

## Fluid transport at the nano- and meso- scales

from fundamentals to applications in energy harvesting and desalination process



**Alessandro Siria**

Starting Grant 2014

Panel: PE 3, Condensed Matter

**Subject: Additional information on the interview**

As announced in our previous communication, please find below additional information regarding your interview.

<b>Applicant name</b>	Alessandro SIRIA
<b>Applicant address</b>	43 Boulevard 11 Novembre 1918 69622 Villeurbanne France
<b>Panel:</b>	PE3
<b>Panel name:</b>	Condensed Matter Physics
<b>Interview date:</b>	23 September 2014
<b>Interview slot:</b>	10:45 - 12:15

**Please bring a printed copy of this document together with your identity card or passport to be able to enter the building.**

**b) General interview format**

After a brief introduction by the Panel Chair or his/her delegate, the panel will ask you to give a **10 minute presentation** on the proposed research project and any critical information not included in the written proposal. The remaining time will be devoted to questions and answers on the scientific content and implementation of the project, and the project's budget and resources.

The time limit will be strictly enforced.

## **Annex II: Specific requests from Panel PE3 (Condensed Matter Physics)**

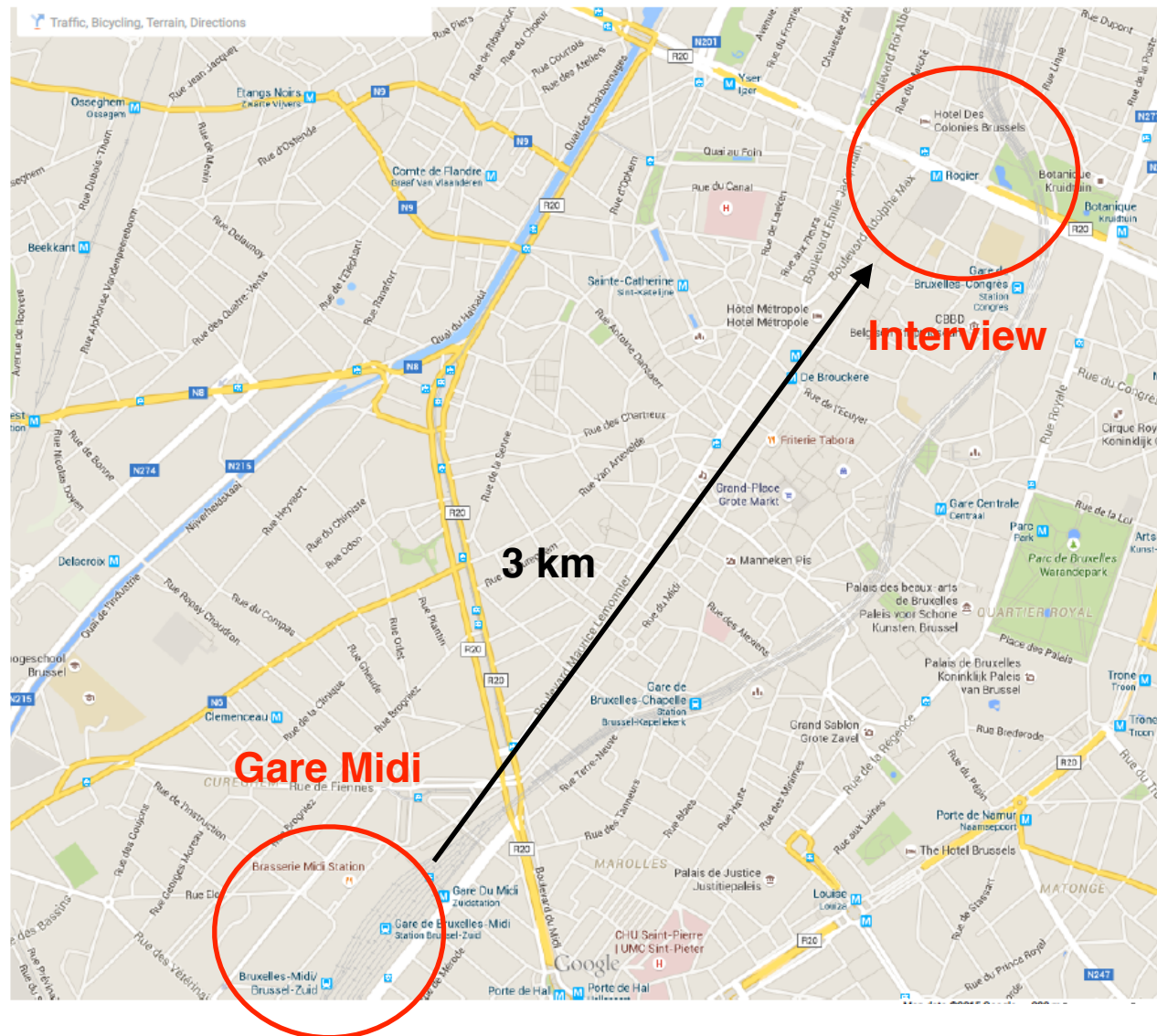
PANEL - ID	PE3
Presentation means	Electronic
Project presentation duration	10 minutes
Documentation to be brought	Print-out of presentation document (15 copies) – minimum one copy.
Total interview duration	25 minutes

