Thesis subject

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Subject's title: **Nano-mechanical and piezoelectric studies on semiconductor nanowires**

Subject description:

The ***MNO group*** of IM2NP at Aix-Marseille Université offers a PhD thesis focusing on the mechanical and piezoelectric properties of semiconductor (GaN, ZnO) nanowires. Thanks to their extraordinary characteristics, these nanomaterials are potential candidates for various types of applications in optoelectronics, energy transducers, as sensors, or in nano-electromechanical systems (NEMS). Their extraordinary behavior originates from size effects which occur when the size of these objects becomes comparable to some intrinsic length scales. In the absence of any preexisting defects, they may show ultra-high mechanical strengths reaching the ultimate limit of the material [1-3]. The elevated yield strength found for low-dimensional materials and the fact that elastic strain significantly modifies the electronic structure of semiconducting micro- and nanostructures allow for improving the performance of such low-dimensional materials by elastic strain engineering. Moreover, the coupling of the mechanical deformation to electrical polarization via piezoelectricity opens the possibility of converting elastic strains into electricity for future energy transducers. In addition, plastic behavior instead of brittle fracture has been evidenced for low-dimensional semiconducting materials [4-6] but the impact of extended defects on nanowires piezoelectric response remains an open question. *To understand piezoelectricity at small scales and to avoid mechanical failure of future nanostructure-based components, the responsible mechanisms of energy conversion, fracture, and of defect nucleation and propagation induced by plastic deformation of these nanomaterials are of considerable interest. The large elastic deformations accessible in nanomaterials further grant access to non-linear mechanical and non-linear piezoelectric effects.*

Within the framework of this thesis, the successful candidate will study the nano-mechanical (elasticity, plasticity, fracture) and piezoelectric behavior of individual nanostructures using unique experimental techniques: (i) *in situ* atomic force microscopy coupled with nano-focused X-ray diffraction at 3rd generation synchrotrons (ESRF, SOLEIL, …) [7-8] and (ii) *in situ* electrical actuation during TEM imaging using a novel TEM sample holder in an aberration corrected FEI TITAN [9]. The experiments will be accompanied by finite element method simulations.

Competences: The candidate should hold a Master degree in physics, materials science, or another closely related field. He/she should have a profound knowledge in solid state physics and a vivid interest in working experimentally. Experience in programming languages is appreciable.

Applications including a CV, two letters of recommendation, and a statement of research interests should be sent to michael.texier@univ-amu.fr and thomas.cornelius@im2np.fr.

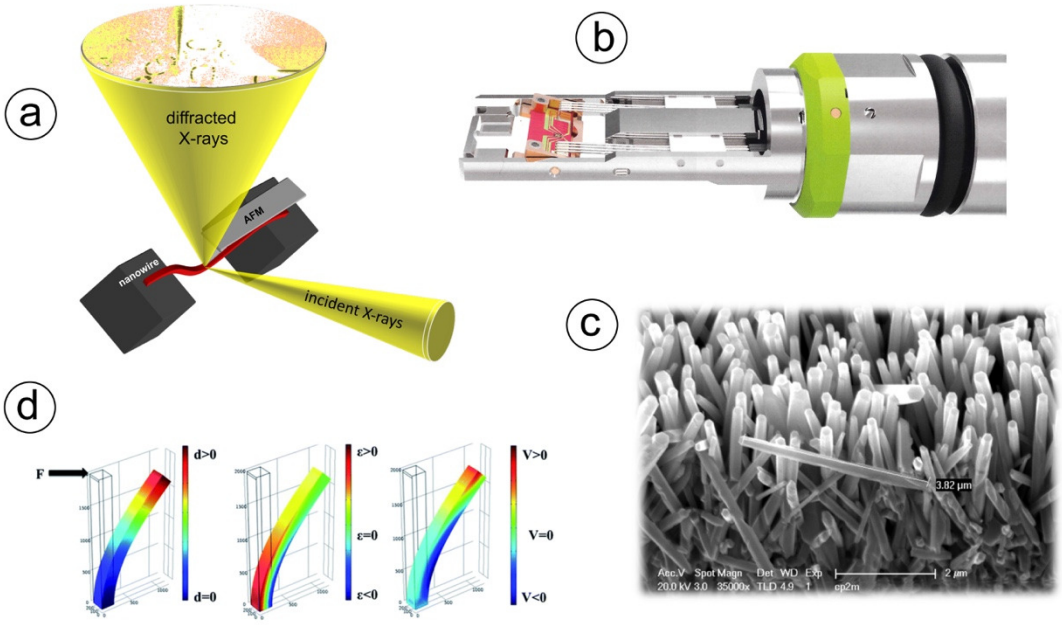

Fig.1. *(a) Schematic representation of the bending experiment under X-ray beam. (b) Head of the in situ biasing TEM sample holder. (c) Scanning electron microscope image of ZnO nanowires. (d) Examples of finite element calculations of nanowires submitted to a bending mechanical stress.*

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