GaN nanowires based piezogenerator

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Semiconductor nanowires (NWs) presenting piezoelectric properties have recently emerged as excellent candidates to fabricate novel ultra-compact and high-efficient piezoelectric generators. Thanks to their superior mechanical properties (larger elastic deformation, higher flexibility and resistance), higher sensitivity to applied force and higher piezoelectric response[1] with respect to bulk materials, the NWs possess three essential properties to fundamentally improve the mechanical-electrical energy conversion. In particular, among different piezoelectric semiconductors, GaN NWs are materials of choice to fabricate high-efficient piezo-generators due to their strong piezoelectric coefficients and high generation potential[2]. Indeed, single GaN NW has shown piezoelectric discharges[2] (-443 mV) higher than the one recorded for ZnO NWs[4] (45 mV), which is the most used material for NWs based piezogenerator.

The piezoelectric properties of GaN NWs were investigated by atomic force microscopy (AFM) equipped with an adapted home-made Resiscope module for local electrical characterization. Under external mechanical solicitation of the nanostructures, an average output voltage about 250 mV per NWs with a maximum output of 350 mV can be generated. This result evidences the strong potential of GaN NWs to convert a mechanical deformation into electrical energy.

These promising GaN nanostructures have been integrated into a first piezogenerator device (Fig. 1a) and tested by using a cyclic flexion strain setup ensuring its mechanical deformation.

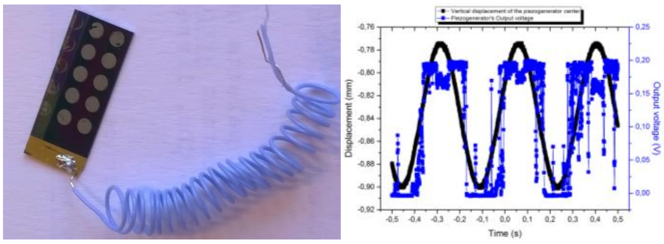

Figure 1: a) GaN NWs based piezogenerator prototype, b) Output voltage generation

Figure 1b presents the output voltage generated by the piezogenerator in response to its deformation. A maximal output voltage of about 200 mV is measured for a deformation force of 1.5 N. The estimated power density reaches a value of the order of 1.3 µW/cm². Although this power density is lower than the one generated by the ZnO NWs based piezo-generators, our first generator device reaches the state of the art[3] for GaN NWs-based piezo-generators. In addition, the generated power density approaches the required power to supply sensors and monitoring electronics. This result opens thus the way toward the development of ultra-compact and integretable renewable energy sources for sustainable, independent and maintenance-free operation of micro-devices.

References

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