### **Interview format**

The panel will ask you to make a **10 minutes presentation** of yourself and your proposal, followed by **15 minutes of questions and answers**.

These time limits will have to be strictly followed.

In order to make good use of the allotted time, you should properly balance the description of your past achievements and the presentation of your project. You should only give a brief overview of your CV since it is contained in the proposal (remember that the panel members have studied the written documents that you submitted). Instead, the main part of the presentation should be devoted to the research project itself: the innovative aspects, the research team, the methodology, the expected results and the potential contribution to the current state of the science in your field. You should also expect that the panel will have questions about the budget you requested.



Address:

COVENT GARDEN, 16 PLACE ROGIER, 1210 BRUSSELS, BELGIUM

- 1 - Hotel de Colonies
- 2 - Hotel Hilton
- 3 - Hotel Sheraton

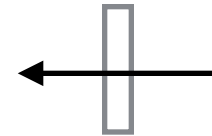




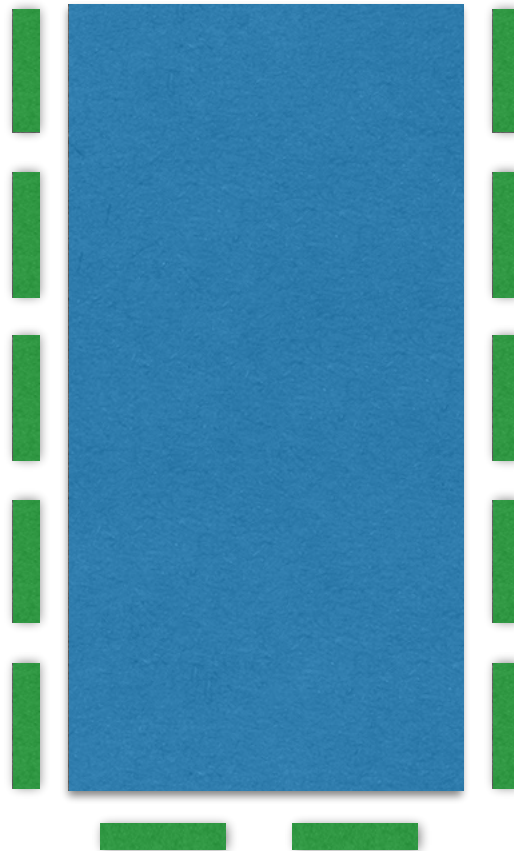
**Ecran 1**



**Ecran 2**



**Porte 1**



**Porte 2**



## Fluid transport at the nano- and meso- scales

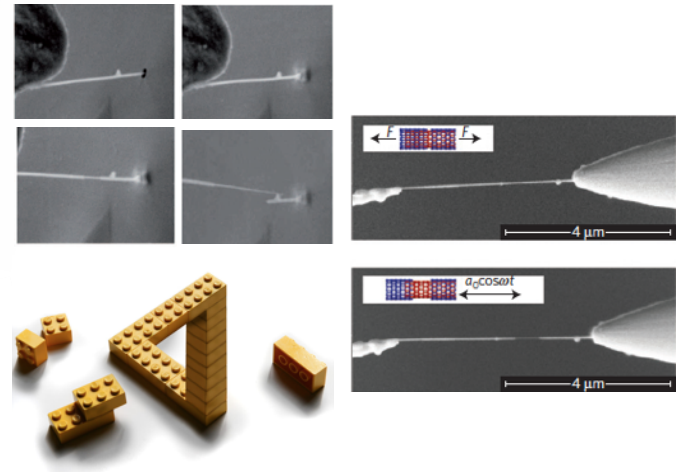
from fundamentals to applications in energy harvesting and desalination process

