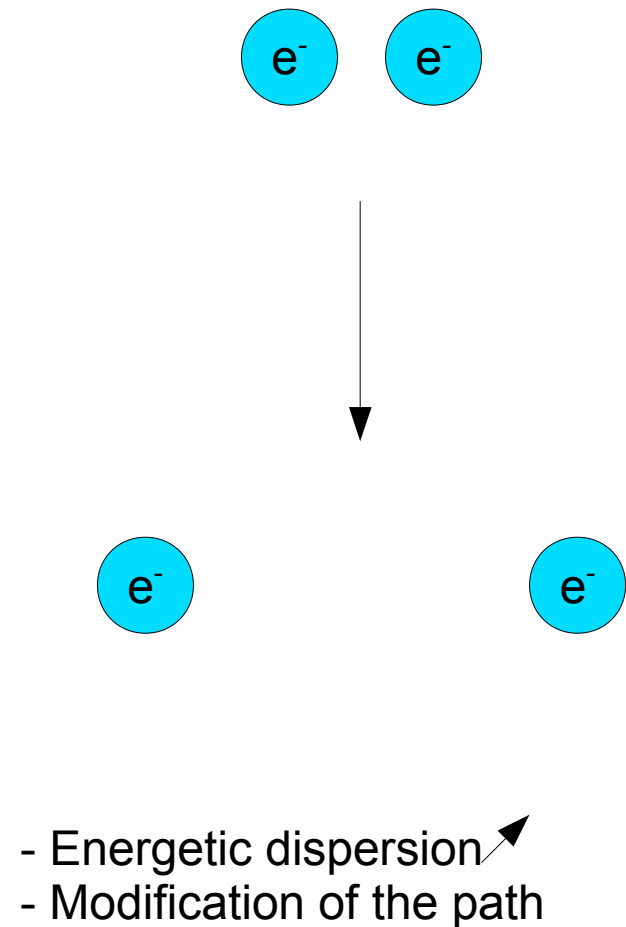
d_d : diffraction limit

Mold fabrication :EBL and more aberrations...

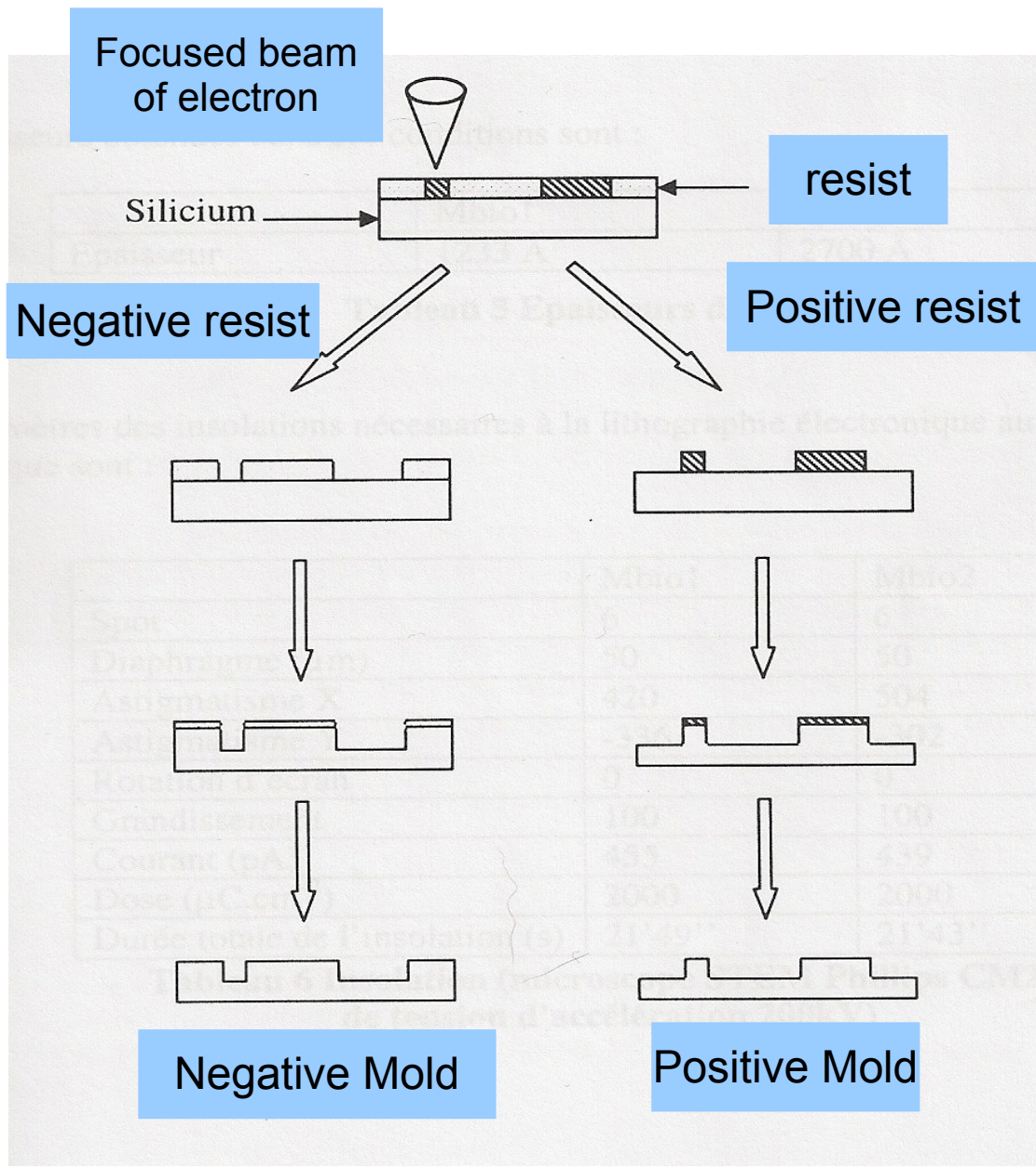
Boersh effect:



Loeffler effect



Mold fabrication: mold / next steps



Insulation

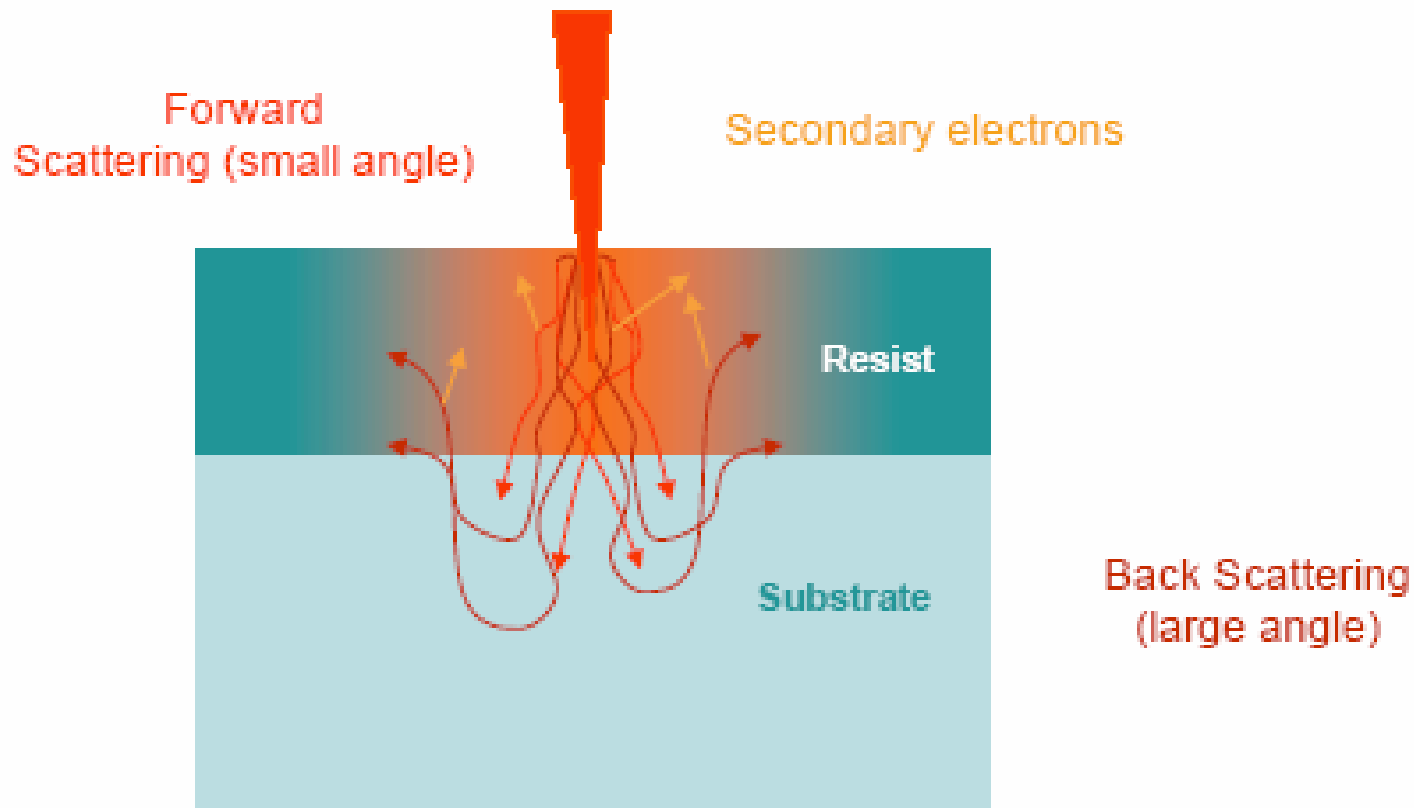
Development

Etching

Cleaning

Mold fabrication : Resist

Electron Scattering in Resist and Substrate

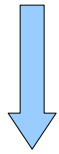


The scattered electrons also expose the resist!

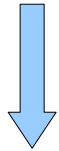
Mold fabrication : Resist

Positive resist:

Bonds breaking



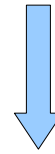
