Robots for Microscopes.

APPLICATION NOTE

Characterization of the Piezoelectric Response of GaN Nanowires for the Design of Flexible Force Sensors

Upon bending, a ZnO or GaN micro/nanowire generates an electric potential. This piezoelectric property makes these particles interesting to create high sensitive and ultra-resolved microsensors that have application in force and pressure sensing [1, 2]. This application note describes a method and the preliminary results that were obtained while attempting to characterize the electrical response measured from bending individual GaN nanowires.

The nanowires were grown vertically by epitaxy on sapphire substrate (MOCVD). Their length and diameter were respectively L~60um and D~1um. The relatively large size of the nanowires enabled carrying out the experiment under a digital optical microscope (Mitutoyo) with 430x of total magnification. Two electric probes mounted on miBot nanomanipulators (Imina Technologies) were connected to an oscilloscope (Agilent Technologies) via a voltage amplifier with high input impedance.

In order to have a good visibility while approaching a nanowire tip and base with the probes, the substrate was mounted vertically on a sample holder [Fig. 1]. A candidate for characterization was first localized. A miBot was then used to meticulously cleanup the surrounding area by pushing away other nanowires. When the candidate was well isolated, the first probe, connected to the ground, was brought into contact with the nanowire base. The second probe was used to apply a deformation at the top of the nanowire in order to bend it. The oscilloscope was parameterized in differential mode to measure the difference of potential between the probe tips, representing the piezoelectric response of the bended nanowire. Response peaks around 30mV were measured for nanowire bendings of roughly 3um [Fig. 2].

[1] R. Agrawal and H. D. Espinosa, "Giant piezoelectric size effects in zinc oxide and gallium nitride nanowires. A first principles investigation." Nano Lett., vol. 11, no. 2, pp. 786–790, 2011

[2] E. Pauliac-Vaujour et al., "Self-Powered Conformable Deformation Sensor Exploiting the Collective Piezoelectric Effect of Self-Organised GaN Nanowires. V. Le Cam, L. Mevel and F. Schoefs. EW-SHM - 7th European Workshop on Structural Health Monitoring, Jul 2014, Nantes, France. (hal-01022023)

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Imina Technologies products in use:

- miBot™ BT-11 micromanipulators
- miBase BS-42 stage
- syDrive SD-10 piezoelectric controller

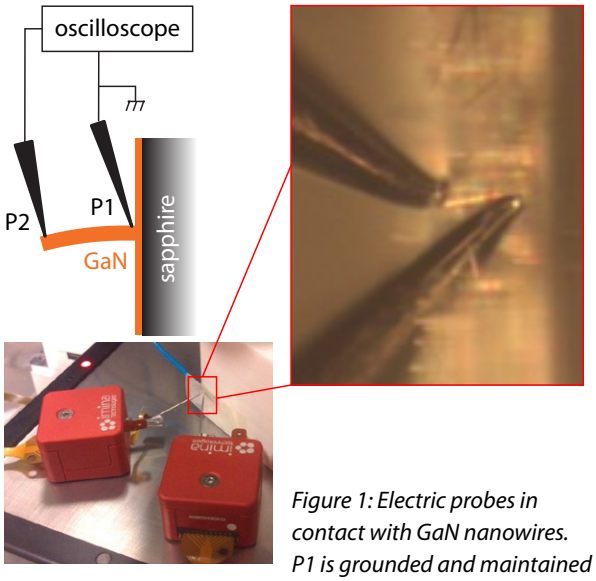

Figure 1: Electric probes in contact with GaN nanowires. P1 is grounded and maintained in position. P2 applies a deformation on the nanowire while acquiring the piezoelectric response.

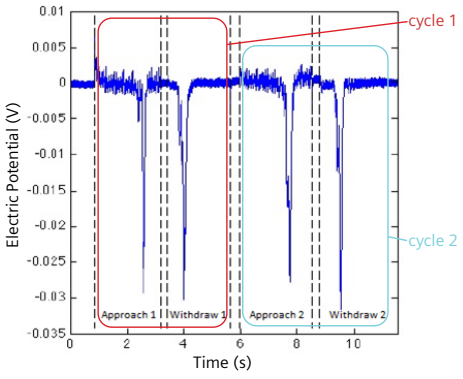

Figure 2: Piezoelectric response of a deformed GaN nanowire. The nanowire was bent and released twice (cycles 1 and 2).