**Alessandro Siria**

Centre National Pour la Recherche Scientifique (CNRS) - France

<https://sites.google.com/site/alessandrosiria/>

Making a link between Solid State  
Physics and Soft Condensed Matter



# Background : a journey through Condensed Matter

## Atomic Force Microscopy and nanomanipulation

- Manipulation and control at nanoscale;
- Radiative heat transfer at nanoscale;
- Dissipation in NEMS;
- Quantum - Classic hybrid systems

Publication in leading scientific journals:  
**Nature Photonics, Nature Nanotechnology,  
Nature Physics, Physical Review Letters,  
Nanoletters...**

| Patent on scanning probe microscopy

2 Thesis awards

## Soft Matter

- Fluid transport in nanotubes;
- Ion transport in nanopores;
- Energy conversion with nanofluidics;
- Friction in individual nanotubes;

Publication in leading scientific journals:  
**Nature, Nature Materials,  
Nanoletters...**

| Patent on energy conversion

| CNRS award

# Curriculum Vitae : a journey through Condensed Matter

## Atomic Force Microscopy and nanomanipulation

- Manipulation and control at nanoscale;
- Radiative heat transfer at nanoscale;
- Dissipation in NEMS;
- Quantum - Classic hybrid systems

## Soft Matter

- Fluid transport in nanotubes;
- Ion transport in nanopores;
- Energy conversion with nanofluidics;
- Friction in individual nanotubes;

**New challenge : nano assembly for nanofluidics !**

Publication in leading scientific journals:

**Nature Photonics, Nature Nanotechnology,  
Nature Physics, Physical Review Letters,  
Nanoletters...**

| Patent on scanning probe microscopy

2 Thesis awards

Publication in leading scientific journal

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Nanoletters...**

| Patent on energy conversion

| CNRS award



# Why Nanofluidics?

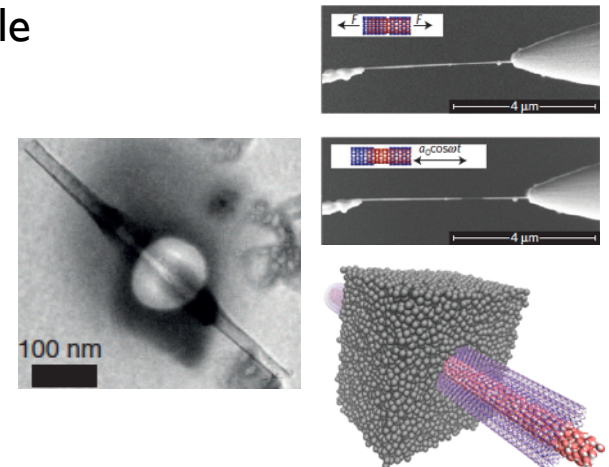
Nanofluidics: field of physics studying the fluid behavior at the nanoscale

## Challenges and benefices from the nano scales :

- ✓ **breakdown of bulk transport properties:** Navier-Stokes, thermal transport, ...
- ✓ **surface to volume effects:** enhanced role of surface phenomena
- ✓ **fluctuations** of transport properties
- ✓ **new functionalities** from fluid behavior at smallest scale

