

PREPARATION OF HIGH QUALITY NANOPORES FOR SUCCESSFUL NANOBIOLOGY EXPERIMENTS



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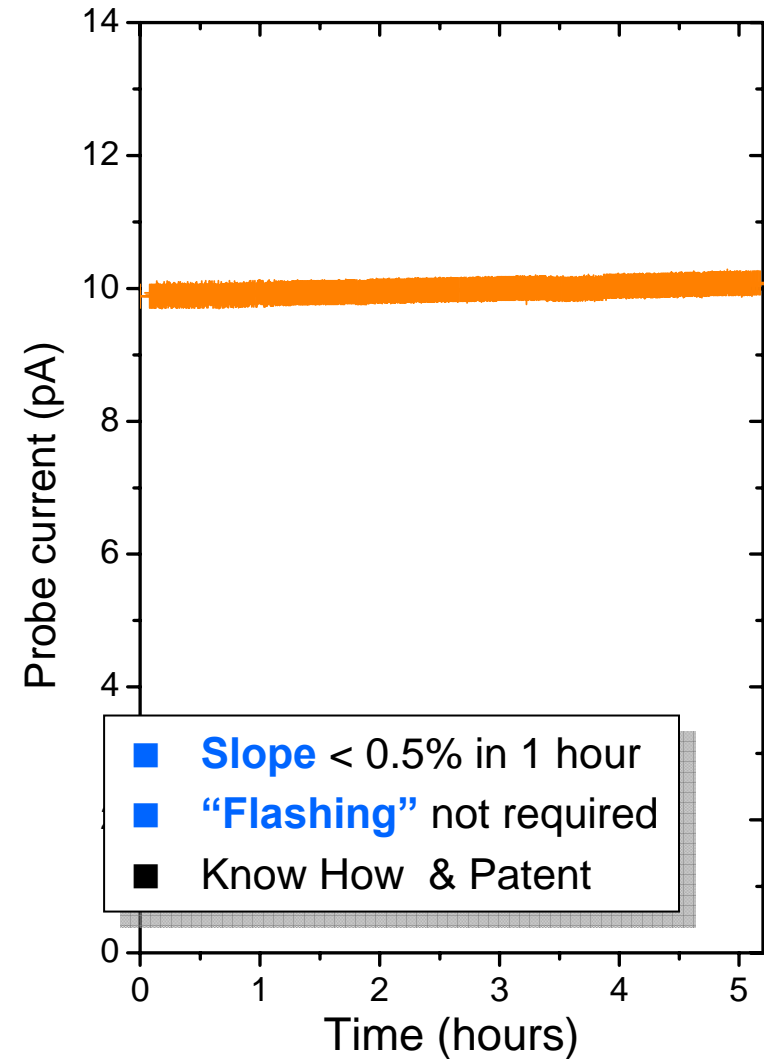
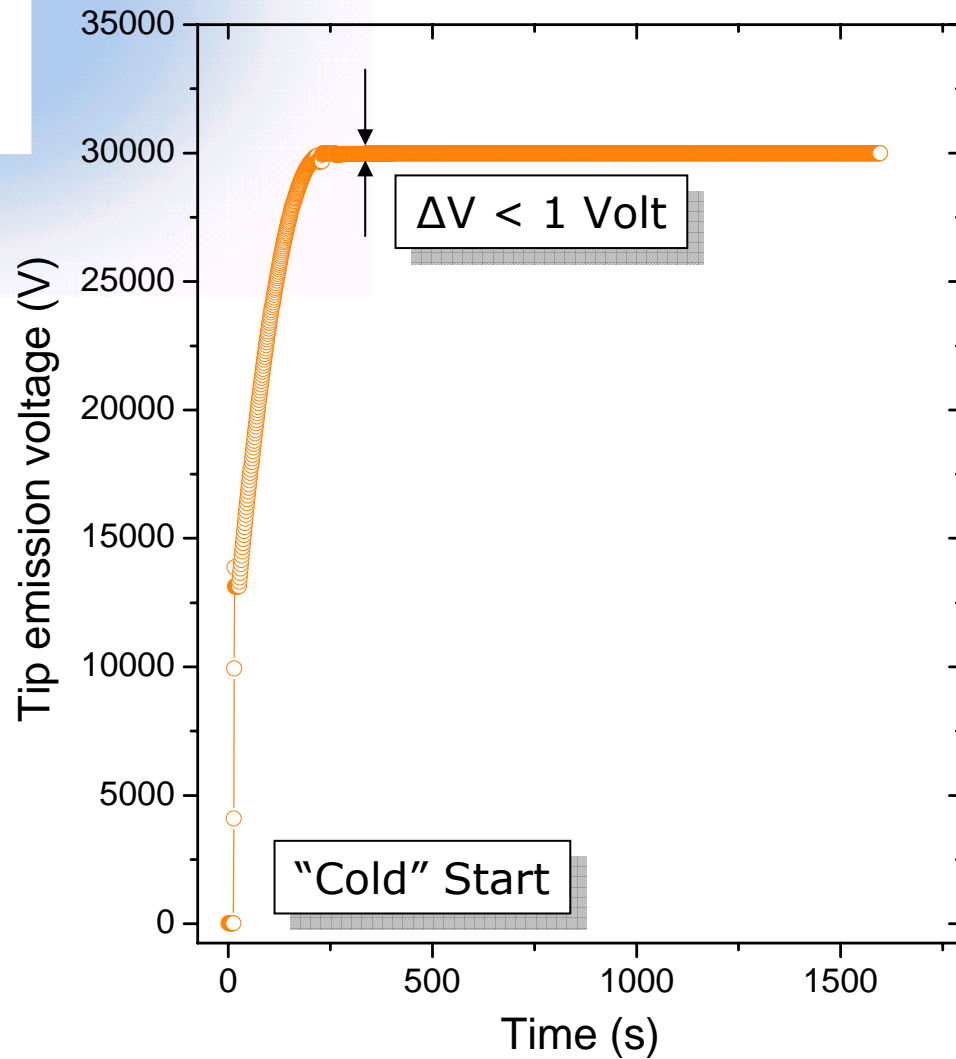
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OUTLINE

