GaN nanowires show more 3D piezoelectricity than bulk GaN

A research team from the Northwestern University has released the details of a study that reveals individual gallium nitride (GaN) nanowires showing strong piezoelectric effect in 3D. This is in spite of the fact that each nanowire only measures 100nm in diameter.

While GaN is ubiquitous in optoelectronic elements such as blue lasers (i.e. blue-ray disk technology) and LEDs, more recently, nanogenerators based on GaN nanowires have been demonstrated that are 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 3D in nature," noted Horacio Espinosa, professor in manufacturing and entrepreneurship at the McCormick School of Engineering and Applied Science. "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."

In addition to their direct bandgap, GaN nanowires exhibit piezoelectricity, making them attractive in energy-harvesting applications for self-powered devices.

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

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

"The measurements were very challenging, since we needed to accurately measure displacements 100 times smaller than the size of the hydrogen atom," stated Majid Minary, postdoctoral fellow and lead author from Northwestern.

The researchers added that the results are especially interesting considering the recent demonstration of GaN nanowires show more 3D piezoelectricity than bulk GaN.
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Likewise, they believe that the method they have developed is applicable to other piezoelectric nanowire materials as well as wires manufactured along different crystallographic orientations.

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