## What is new and why now?

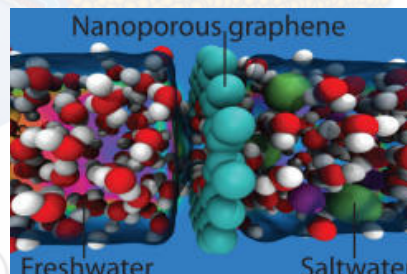
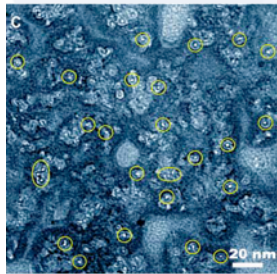
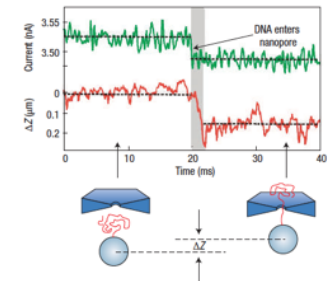
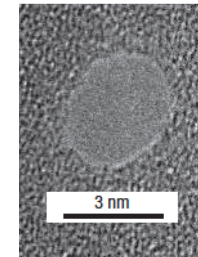
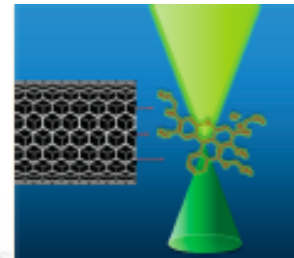
- ✓ ability to build new and controlled nm channel!



# Nanofluidics : state of the art

## Sensing : single particle translocation

C. Dekker, *Nature Nanotechnology* 2, 209 (2007); H. Liu et al., *Science* 327, 64 (2009); W. Song et al, *ACS Nano* 7, 689 (2013)

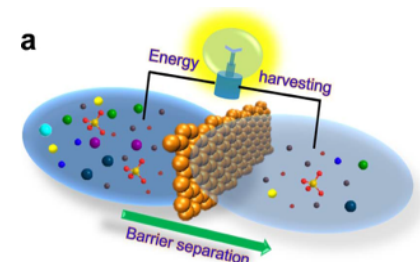
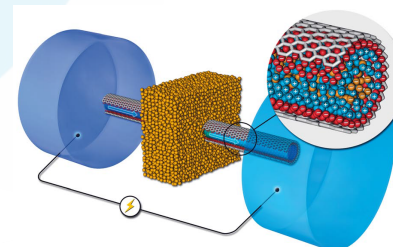


## Ultrafiltration : filter for water desalination

J. K. Holt et al. *Science* 312, 1034 (2006); D. Cohen-Tanugi et al. *Nanoletters* 12, 3602 (2012); R. K. Joshi et al. *Science* 343, 752 (2014);

## Energy harvesting : blue energy

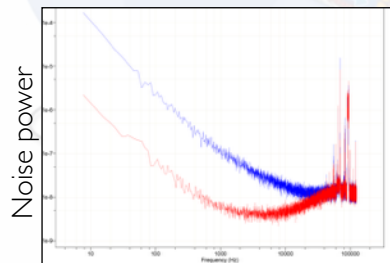
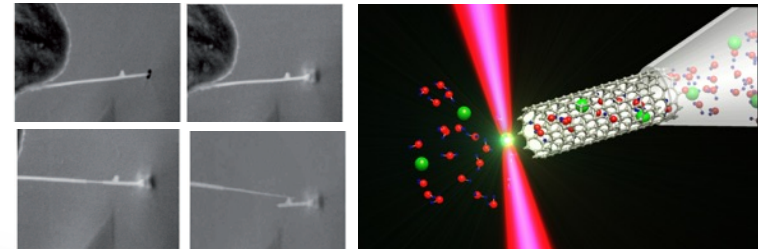
A. Siria et al, *Patent FR1259847* (2012); A. Siria et al., *Nature* 494, 455 (2013); Logan et al. *Nature* (2012); P. Sun et al., *Scientific Reports* 4, 5528 (2014);



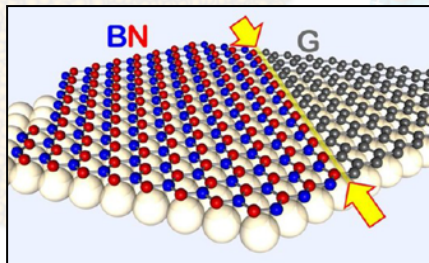
# NanoSOFT : aim of the project

## New artificial devices and experimental techniques

**Task 1 :** study nanofluidics in a controlled and systematic way



Frequency (Hz)

