Flexible capacitive piezoelectric sensor with ultra-long vertical GaN wires

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GaN piezoelectric wire-based flexible devices can provide original solution for mechanical sensing applications thanks to their self-powered characteristic, robustness and long life-time. To investigate this track, we developed specific materials, i.e. the growth of ultra-long N-polar GaN wires by self-catalyst Metal Organic Vapor Phase Epitaxy on sapphire substrate with silane addition [1,2]. These 1D materials exhibit hexagonal cross-section (diameter < 2 µm), slight conical shape (conicity <2 deg.) and length varying from 10 to 700 micrometers.
The aim of this communication will be to report a simple and scalable fabrication process of flexible capacitive piezoelectric sensors using vertically aligned GaN wires as well as to highlight their physical principles of operation [2]. Growth & structural studies will be reported first, enlightening the specificities of the MOVPE process.
The as-grown N-polar GaN wires are embedded into a polydimethylsiloxane (PDMS) matrix by spin-coating and directly peeled off from the sapphire substrate before metallic electrode contacting. This geometry provides an efficient control of the wire orientation and an additive contribution of the individual piezoelectric signals. The device output voltage and efficiency are studied by finite element calculations for compression mechanical loading as a function of the wire geometrical growth parameters (length and density). We demonstrate that the voltage output level and sensitivity increase as a function of the wire length and that a conical shape is not mandatory for potential generation as it was the case for horizontally assembled devices [4]. The optimal design to improve the overall device response is also optimized in terms of wire positioning inside PDMS, wire density, and total device thickness. Following the results of these calculations, we have fabricated experimental devices exhibiting outputs of several volts with a very good reliability under cyclic mechanical excitation [2].
As a conclusion, we will discuss the physical phenomena that have to be further studied in this type of materials, i.e. pyroelectricity, doping effects and technological issues.

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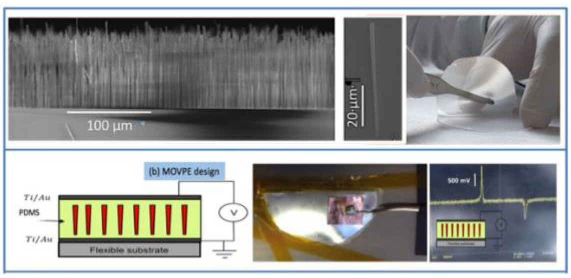

Fig. 1. (Top) Example of 100 µm long wire growth assembly & single wire, and peeling of PDMS containing wires. (Bottom) Design of the capacitive device & example with electrical results.