Active Nanopores (3rd report)

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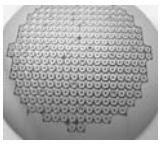
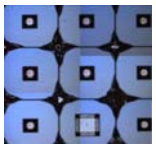
Abstract: In recent years, nanopores have become an important tool to **study the properties of single biomolecules** in ionic solutions. This technique is based on the translocation of these molecules through a pore of comparable size, which are recorded as changes in the pore conductance.
One of the aim of our project is to compare the transport properties of biomolecules through protein channels [1] and solid-state nanopores. Here we focus on our new results 1) on nanopores fabrication by Focused Ion Beam in SiC [2] and Si_3N_4 ultrathin homemade or commercial membranes , 2) on their integration [3-4] and 3) on the first translocation studies of different test systems, DNA, proteins and nanoparticles [5-6]. Our work will provide easy access to the use of nanopores in biology and biotechnology.

1. Large scale production of SiC and Si_3N_4 nanopores by FIB drilling

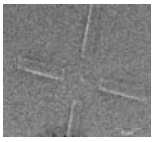
Reference file Lithograph

200 membranes on 2'' wafer



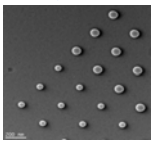


Mark on each membrane



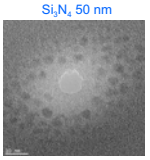
Shape

Si_3N_4 50 nm



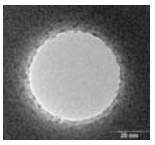
Smallest pores

Si_3N_4 50 nm

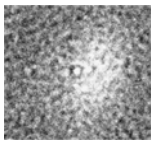


d = 8 nm

SiC 50 nm



SiC 20 nm

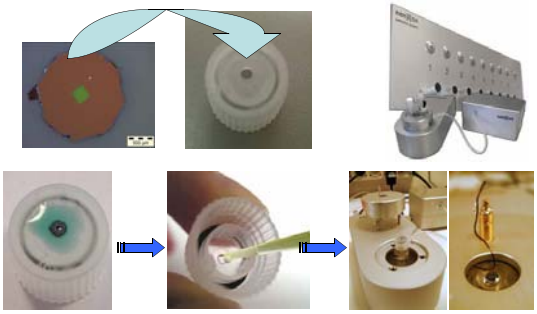


d = 3 nm

d = 40 nm

Integration / Measurement Setup

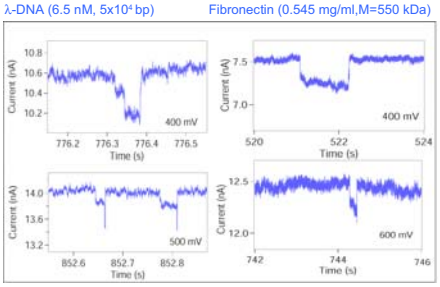
Nanion GmbH (Munich) chips and patch-clamp on a chip setup



2. ds-DNA and protein translocation

Si_3N_4 Pore: 25 nm
Electrolyte: 250 mM KCl, 10 mM Tris, 0.5 mM EDTA, pH 7.25

λ-DNA (6.5 nM, 5x10⁴ bp) Fibronectin (0.545 mg/ml,M=550 kDa)

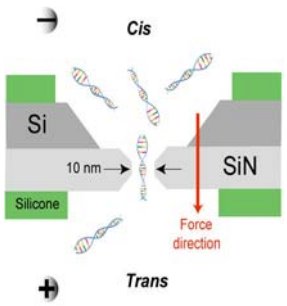


DNA and Fibronectin results for variious applied voltage
Across a 25 nm nanopore size and 50 nm nanopore length.

