# Spécialité de Master « Optique, Matière, Paris »

*Stage de recherche (4 mois minimum, à partir de début mars)*

## Proposition de stage

*Date de la proposition : le 13/10/2016*


**Responsable du stage** / *internship supervisor*:

Nom/*name*: BOYKO
Prénom/ *first name* : Olga
Tél : 0144274533
Fax :
Courriel / *mail*: Olga.Boyko@insp.jussieu.fr

**Nom du Laboratoire** / *laboratory name*: Institut des NanoSciences de Paris

Code d'identification : UMR 7588
Organisme : CNRS-UPMC
Site Internet / *web site*: http://www.insp.jussieu.fr/
Adresse / *address:* 4, Place Jussieu 75252 Paris Cedex 05
Lieu du stage / *internship place*: Jussieu tour 22-32


## Mechanical and electrical properties of Nitride nanowires in MHz and GHz range

*"If you want to find the secrets of the universe,*
*think in terms of energy, frequency and vibration." ~ Nikola Tesla*

The research in our group focuses on the elastic behavior of advanced materials that are realized through clean room technology. We have both an experimental and numerical approach to investigate the generation of high-frequency elastic waves, the interaction between wave and matter, and the control of wave propagation at the nanoscale. The engineered materials we design are generally composed of inclusions in solid matrix. Such materials exhibit exotic and unique propagation properties. For example, the periodic inclusion of holes into a silicon plate (the so-called "phononic crystal") can be applied to guide and to focus the elastic energy over a spot smaller than half the wavelength [1]. Another example is the localization of the elastic energy within a cavity [2] obtained when altering the geometrical properties of the otherwise perfect periodic structure.

We want to go one step further and investigate now the elastic and piezoelectric properties of disordered nanostructures. Actually, the evolution of technology makes it now possible the advanced structuring of mater at the nanometer scale. The use of nanotechnologies, and more especially of 1D-nanomaterials characterized by diameter below the hundreds of nanometers (nanowires), appears to be a promising solution to efficiently convert deformation energy into electric energy [3]. In fact, due both to their high flexibility giving rise to high deformation under small forces and to the enhancement of the piezoelectric coefficients compared to the bulk materials, nanowires have the potential to efficiently achieve high mechanical-electric conversion and to generate electrical powers sufficient for micro-electronic device operation. Depending on the size of the nanowires, the deformation at resonant frequencies may cover MHz to GHz range. We propose here to analyse the subsequent deformation of nanowires, using the Transient Grating method, which is based on four-wave mixing both to optically generate high-frequency elastic waves and to detect them. This will lead to a accurate understanding of the vibrations of nanowires properties allowing thereby for the prediction of the piezoelectric behavior, the enhancement of the energy conversion and in return to an improved design of the nanowires.

Multi-disciplinary competences are required for this work: modeling, physic characterization at nanoscale, surface structuration engineering, and piezoelectric testing.

References:


[1] J. Zhao and al., Phys. Rev. B 93 (17), 174306 (2016)
[2] R. Marchal and al., Phys. Rev. B 86, 224302 (2012)
[3] M. Tchernycheva and al., Nanotechnology 17 (16), 4025 (2006)


**Ce stage pourra-t-il se prolonger en thèse ?** *Possibility of a PhD* **? : Yes**

**Si oui, financement de thèse envisagé/** *financial support for the PhD***: Ecole Doctorale**

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