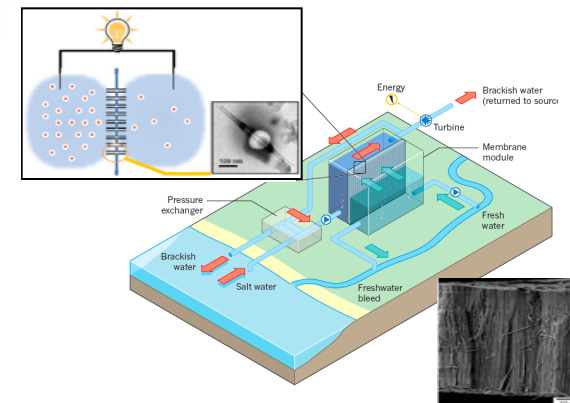


## New physical principles

**Task 2 :** explore properties of fluids at nanoscale

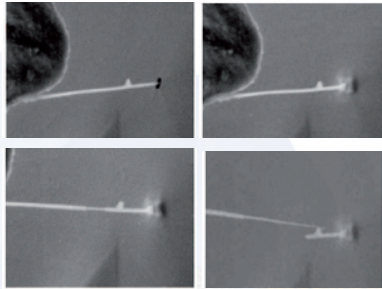
## New industrial applications

**Task 3 :** assure a fruitful transfer between the fundamental findings and technology

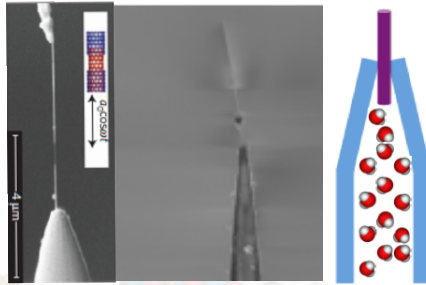


# Task I: developing new devices and tools

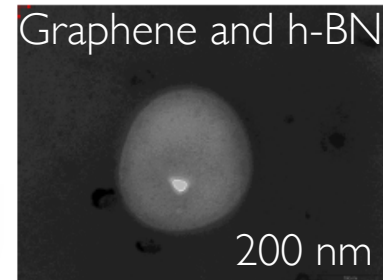
**New geometry and materials:** make use of **nano manipulation** tools



A. Siria, Nature (2013)



A. Siria, Nature Mat. (2014)



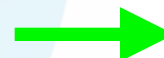
A. Siria, et al (2014)

**New experimental tools :** new **experimental techniques** to measure minimal water flux, ion and mass transport

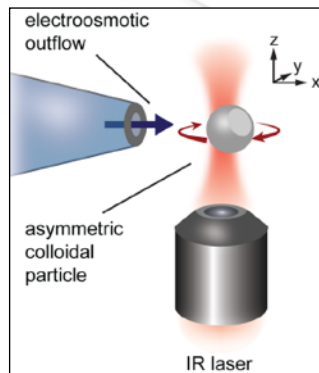
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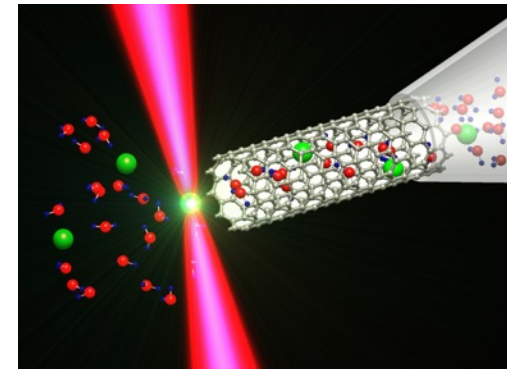
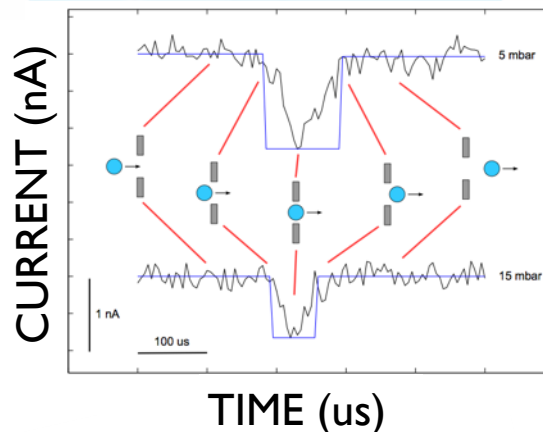
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~100 zL/sec res.