Molecular Weight ↘



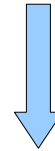
Solubility ↗

Negative resist:

Cross linking



Molecular Weight ↗



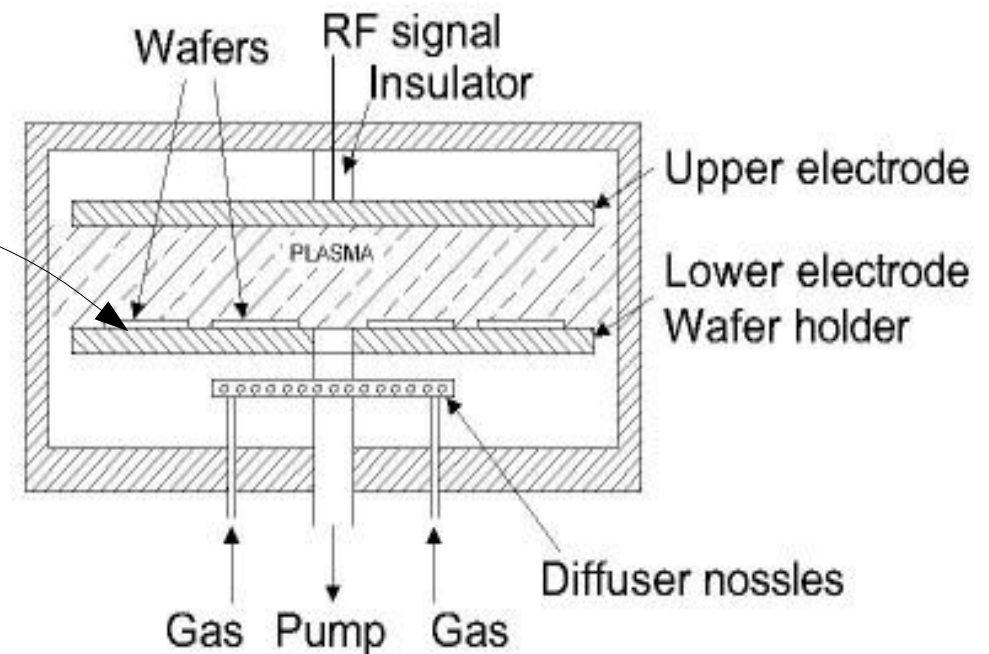
Solubility ↘

Mold fabrication : RIE

RIE = Reactive Ion Etching

- 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

**Ion bombardement +
chemical reaction**

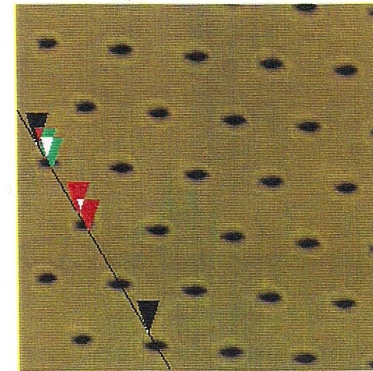


Interest: very anisotropic.

