

3-D view of 1-D nanostructures

Written by Editor
Friday, 06 January 2012 11:06

(Jan. 6, 2012) □ Just 100 nanometers in diameter, nanowires are often considered one-dimensional. But researchers at Northwestern University have recently reported that individual gallium nitride nanowires show strong piezoelectricity -- a type of charge-generation caused by mechanical stress -- in three dimensions.

The findings, led by Horacio Espinosa, James N. and Nancy J. Farley Professor in Manufacturing and Entrepreneurship at the McCormick School of Engineering and Applied Science, were published online Dec. 22 in *Nano Letters*.

Gallium nitride (GaN) is among the most technologically relevant semiconducting materials and is ubiquitous today in optoelectronic elements such as blue lasers (hence the blue-ray disc) and light-emitting-diodes (LEDs). More recently, nanogenerators based on GaN nanowires were demonstrated capable of converting mechanical energy (such as biomechanical motion) to electrical energy.

"Although nanowires are one-dimensional nanostructures, some properties -- such as piezoelectricity, the linear form of electro-mechanical coupling -- are three-dimensional in nature," Espinosa said. "We thought these nanowires should show piezoelectricity in 3D, and aimed at obtaining all the piezoelectric constants for individual nanowires, similar to the bulk material."

The findings revealed that individual GaN nanowires as small as 60 nanometers show piezoelectric behavior in 3D up to six times of their bulk counterpart. Since the generated charge scales linearly with piezoelectric constants, this finding implies that nanowires are up to six times more efficient in converting mechanical to electrical energy.

To obtain the measurements, researchers applied an electric field in different directions in single nanowire and measured small displacements, often in pico-meter (10-12 m) range. The group devised a method based on scanning probe microscopy leveraging high-precision displacement measurement capability of an atomic force microscope.

"The measurements were very challenging, since we needed to accurately measure

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displacements 100 times smaller than the size of the hydrogen atom," said Majid Minary, a postdoctoral fellow and the lead author of the study.

These results are exciting especially considering the recent demonstration of nanogenerators based on GaN nanowires, for powering of self-powered nanodevices.

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Journal Reference:

1. Majid Minary-Jolandan, Rodrigo A. Bernal, Irma Kuljanishvili, Victor Parpoil, Horacio D. Espinosa. **Individual GaN Nanowires Exhibit Strong Piezoelectricity in 3D.** *Nano Letters*, 2012; : 120103071655004 DOI: [10.1021/nl204043y](https://doi.org/10.1021/nl204043y)

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