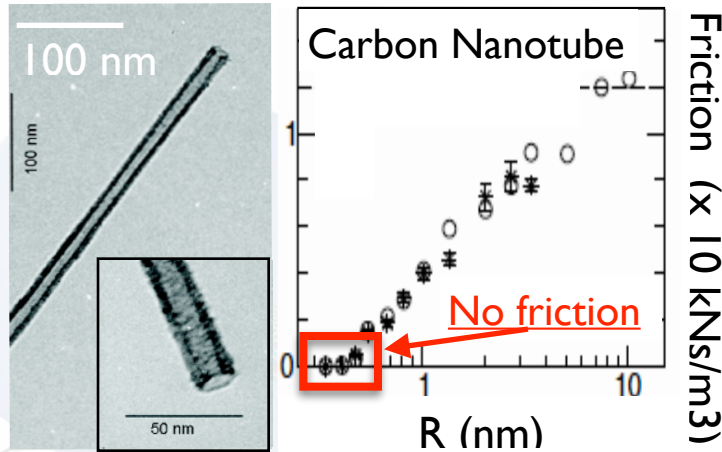
U. Keyser, NanoLetters (2013);



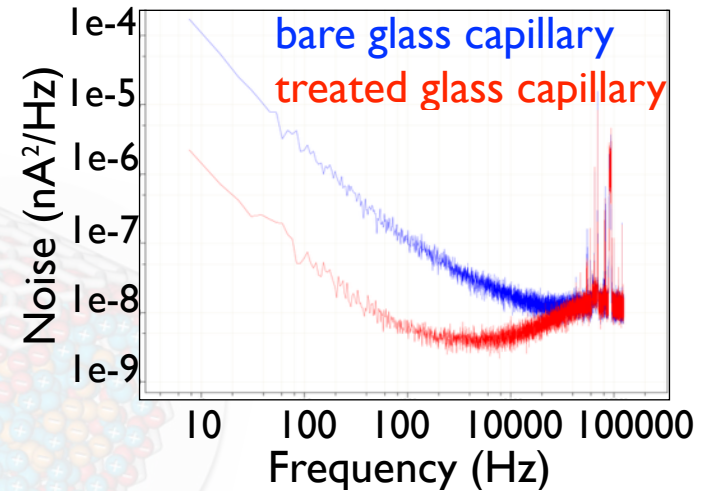


# Task 2: fundamental study of fluid transport at nanoscale

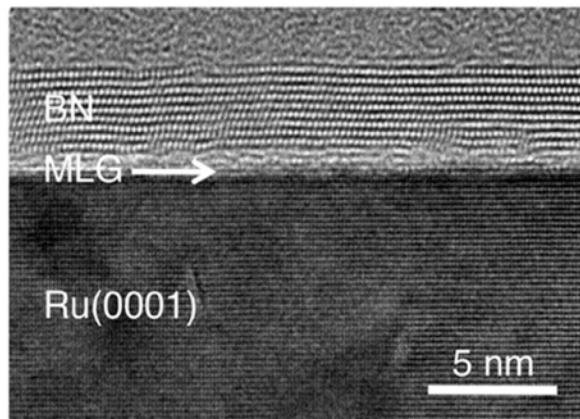
## Transport beyond continuum model and non linear behavior:



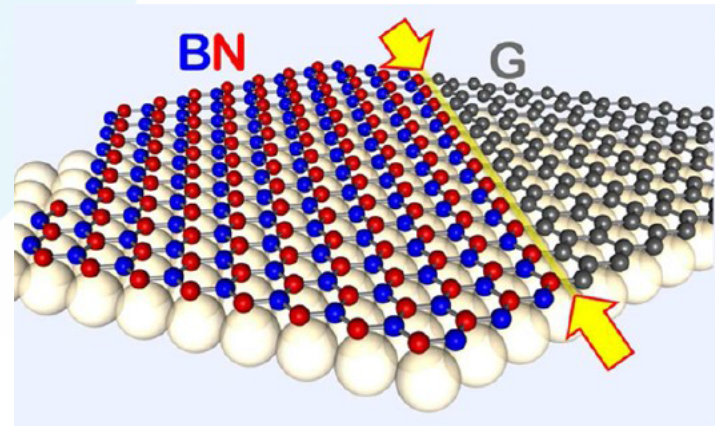
K. Falk et al. *NanoLetters* (2010);