Source: www.memsnets.org

Mold fabrication: cleaning + SAM

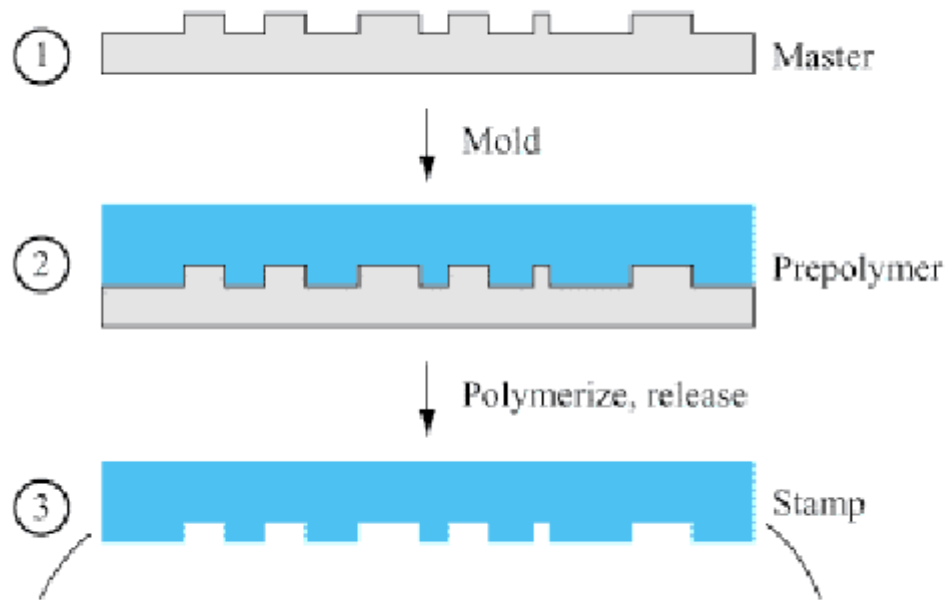
- Ultrasonic cleaning in acetone (remove the residues)
- SAM (preparation to receive the elastomer)



*AFM picture of a mold
Diameter of the holes : 200 nm
Period of the array: 500 μ m*

