Nanowire generates power by harvesting energy from the environment

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As the sizes of sensor networks and mobile devices shrink toward the microscale, and even nanoscale, there is a growing need for suitable power sources. Because even the tiniest battery is too big to be used in nanoscale devices, scientists are exploring nanosize systems that can salvage energy from the environment.

Now, researchers at the University of Illinois have shown that a single nanowire can produce power by harvesting mechanical energy. Made of piezoelectric material, the nanowire generates a voltage when mechanically deformed. To measure the voltage produced by such a tiny wire, however, the researchers first had to build an extremely sensitive and precise mechanical testing stage.

"With the development of this precision testing apparatus, we successfully demonstrated the first controlled measurement of voltage generation from an individual nanowire," said Min-Feng Yu, a professor of mechanical science and engineering, and a researcher at the university's Beckman Institute. "The new testing apparatus makes possible other difficult, but important, measurements, as well."

Yu and graduate students Zhaoyu Wang, Jie Hu, Abhijit Suryavanshi and Kyungsuk Yum describe the measurement, and the measurement device, in a paper accepted for publication in the journal *Nano Letters*, and posted on the journal's Web site.

The nanowire was synthesized in the form of a single crystal of barium titanate, an oxide of barium and titanium used as a piezoelectric material in microphones and transducers, and was approximately 280 nanometers in diameter and 15 microns long.

The precision tensile mechanical testing stage is a finger-size device consisting of two coplanar platforms – one movable and one stationary – separated by a 3-micron gap. The movable platform is driven by a single-axis piezoelectric flexure stage with a displacement resolution better than 1 nanometer.

When the researchers' piezoelectric nanowire was placed across the gap and fastened to the two platforms, the movable platform induced mechanical vibrations in the nanowire. The voltage generated by the nanowire was recorded by high-sensitivity, charge-sensing electronics.

"The electrical energy produced by the nanowire for each vibrational cycle was 0.3 attojoules (less than one quintillionth of a joule)," Yu said. "Accurate measurements this small could not be made on nanowires before."

While the researchers created mechanical deformations in the nanowire through vibrations caused by external motion, other vibrations in the environment, such as sound waves, should also induce deformations. The researchers' next step is to accurately measure the piezoelectric nanowire's response to those acoustic vibrations.

"In addition, because of the fine precision offered by the mechanical testing stage, it should also be possible to quantitatively compare the intrinsic properties of the nanowire to those of the bulk material," Yu said. "This will allow us to study the scale effect related to electromechanical coupling in nanoscale systems."

Source: University of Illinois at Urbana-Champaign