## Influence of material and electronic properties on fluidic transport :



P. Sutter, *NanoLetters* (2013);

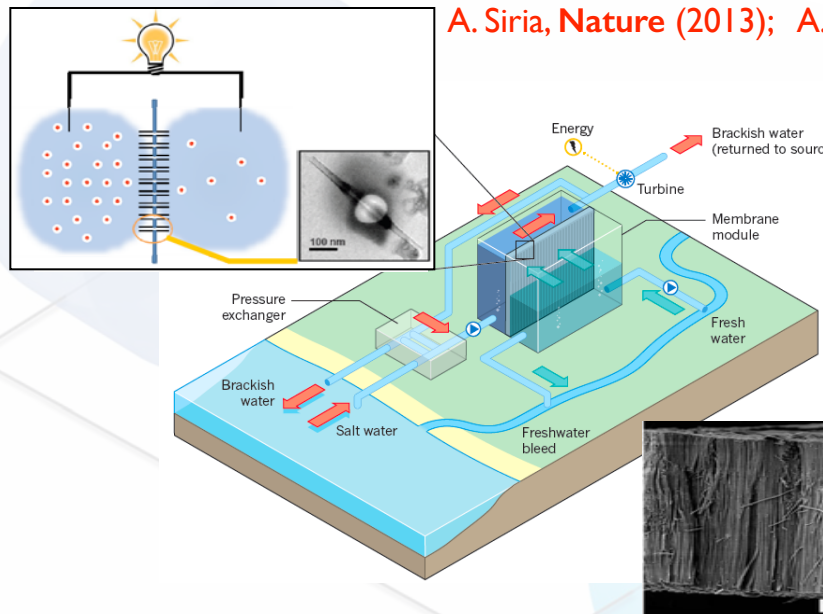


P. Sutter, *NanoLetters* (2014);



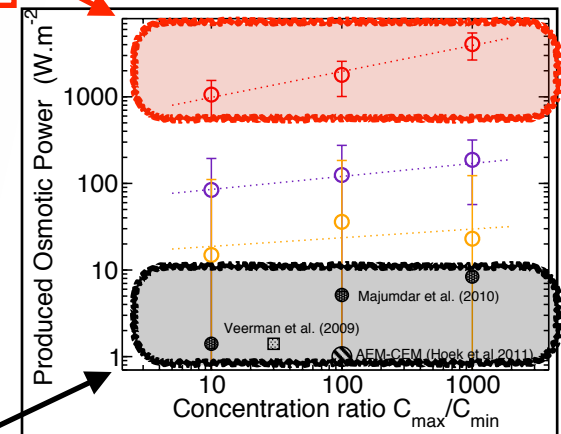
# Task 3 : transfer to new industrial applications

**Energy harvesting** : **New membranes** for salinity gradient **energy conversions**.



My work

$$P_{max} = I_{osm}^2 / 4G_{ion}$$



State of the art

**Ultrafiltration** : **New membranes** for water **filtration** and salt rejection

Requested budget : **1 494 000 €**

- Personnel : 2 Post Doctoral per year = 1 Post doctoral per task;
- Equipment : 220 K€ for development of new experimental set ups;

Hosting laboratory : **CNRS and Ecole Normale Supérieure**

- Access to talented PhD students with allocated grant;
- Access to dedicated Scanning Electron Microscope;
- Access to Graphene and h-BN growth facility;

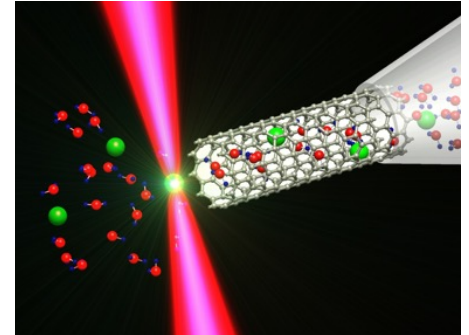
## EARLY DAYS OF NANOFUIDICS

Back to fundamentals :

- make use of nano manipulation tools
- new experimental techniques to measure minimal water flux, etc.

