Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Lundi 26 septembre
14h00
Amphithéâtre

« Novel solutions for piezogeneration enhancement in GaN nanowires »

Tanbir SODHI

Jury members :

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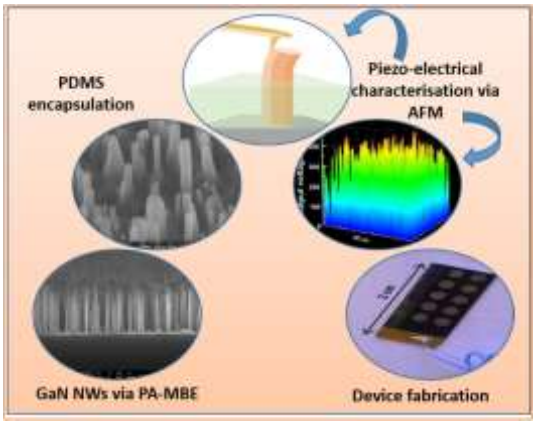
Abstract :

In the last decade, GaN nanowires (NWs) have emerged as promising candidates in the field of small-scale energy harvesting. Their superior mechanical and piezoelectric properties confers to them the ability to effectively convert the ambient vibrational and mechanical energies into electrical energy, and thus develop a new generation of ultra-compact, high-efficient and self-sustainable piezoelectric generators to assist or power microelectronic devices. Despite the demonstration of first promising NW-based piezo-generators, it is today indispensable to further increase the piezo-conversion capacity of these new harvesters. The exploration of novel solutions to enhance their performances is the research axis of this thesis. Here, plasma-assisted molecular beam epitaxy (PA-MBE) is employed to grow intrinsically p-doped GaN NWs with high crystalline quality. Thanks to a nano-characterization tool based on atomic force microscope equipped with the Resiscope electric module specifically adapted for piezoelectric conversion measurements, the piezoelectric response of NWs is investigated as a function of the explored solutions. The piezo-generation efficiency of the NWs is strongly affected by the external circuit. For the first time in the nanoscale regime. We experimentally demonstrate its influence on the piezo-generation efficiency of the NWs. The limitations of the formerly established protocol to judge the piezo-generation capacity of 1D-nanostructures are addressed and solutions are proposed. The piezo-generation efficiency of the NWs is also deeply affected by the surface charges, which are strongly pronounced in sub-100 nm wide GaN NWs. We demonstrate that these surface charges can be advantageous for piezoelectric applications as they offer the possibility to tune the free charge carrier concentration as a function of NW diameter. Thus, we establish experimentally that in the presence of surface charges, the electromechanical coupling efficiency of GaN NWs increases up to 43.4 % for diameters in the range of 45-60 nm. The piezoelectric measurements on GaN and GaN/Al_2O_3 core-shell NWs are also performed. The reduction of surface charge density by the Al_2O_3 shell results in a degradation of the piezoelectric response of the NWs. These results confirm the importance of the surface charges for improving the piezo-response of GaN NWs. Finally, by taking advantage of these solutions, output voltages reaching up to 520 mV per NW have been measured, stating a new-state-of-the-art, in the commonly used protocol, for 1D piezoelectric nanostructures.



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