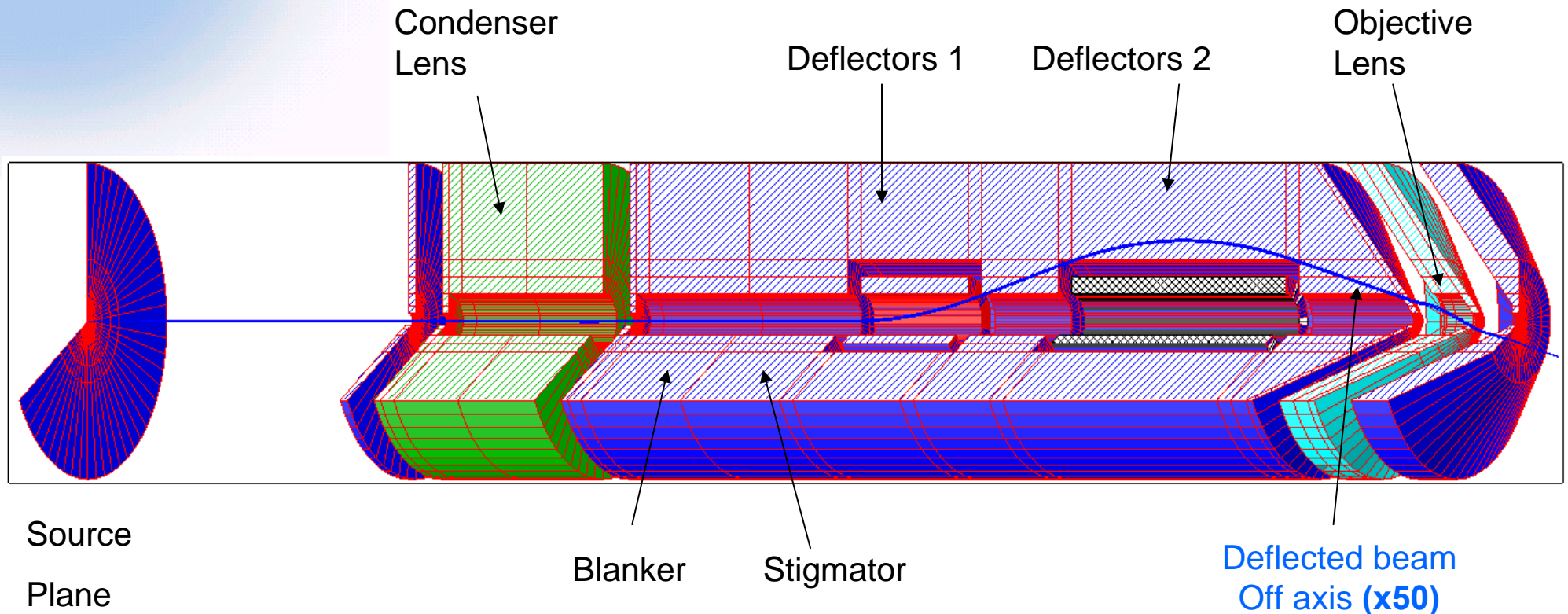
- 1 - The NanoFIB technology
- 2 - Nanowriter performances
- 3 - Translocation experiments
- 4 - Conclusions and outlook