Many games to play :

- how material properties modify water and ion transport: superlubricity of carbon, BN versus C, ...
- meso-scales influence of electronic properties on fluidic properties ?
- new functionalities and new applications



# Curriculum Vitae

## Personal Informations:

### **Alessandro Siria**

Date of birth: 05/10/1982

Nationality: Italian

Web site: <https://sites.google.com/site/alessandrosiria/>

Researcher ID: C-7030-2014

## International mobility and education:

### **2013 - 2014:**

Visiting scientist at Stein Lab, Physics Departement, Brown University, USA;

### **2012 - today:**

Researcher at the Centre National pour la Recherche Scientifique (CNRS), France

### **2009 - 2012:**

Post-Doctoral Fellowship, Université Claude Bernard, Lyon France

### **2006 - 2009:**

PhD student at Institut Neel, Grenoble France

### **2005 - 2006:**

Master of Science, Physics Departement, Università degli studi di Genova, Genova Italy

## Awards:

**2013:** Prime Excellence Scientifique from CNRS;

**2010:** C'NANO Thesis awards - Fundamental research;

**2008:** Thesis awards from the ESRF - performance

## Supervisions and responsibility:

- Co-supervision of 1 Phd student (C. Sempere);
- Supervision of 4 Post-Doctoral researchers (A. Gadaleta, C. Lee, A. Nigues, E. Tamborini);
- Supervision of 2 Master students (R. Brossard, K. Vilella);

## Fundings:

- 2 National Fundings as Principal Investigator (CNRS-DEFI and FRAMA) : **15k€ and 25k€ over 1 year;**
- 1 National Funding as co Principal Investigator (PALSE) : **300k€ over 2 years;**
- 3 National Fundings as Partner (2 x ANR-BLANC and ANR-Young Scientists): **500k€, 250k€ and 180 k€ over 3 years**

## Key publications:

- *Ultra-high interlayer friction inside Boron-Nitride nanotubes*, **Nature Materials**, 13 , 688 (2014);
- *Bidimensional nano-optomechanics and topological backaction in a non-conservative radiation force field*, **Nature Nanotechnology**, accepted for publication (2014);
- *Giant osmotic energy conversion measured in a single transmembrane boron-nitride nanotube*, **Nature** 494, 458 (2013);
- *A single nitrogen-vacancy defect coupled to a nanomechanical oscillator*, **Nature Physics** 7, 879 (2011).
- *Radiative heat transfer at the nanoscale*, **Nature Photonics** 3, 514 (2009);

## Question time:

- 14 questions about the project in 15 minutes!
- No questions on the funding or the management
- Large part of the question coming from the referees

## Evaluation

- 7 external referees very positive
- 13 satisfactory answers
- 1 question not fully addressed (they say....)



**Subject: Outcome of the evaluation of proposals submitted to the Call for Proposals ERC-StG-2014 - Proposal n° 637748 NanoSOFT**

The ERC evaluation panels, composed of independent experts, have carried out their review of the proposals submitted to the above-mentioned ERC-StG-2014 Call. This includes your proposal entitled: *"Fluid transport at the nano- and meso- scales : from fundamentals to applications in energy harvesting and desalination process"*.

I am pleased to inform you that the panel has recommended your proposal for funding. |

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I am pleased to inform you that the panel has recommended your proposal for funding. However, your proposal has been ranked in a position that falls outside the published call budget. For your information, only the top 38% of the proposals evaluated in panel PE3 in Step 2 were funded. Your proposal is included in a short reserve list of proposals, which might be granted if additional budget becomes available in the coming months. I would appreciate your patience and as soon as the situation changes with respect to your proposal we will inform you.

**Subject: Invitation to grant preparation  
H2020 - ERC-2014-STG  
637748 - NanoSOFT**

**Dear Alessandro SIRIA,**

We are pleased to inform you that the European Research Council Executive Agency (ERCEA) is now in a position to initiate the preparation of the grant agreement for your abovementioned proposal.

The ERCEA intends to follow the Evaluation Report advice which has been already transmitted to you and consequently, it is estimated that the maximum EU financial contribution to your project could be up to 1 494 000.00 Euro for a period of up to 60 months.

With reference to the submitted proposal and its evaluation, the grant preparation shall be based on the following:

**The deadline for the submission of the data required for the grant agreement, including any additional documents, as detailed in the Annex attached is 05/03/2015.**

**Failure to respect the deadline indicated above will be considered as a wish not to enter into the grant preparation and, therefore, to withdraw your proposal. In such a case, the ERCEA will initiate the procedures to reject your proposal, unless alternative arrangements have been accepted by the ERCEA.**