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

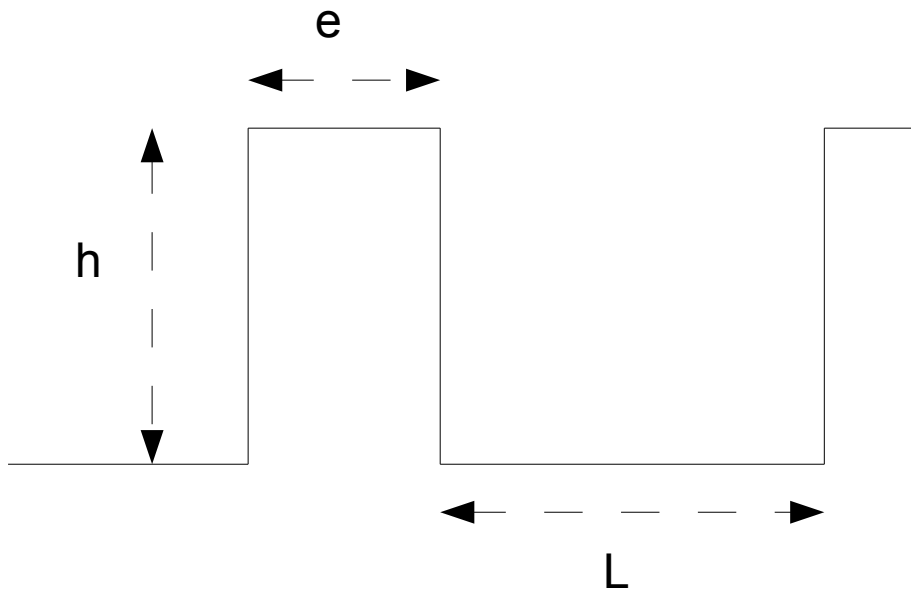
Stamp fabrication



PDMS,
e.g Sylgard 184,
DOW Corning

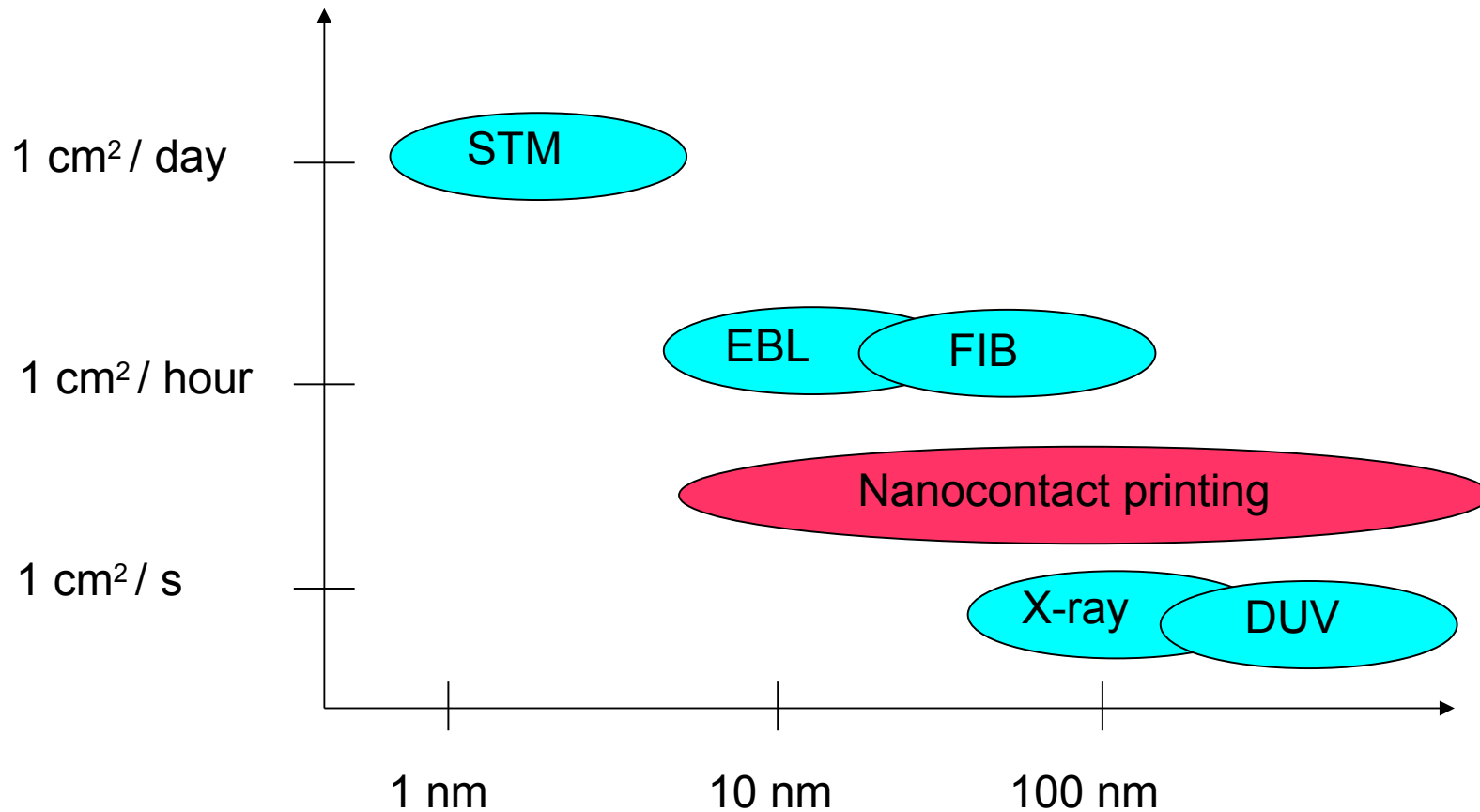
Stamp fabrication

Dimensions conditions:
 $L < 20h$ $h < 2e$



AFM picture of the stamp

Nano contact printing



STM = Scanning Tunneling Microscope

EBL = Electron Beam Lithography

FIB = Focused Ion Beam

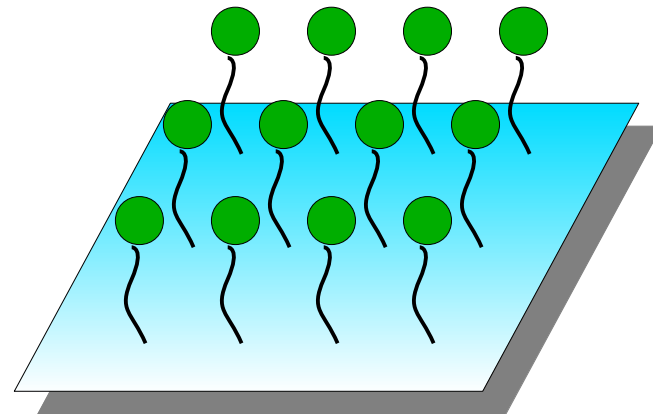
Nano contact printing / DNA fixation

Printing of biological molecules:

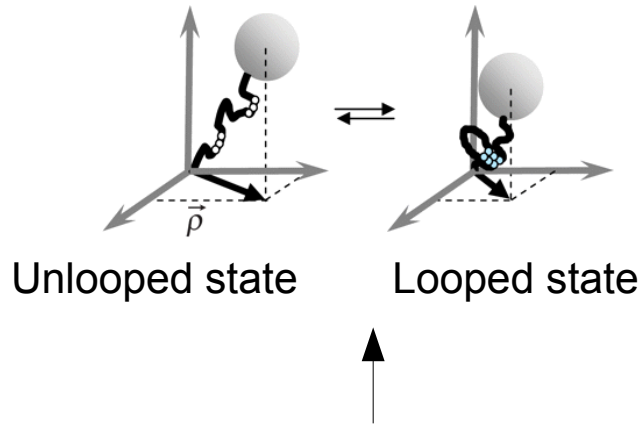
- The method fits to any **kind of molecules**
- The **dilution** well selected lead to the possibility to make arrays of single molecules. (see ref.)
- Important works: J.P. Renaud, A. Bernard, A. Bietsch, B. Michel, H.R. Bosshard, E. Delamarche, IBM Zurich.

Example of application:
DNA

1. Functionalization of the surface = stamping of oligomers
2. Hybridization (DNA brought using capillarity)
3. Addition of biotine molecules

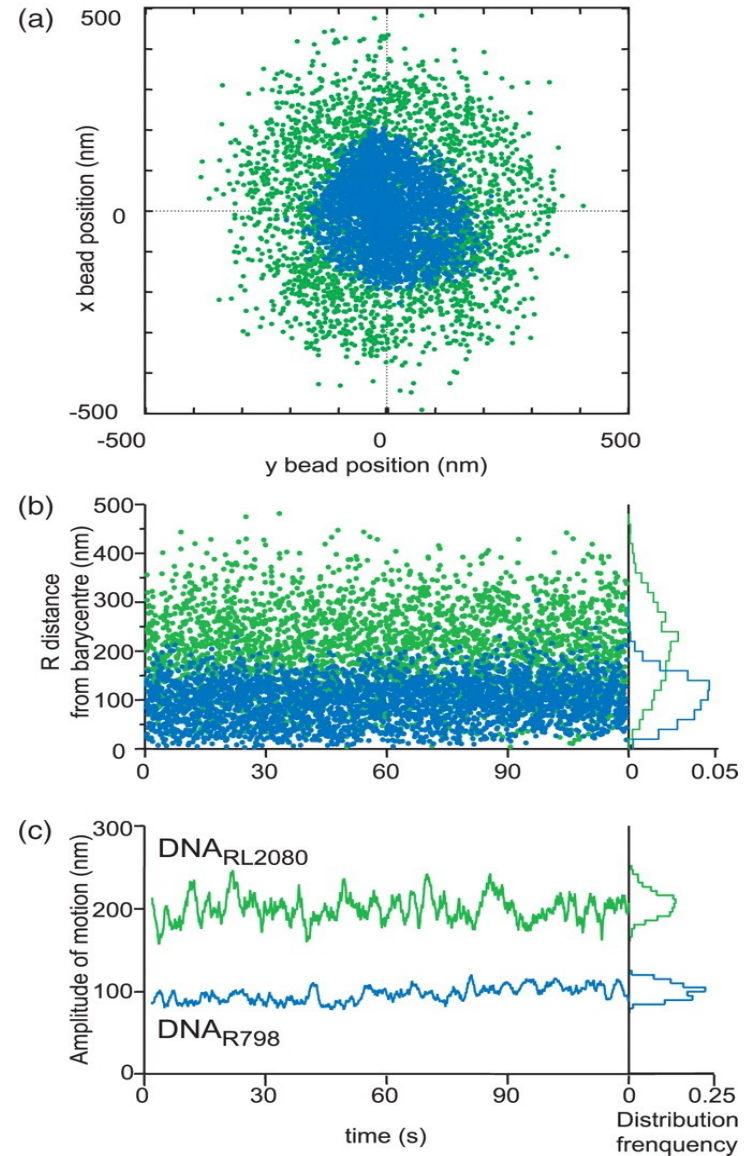


Video microscopy / Image analysis



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

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