- Axe de GANEX : Axe 6 - Photovoltaïque et convertisseurs d'énergie
- Titre du sujet : **Piezo-generators based on heterostructured III-Nitride NWs**
- Nom et e-mail du porteur du projet : N. Gogneau, noelle.gogneau@lpn.cnrs.fr
- Nature du post doc
  - ▉ académique : laboratoire bénéficiaire : LPN
- Date souhaitée de démarrage : Printemps 2016
- Durée : demandé **18 mois**, accordé **12 mois**
- Lien avec un projet ANR ou H2020: Fabrication et caractérisation à l'IEF dans le cadre de l'ERC "NanoHarvest" _ M. Tchernycheva
- Lien avec un autre partenaire de GANEX : INAC & IEF
- Sujet développé :

The piezo-generators based on nanowires (NWs) have emerged as excellent candidates to fabricate novel ultra-compact and efficient power sources for micro-electronic device operation. However, in spite of the current research efforts on nanomaterials and the recent spectacular development of NW-based generators, the improvement of the energy conversion efficiency and of the performance of the final device still remains the key objectives.
Through our exploratory project funded by GANEX in 2013, we have demonstrated:
1) The **high capability of mechanical-electrical conversion from GaN NWs**, leading to the highest measured so far **output voltages of -440 mV from single GaN NWs**;
2) The fabrication of a **first piezo-generator based on a vertical array of GaN NWs** with a surface of several mm^2, **delivering a power density of ~12.7 mW/cm^3**. This value settles **a new state of the art for GaN piezo-generators** and offers promising prospects for the use of GaN NWs for high-efficiency ultra-compact energy harvesters.

These first results constitute the building blocks for developing **new generation of piezoelectric generators** capable to efficiently convert the ambient mechanical energy into electricity. Now, we propose to enhance the piezoelectric conversion efficiency by nanoscale engineering of the active material. This original approach is organized in two key axes:
1- The development of **GaAlN/GaN and GaInN/GaN pre-strained axial heterostructures** in the active region of the NW volume to engineer the piezo-response. We believe that these novel heterostructures have the potential to **enhance the energy generation efficiency**, either increasing the conversion capacity, or reaching the maximum conversion for a lesser solicitation. Piezoelectricity calculations with COMSOL finite element method (and NextNano for band diagram) will be undertaken to design/optimize pre-strained NWs with enhanced piezoelectric properties.
2- The fabrication and testing of NW based piezo-generators. The flexibility being the key point enabling the conformal integration of generators on different objects with arbitrary shape, the piezoelectric NWs will be **integrated onto soft flexible substrates** via lift-off and transfer steps. The accurate determination of the real capacity of the piezo-generator in terms of generated electrical power and mechanical-electrical conversion efficiency will be tested in laboratory under compressive, flexural and shear mechanical stress.

In this context, this post-doc request, for duration of 18 months, is in direct relation with our previous successful exploratory project. The main focus of the present postdoc will be on the MBE growth of organized NW arrays containing pre-strained heterostructures to maximize the piezogeneration (60% of the time at LPN). In close collaboration with INAC (team of J. Eymery), the candidate will perform ultimate modeling of NW hétérostructures to undertstand the pre-strain impact on the piezoelectric generation (15% of the time). Finally, the candidate will also participate in the device fabrication and testing (25% of the time), which will be performed in collaboration with IEF (teams of E. Lefeuvre and M. Tchernycheva) in the frame of the "NanoHarvest" ERC project of M. Tchernycheva.

The LPN has a strong expertise in the growth of III-N NW growth by MBE and on the characterization of nano-objects. INAC has an important know-how on the piezoelectric properties simulations. IEF has a strong know-how in the field of NW devices (team of M. Tchernycheva) and more than ten-years of expertise on the characterization of small-scale piezoelectric materials with experiences on piezoelectric MEMS for Energy Harvesting (team of E. Lefeuvre).