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OPTIMISED GEOMETRY WITH HIGH STABILITY



SUB-10 nm DESIGNED ION OPTICS



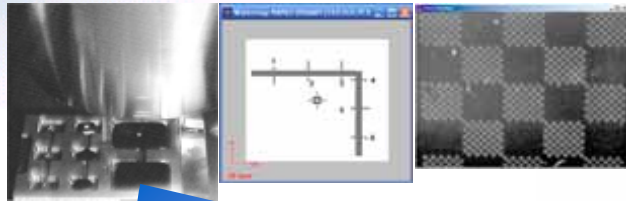
- Design
- Modeling
- User Validated

2 Lens concept, collimated mode, X-short WD
5 nm probe size calculated **and** achieved
Optimum focus set/ beam shaping or corrections

NANOWRITER PROCESSING CAPABILITIES

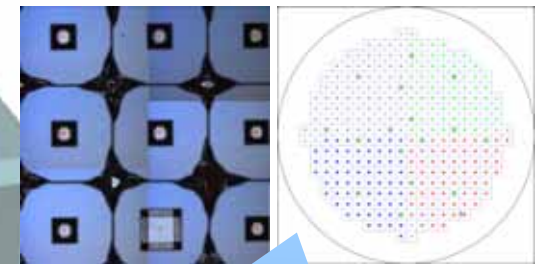
■ Sample identification

Optical Microscope



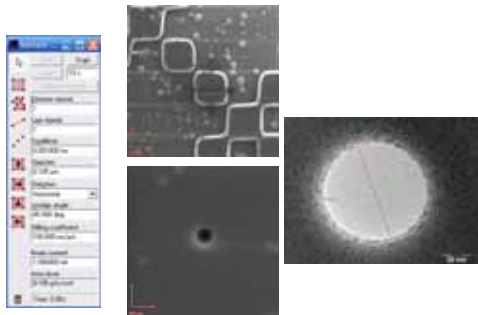
■ FIB Processing

*GDSII Files loaded
Task List
Blind Navigation*



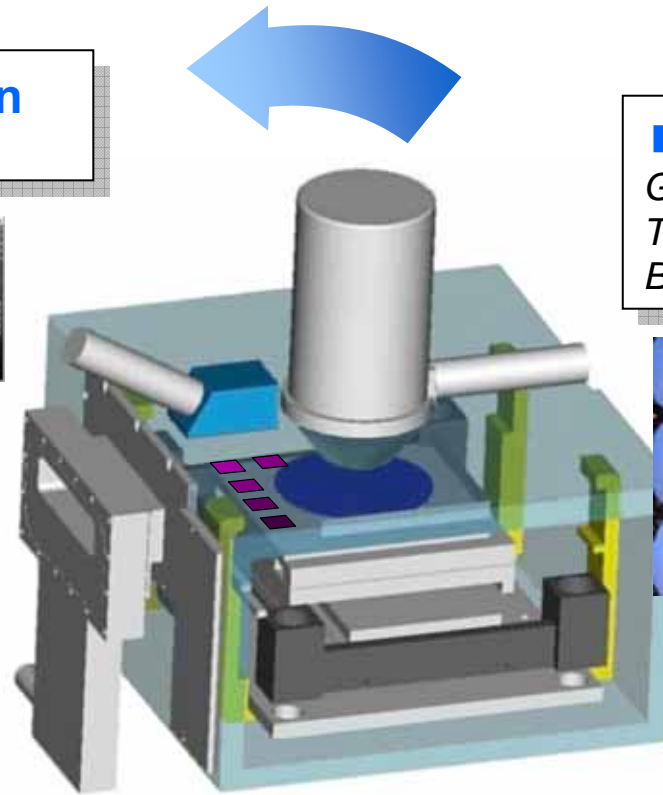
■ FIB Beam Shaping

Focus Stigmatism, Field stitching



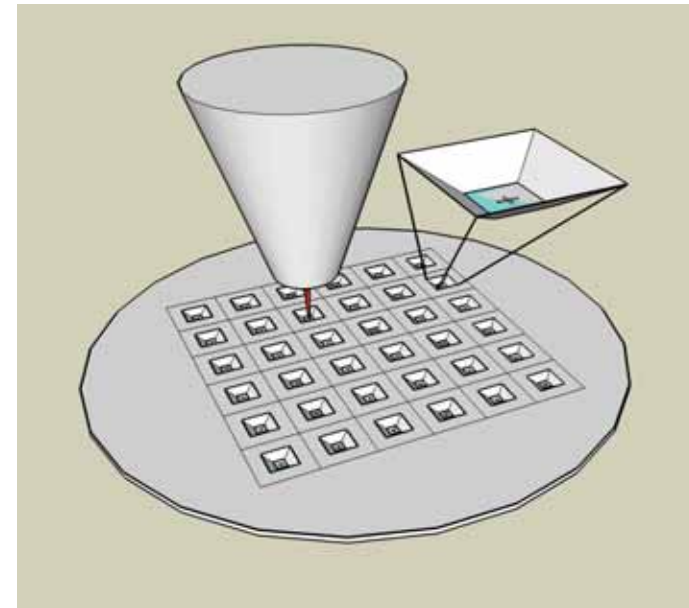
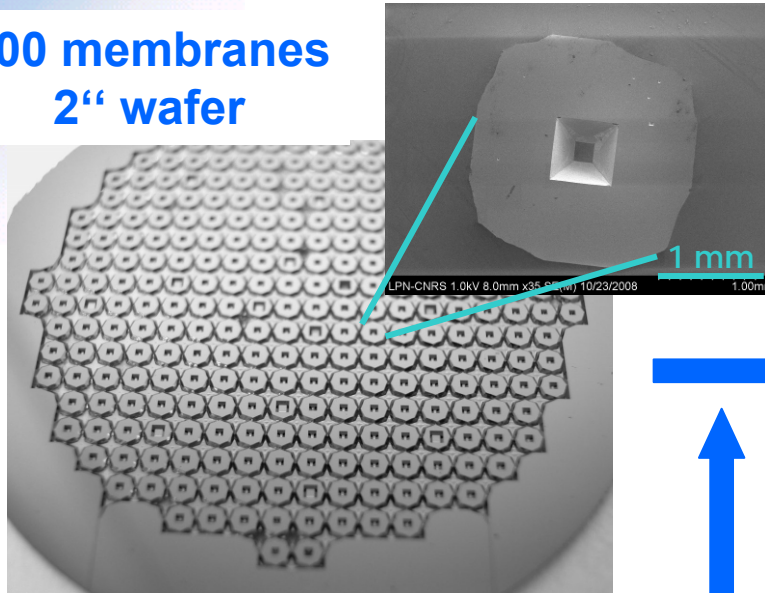
■ FIB Pattern Calibration

