MASTER DE PHYSIQUE ET APPLICATIONS - 2ème année

Spécialité Sciences des Matériaux et Nano-objets

International Nanomat Master Program

Internship proposal

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Mechanical dissipation in a semiconductor micro-nano disk.

« *Optomechanics* » is a new emerging field of physics which studies the coupling betwwen light and a mechanical oscillator, at the crossroads of optics, condensed matter physics and micro-nanomechanics [1]. It is for example now possible to use light to cool down optically the motion of a mechanical oscillator, in analogy with the laser cooling of atoms. At low enough temperature (that we can not reach by standard cryogeny but only by optical cooling), the mechanical system should enter its quantum regime of oscillation, a macroscopic quantum phenomenum which remains un-observed to date. This regime would bring exciting perspectives: how does a mechanical system loose its quantum nature and becomes classical ? Is it possible to create non-classical states of motion? What are the ultimate limits of sensitivity of a quantum mechanical sensor ?

A key point for entering the quantum regime is to control the mechanical dissipation of the mechanical system, which describes its amount of coupling to the environment. The mechanisms driving mechanical dissipation in micro-nanomechanical systems are manyfold, sometimes unclear and many questions still remain open in this field. In our labs, we are using as optomechanical system a GaAs (gallium arsenide) micro-nanodisk (2 microns diameter, 100 nm thickness, see picture) to enter the quantum regime.

During this internship, we will study experimentally the mechanical dissipation of this system. To this purpose, we will use optical interferometry to probe with extreme sensitivity the mechanical displacement of the disk, which will be driven by ultrasonic piezo-electric actuation and electrostatic force modulation. These results will be correlated to high resolution SEM (Scanning Electron Microscopy) and later TEM inspections, allowing to isolate possible mechanisms of dissipation at the surface and in the « bulk » of the disk. The trainee will get acquainted to a broad range of techniques: fiber optics interferometry, micro-manipulation, mechanical isolation, piezo-ceramic modeling and ultrasonic actuation, numerical modeling of mechanical systems, SEM. This study will allow to evaluate the potential of highly pure crystalline GaAs for nanomechanics applications, and will therefore venture well beyond the mere field of optomechanics

This work is carried out in collaboration with the LPN labs (projet C-Nano Ile de France).

[1] for a review on optomechanics, I. Favero, and K. Karrai, Nature Photonics 3, 201 (2009).