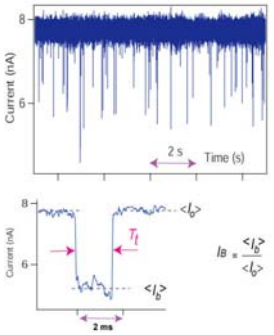
Applied Voltage (mV)	Dwell time (ms) λ-DNA	Dwell time (ms) Fibronectin
400	67	1160
500	36	
600		173

These results are consistent with the diffusion coefficients

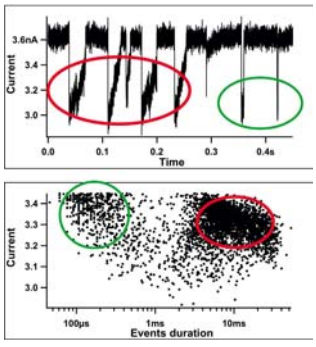
Nanopore experiments



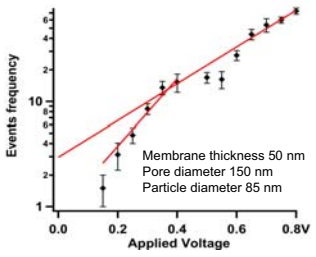
Si_3N_4 Pore: 10 nm
Electrolyte: 1M KCl, 10 mM Tris, 0.5 mM EDTA, pH 7.6
λ-DNA (0.7 nM, 5x10⁴ bp)



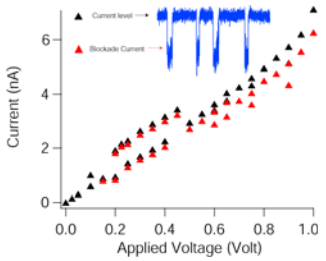
3. Silica Particles Translocation through Si_3N_4 nanopores



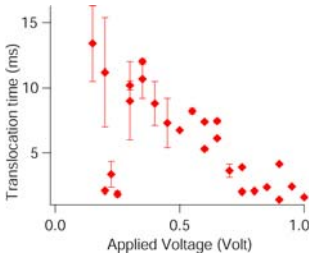
Frequency of bockades vs voltage



Open and Blockade current *vs* voltage



Dwelling time *vs* Voltage



4.Conclusions and perspectives

- Premiere: One step nanopore fabrication allows biomacromolecules experiments
- Promising: – Size pore uniformity attested by electrical measurement –Integration in commercial set-up.
- Functionalization: Chemical modification of the pore/coupling electrical measurement with optical experiments/using a nanopore as a force machine.
- Valorisation.

5.Reference

[1] G. Oukhaled, J. Mathé, A.-L. Biance, L. Bacri, J-M. Betton, D. Lairez, J. Pelta, and L. Auvray, ***Unfolding of proteins and long transient conformations detected by single nanopore recording***. Physical Review Letter (2007) 98, 158101.
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[3] E M. Huisman, A-L. Biance, A. Madouri, G. Patriarche, E. Bourhis, G. Oukhaled, L. Auvray, J.Gierak, ***A new way to integrate solid state nanopores for translocation experiments***. Micro Electronic Engineegring, (2008) 85 : 1311.
[4] B. Schiedt, L. Auvray, L. Bacri, A.-L. Biance, J. Gierak, A. Madouri, G. Patriarche, J. Pelta and R. Jede, **Direct FIB fabrication and integration of solid-state nanopore for biomacromolecules manipulation**, Mater. Res. Soc. Symp. Proc. Vol. 1191 (2009).
[5] B. Schiedt, L. Auvray, L. Bacri, A- L. Biance, A. Madouri, E. Bourhis, G. Patriarche, J. Pelta, R. Jede, J. Gierak, ***Direct FIB fabrication and integration of single nanopore devices for the detection of macromolecules*** EuroNanoForum European Commission (2009).
[6] B. Schiedt, L. Auvray, L. Bacri, G. Oukhaled, A.-L. Biance, A. Madouri, E. Bourhis, G. Patriarche, J. Pelta, R. Jede and J. Gierak, ***Direct FIB fabrication and integration of "single nanopore devices" for the manipulation of macromolecules*** (to be published MNE).