Etching speed, scanning strategy

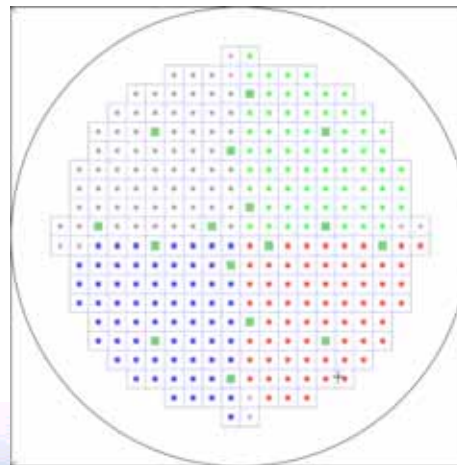


MULTIPLE AND REPRODUCIBLE NANOPORE FABRICATION

200 membranes
2" wafer

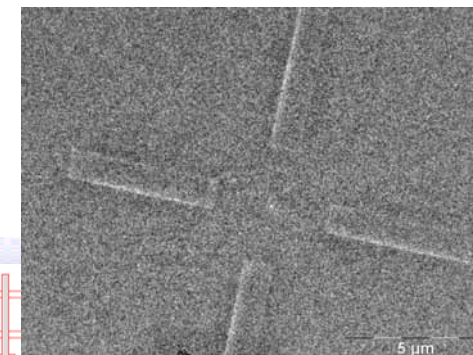


Reference file
Lithography



EFUG 2009, 5/10/2009, Arcachon

On each membrane:



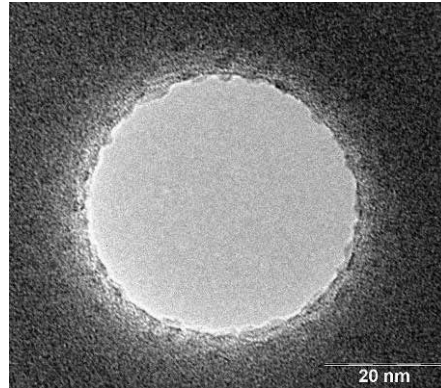
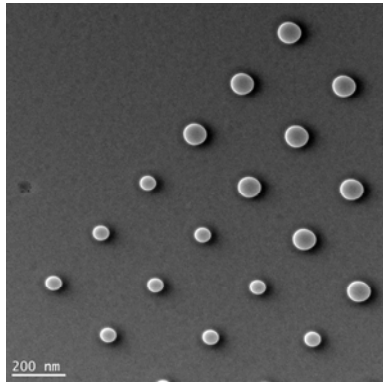
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NANOWRITER PERFORMANCES

Shapes

SiN 50 nm

SiC 50 nm

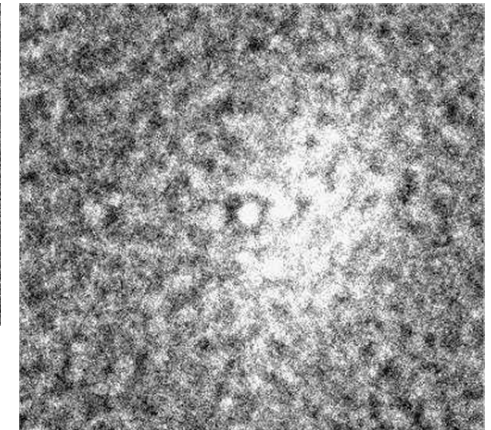
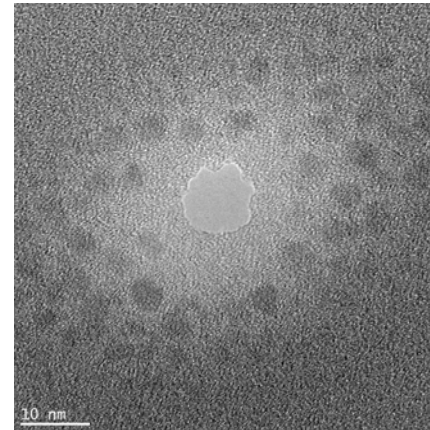


