- 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 : Centre des Nanosciences et des Nanotechnologies (C2N), Depts. Matériaux, Photonique et Electronique
- Date souhaitée de démarrage : 1er Juillet 2017
- Durée : 6 months (prolongation of PD 6.51 – N. Jegenyes)
- Lien avec un projet ANR ou H2020: Fabrication et caractérisation dans le cadre de l'ERC "NanoHarvest" de M. Tchernycheva
- Lien avec un autre partenaire de GANEX : CEA-INAC (J. Eymery)
- Sujet développé :

The GaN nanowires have demonstrated their potential to fabricate novel ultra-compact and efficient power sources for supplying micro-electronic devices. Especially, we have demonstrated 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;** and the development of the 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, then establishing the new state of the art for III-N based generators. Based on our expertize, we are developing a **new generation of piezoelectric generators** capable to efficiently convert the ambient mechanical energy into electricity.

To enhance the piezoelectric conversion efficiency of generators, we propose to nanoscale engineer the active material, by integrating **GaInN/GaN pre-strained axial heterostructures** in the active region of the NW volume. 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. Our original approach is based on two key axes:

1- The development of GaInN/GaN pre-strained axial heterostructures in the NW volume to engineer the piezo-response.

2- The fabrication and testing of GaInN/GaN NW based piezo-generators to efficiently convert the ambient mechanical energy into electricity.

From the beginning of the project (July 1st, 2016), **the growth by catalyst-free PA-MBE of high-homogeneous axial GaInN/GaN NWs with In content tuned from 5% up to 40% has been mastered**. In addition, the piezoelectric response of these axial heterostructures has been characterized by AFM- Resiscope. Hence, for the same experimental conditions (NW dimensions, AFM tip applied force and velocity), a maximum output voltage of 200 mV is generated by GaN NWs, while a maximum one of **250 mV can be reached by $Ga_{0.66}InN_{0.34}$/GaN NWs.** This result constitutes the first demonstration of mechanical-electrical conversion from axial GaInN/GaN NWs and **highlights the impact of GaInN insertion to enhance the energy generation**.

To develop the new generation of piezo-generators, the post-doc candidate, N. Jegenyes, will focus on:

1- The engineering of the piezo-response of pre-strained axial GaInN/GaN NWs (50 %), based on the expertize of nanomaterial growth at C2N-Dept Matériaux (LPN);

2- The optimization/design of the pre-strained heterostructures to improve the piezo-potential (20 %), by using COMSOL finite element method (and NextNano for band diagram) in close collaboration with J. Eymery team (CEA-INAC), who has an important know-how on the piezoelectric properties simulations;

3- The validation of the piezo-conversion efficiency improvement by using the III-N pre-strained NW through the fabrication and testing of piezo-generator devices integrated onto soft flexible substrates (30 %). This step is based on the strong know-how in the field of NW devices (team of M. Tchernycheva, C2N-Dept. Photonique (IEF)) and in the characterization of small-scale piezoelectric materials for Energy Harvesting (team of E. Lefeuvre, C2N-Dept. Electronique (IEF)).

In this context and in order to reach the final objective of our project, we apply to the Labex GaNeX 2017 for a prolongation of 6 months of the running postdoc (N. Jegenyes), bringing then the total duration of the postdoc to18 months as was initially requested (GaNeX 2016).