Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Mardi 13 novembre

14h00

Salle 44 –C2N site Orsay

Lu LU

" Piezoelectric nitride nanowires for energy harvesting and piezosensing "

Jury members :

Maria TCHERNYCHEVA	Directeur de recherche	Université Paris-Sud	Directeur de thèse
François JULIEN	Directeur de Recherche	Université Paris-Sud	CoDirecteur de thèse
Joel EYMERY	Directeur de Recherche	CEA-INAC	Examinateur
Olga BOYKO	Maître de Conférences	L'Institut des NanoSciences de Paris (INSP)	Examinateur
Elie LEFEUVRE	Professeur	Université Paris-Sud	Examinateur
Guilhem LARRIEU	Chargé de Recherche	LAAS	Rapporteur
Guylaine POULIN-VITTRANT	Chargé de Recherche	Université de Tours	Rapporteur
Noëlle GOGNEAU	Chargé de Recherche	C2N	Invitée
Pascal CHRETIEN	Ingénieur de recherche	GEEPS	Invité

Abstract :

This PhD work focuses on the study of GaN nanowire-based piezogenerating devices. The main objective is to develop novel devices for mechanical-to-electrical energy conversion for energy harvesting and for detection of transient deformations. The active material of the developed devices consists of a polymer-embedded nanowire membranes containing either molecular beam epitaxy (MBE) grown GaN nanowires or metal-organic chemical vapor deposition (MOCVD) grown GaN microwires.

Three device architectures are explored, namely a piezogenerator with a rigid matrix, with a flexible matrix and a fully flexible device. Two home-made mechanical excitation set-ups are used to characterize the generators. In particular, tapping mode and continuous compression deformations are applied to explore the devices' electrical performance in a large frequency range (from 1 Hz to 3 kHz). Based on these extensive experimental investigations, a panoramic summary of the generator transient behavior under various deformation conditions are made. A Schottky diode design and different versions of capacitive design for the piezogeneration are compared, and their equivalent electrical circuits are proposed. The piezogenerators' working mechanisms are further validated by experimental investigations.

Finally, a process to fabricate fully flexible generators and sensors is developed and these flexible devices are extensively characterized. In particular, a flexible device composed of a matrix of active pixels is demonstrated.

For the MBE nanowire-based piezogenerators on a rigid substrate, the best recorded average power output density reaches 22.1 mW/cm^3. For the MOCVD microwire based flexible generators, the best recorded average power output density attains 16.5 $\mu W/cm^3$. The flexible devices show a good sensitivity to ambient vibrations and respond stably to finger tapping deformations. An average energy of about 100 pJ can be delivered by the flexible device under one finger tapping gesture.

Keywords : piezogenerator, nitride, nanowire, piezoelectric semiconductors

91120 Palaiseau