d = 40 nm

Nanometre-sized pores

SiN 50 nm

SiC 20 nm



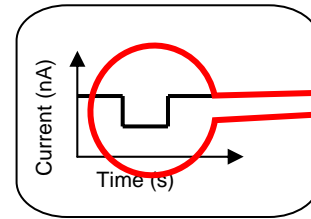
d = 8 nm

d = 3 nm

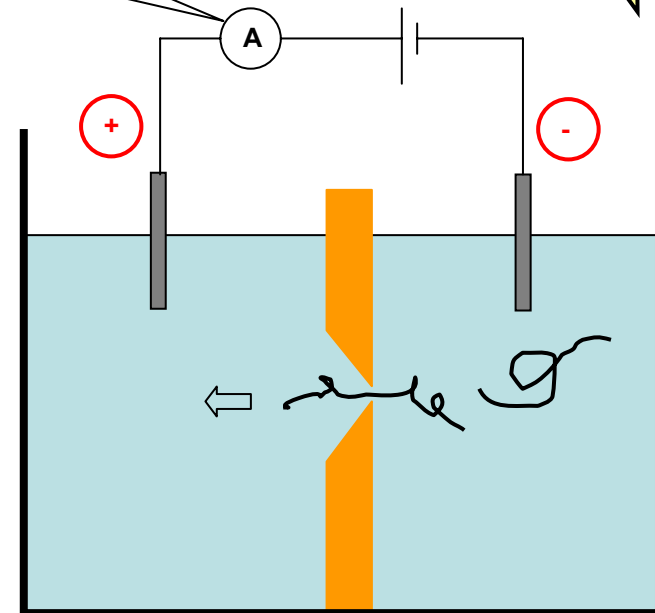
■ Aspect ratio 1/7

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TRANSLOCATION OF MOLECULES : PRINCIPLE



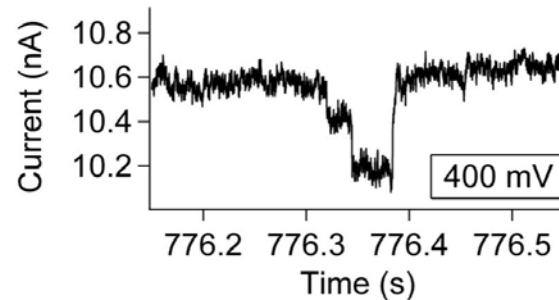
shape of event gives information about molecules size/properties



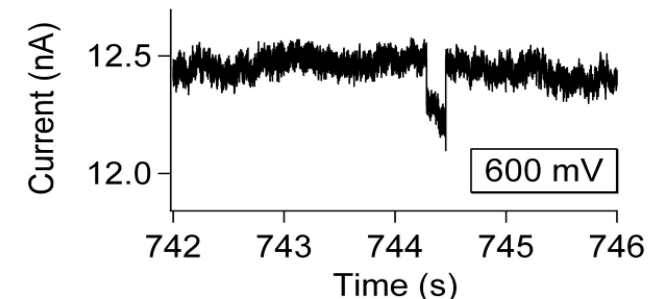
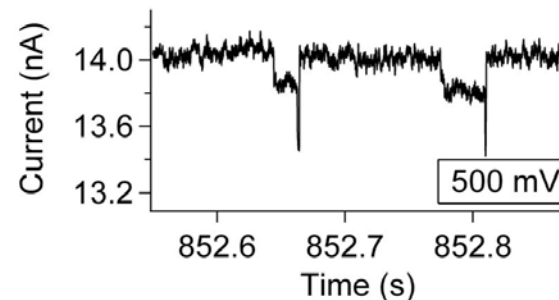
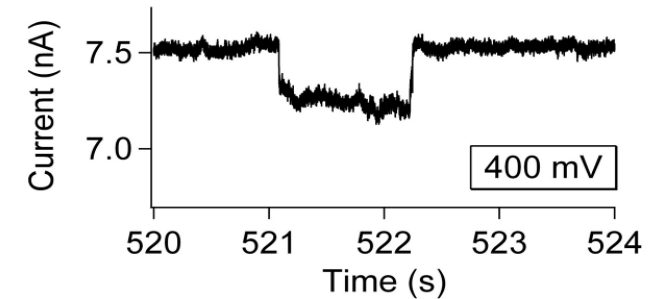
- Nanopore size must be $\ll 10$ nm !!!
- Reproducible size, shape and surface properties

