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GaN Nanowires for Piezoelectric Generation

Noelle Gogneau[1*], Nicolas Jamond[1], Pascal Chrétien[2], Laurent Travers[1], Jean-Christophe Harmand[1], and Frédéric Houzé[2]

[1] *Laboratoire de Photonique et de Nanostructures, CNRS-LPN-UPR20, Route de Nozay, 91460 Marcoussis, France*
[2] *Laboratoire de Génie Electrique de Paris, UMR CNRS-Supélec 8507, Universités Pierre et Marie Curie et Paris-Sud, 11 rue Joliot-Curie, 91192 Gif sur Yvette, France*

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The development of autonomous micro-devices for sensing, monitoring and nomad electronics constitutes an important challenge. The nanowires (NWs) based piezo-generators (PGs), which convert the mechanical deformations and vibrations found in the vicinity of the device into electric energy, have emerged as excellent candidates to fabricate novel ultra-compact and efficient power sources. Thanks to their superior mechanical properties, higher sensitivity to applied force and higher piezoelectric response over conventional PGs, the NWs have the potential to fundamentally improve the electrical generator performance.

In spite of the current research efforts on nanomaterials with the increased discussions on the benefits of NWs to improve the energy conversion efficiency, there is a lack of fundamental understanding of piezoelectric properties of these nanostructures. This lack compromises the prediction of the piezoelectric potential, the improvement of the mechanical to electrical energy conversion, and thus the development of optimized nanowire based piezo-generators.

In the present work, we investigate the piezoelectric generation properties of GaN NWs by atomic force microscopy (AFM) equipped with an adapted home-made Resiscope module for local electrical characterization. We demonstrate the high potential of these nanostructures to convert mechanical energy into electric energy, since they can generate an average output voltage of -246 mV with a maximal detected value reaching –443 mV ± 2%. This latter value is the highest reported so far for GaN NWs and offers promising prospects for the use of GaN NWs for high-efficiency ultra-compact piezo-generators. We also investigate the piezoelectric generation mechanism involved in bended GaN NWs by AFM. Hence, we demonstrate the strong impact of the Nitrogen polarity of the GaN NWs on the rectifying behavior of the Schottky diode formed between the NWs and the electrode of measurement, the electric contact ensuring the charge recuperation for piezo-generation. The understanding of this mechanism is of crucial importance to design an adapted architecture of piezo-generator.

Keywords: GaN nanowires, piezoelectricity, piezogenerators, energy harvesting