REPRODUCIBLE TRANSLOCATION EXPERIMENTS

λ -DNA (6.5 nM)



Fibronectin (0.545 mg/ml)



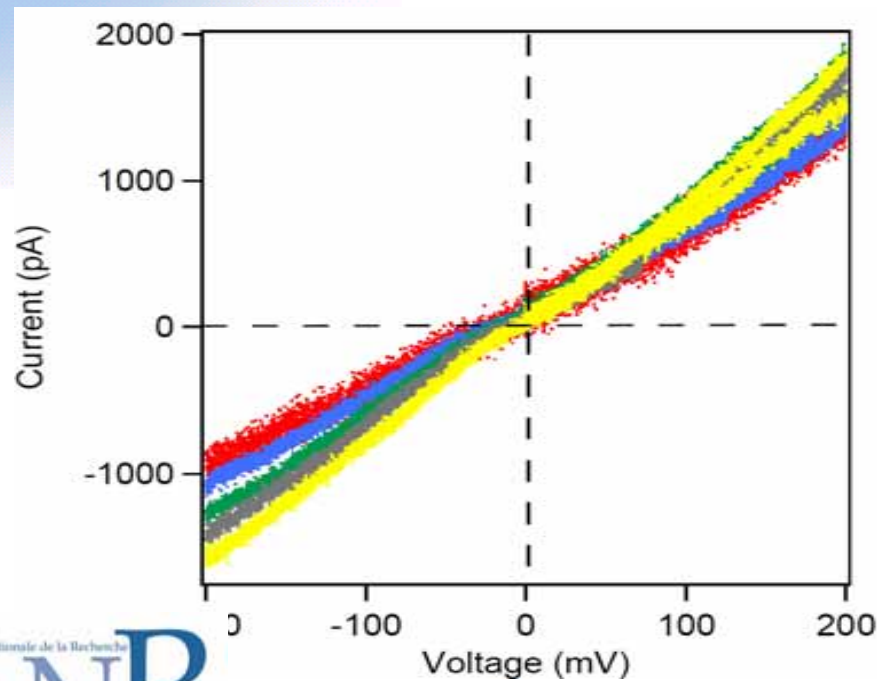
- **Translocation events observed** “unique” for FIB single step engraved artificial nanopores
- **Blockade Current** ~ 50% (less than 10 % for competitors)



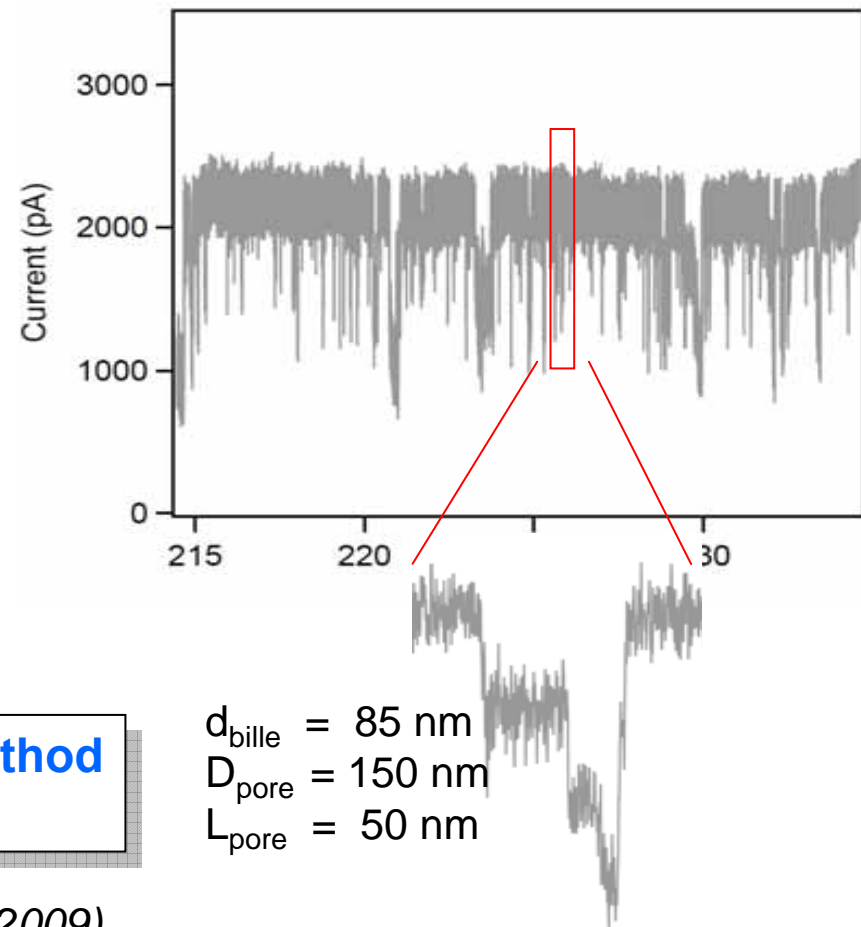
Bigitta Schiedt
Highlighted presentation MRS 2009

SILICA BALLS TRANSLOCATION DETECTION THROUGH ARTIFICIAL NANOPORES

I-V Curve



Current blockage evidences



- Pore size calibration method
- No equivalent results

$d_{\text{bille}} = 85 \text{ nm}$
 $D_{\text{pore}} = 150 \text{ nm}$
 $L_{\text{pore}} = 50 \text{ nm}$

Under investigations (G. Oukhaled – 2009)

Agence Nationale de la Recherche
ANR


UNIVERSITÉ D'EVRY
VAL D'ESSONNE


LABORATOIRE
DE PHOTONIQUE
ET DE
NANOSTRUCTURES

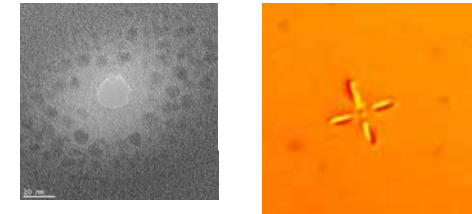
EFUG 2009, 5/10/2009, Arcachon



CONCLUSIONS AND OUTLOOK

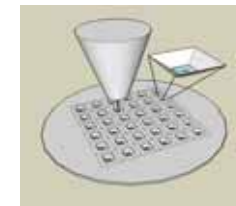
■ Single-step fabrication of nanopores

- Pores having measured sizes down to 3 nm (1/7)
- Creation of alignment marks allowing to relocate the pore for post-processing

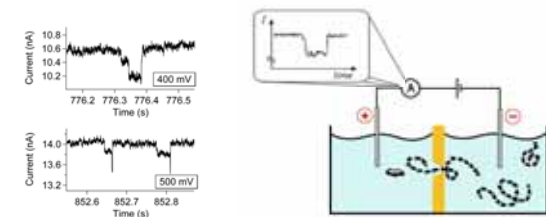


■ Capability of « mass-production »

- First time market viable application for FIB
- Capability to pattern complete 2" wafer of membranes in single-step operation



■ Successfully used for bio sensing applications



■ Functionalize the pore / environment of the pore using FIB

- Use same tool for pore patterning & post processing